MISSOURI STANDARD SPECIFICATIONS FOR HIGHWAY CONSTRUCTION

MoDOT

2019

Missouri Highways and Transportation Commission

I, Pamela J. Harlan, as the duly appointed Secretary to the Missouri Highways and Transportation Commission, hereby certify the following specifications are a full, true and complete copy of the Missouri Standard Specifications for Highway Construction, 2019.

Secretary to the Commission

I, Edward W. Hassinger, Chief Engineer of the Missouri Department of Transportation, hereby certify the following specifications are a full, true and complete copy of the Missouri Standard Specifications for Highway Construction, 2019.

Chief Engineer

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SECTION 101
DEFINITION OF TERMS

Wherever the following abbreviations, terms or descriptive words are used in the plans, specifications or other contract documents, the intent and meaning shall be interpreted as follows:

101.1 Abbreviations.

AASHTO American Association of State Highway and Transportation Officials

AISC American Institute of Steel Construction

AGC Associated General Contractors of America

ANSI American National Standards Institute

AREA American Railroad Engineering Association

ASME American Society of Mechanical Engineers

ASTM ASTM International

AWG American Wire Gauge

AWPA American Wood-Preservers' Association

AWS American Welding Society

AWWA American Water Works Association

CFR Code of Federal Regulations

CS Commercial Standards, U. S. Department of Commerce

CSR Code of State Regulations

COE Corps of Engineers

CUF Commercially Useful Function

DBE Disadvantaged Business Enterprise

EEI Electrical Engineer's Institute

EEO Equal Employment Opportunity

EPA Environmental Protection Agency

EPG Engineer Policy Guide

ESAL Equivalent 18-kip Single Axle Load

FCC Federal Communications Commission

FHWA Federal Highway Administration

GGBFS Ground Granulated Blast Furnace Slag

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GRI Geosynthetic Research Institute

ICEA Insulated Cable Engineers Association

IMSA International Municipal Signal Association

ITE Institute of Transportation Engineers

LED Light Emitting Diode

MASH AASHTO Manual for Assessing Safety Hardware

MDC Missouri Department of Conservation

MDNR Missouri Department of Natural Resources

MGS Midwest Guardrail System

MHTC Missouri Highways and Transportation Commission

MoDOT Missouri Department of Transportation

MSDS Material Safety Data Sheet

MUTCD Manual on Uniform Traffic Control Devices

NCHRP 350 National Cooperative Highway Research Program (NCHRP) Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features*

NEC National Electrical Code

NEMA National Electrical Manufacturers Association

NESC National Electrical Safety Code

NFPA National Fire Protection Association

NRCS Natural Resources Conservation

NRMCA National Ready Mixed Concrete Association

NTPEP National Transportation Product Evaluation Program

OSHA Occupational Safety and Health Administration

PAL Pre-Acceptance List

PS U.S. Product Standard, U.S. Department of Commerce

PWL Percent Within Limits

QA Quality Assurance

QC Quality Control

RETMA Radio Electronics Television Manufacturer's Association

RSMo Revised Statutes of the State of Missouri

SAE Society of Automotive Engineers

SHPO State Historic Preservation Office

SSPC Society of Protective Coatings

SWPPP Stormwater Pollution Prevention Plan

UCP Unified Certification Program

UL Underwriter's Laboratory

USA United States of America

USACE United States Army Corps of Engineers

USC United States Code

USCG United States Coast Guard

USFW United States Fish and Wildlife

VOC Volatile Organic Compound

101.1.1 Unit Symbols.

h hour

ppm parts per million

rpm revolutions per minute

vpm vibrations per minute

cf cubic feet

cy cubic yards

F degrees Fahrenheit

ft foot/feet

in inch/inches

lb pound/pounds

lf linear foot/feet

psf pounds per square foot

psi pounds per square inch

sf square foot/square feet

sy square yard/square yards

101.2 Definitions of Terms.

Advertisement. The public announcement, as required by law, inviting bids for work to be performed or material to be furnished.

Appreciable Error. Any of the following will be considered an appreciable error: an error resulting in a change in quantity of 10 percent from the original contract quantity of an item; an error resulting in a monetary change of at least $5,000 from an original contract item amount; or an error in the calculation of a contract item quantity based on the finite dimensions shown on the plans.

Auxiliary Lane. The portion of the roadway adjoining the traveled way and designated for speed change, or for other purposes supplementary to through traffic movement.

Award. The action of the Commission accepting the bid of the lowest responsible bidder for the work, subject to the execution and approval of a satisfactory contract therefore and bond to secure the performance thereof, and to such other conditions as may be specified or as required by law.

Bid. The written offer submitted by the bidder in the required manner on the bid to perform the work provided in the bidding documents at contract bid prices.

Bid Guaranty. The security furnished with a bid to ensure that the bidder will enter into the contract if the bid is accepted.

Bid Records. All writings, working papers, computer printouts, charts and all other data compilation that contain or reflect information, data or calculations used by the bidder to determine each contract unit price in the bid submitted, including but not limited to material relating to the determination and application of:

labor rates

equipment rates

home and field overhead rates and related time schedules

efficiency or productivity factors

arithmetic extensions

subcontractors, truckers and material supplier quotations

profit

contingencies

Any manuals standard to the industry that are used by the bidder in determining the bid shall be included in the bid records by reference and shall show the name and date of the publication and the publisher.

Bidder. Any individual, partnership, corporation, joint venturer or other entity submitting a bid to perform the contemplated work.

Bidding Documents. The documents furnished by the Commission comprising the Request for Bid, plans, *Missouri Standard Plans for Highway Construction*, addenda, Supplemental Specifications and General Provisions, *Missouri Standard Specifications for Highway Construction* and all other documents included in or referred to in those documents.

Bridge. A structure having a clear span greater than 20 feet measured on a horizontal plane along the centerline of roadway; also a multiple span structure where the total length of spans is in excess of 20 feet. For both single and multiple span bridges, the clear span shall be construed to mean the total distance from stream face to stream face of end bents or outer walls of the structure.

Business Day. A day that MoDOT is open for business, excluding holidays, Saturdays and Sundays.

Calendar Day. Any day of the calendar year, including holidays, Saturdays and Sundays.

Central Laboratory. The central testing laboratory of the Commission for inspecting and determining the suitability of material.

Change Order. A written order from the engineer to the contractor, as authorized by the contract, directing changes in the work as made necessary or desirable by unforeseen conditions or events discovered or occurring during the progress of the work.

Change in the Work. An item of work not provided for in the contract as awarded, but found essential to the satisfactory completion of the contract. Contract adjustments for changes in work related to differing site conditions shall be determined in accordance with the contract provisions relating to differing site conditions.

Claim. A written request or demand for adjustment to the compensation due or time of performance of the contract made within the time, in the form, and pursuant to the provisions for such contract adjustments specified elsewhere in the contract documents of which these specifications are a part.

Commission. The Missouri Highways and Transportation Commission.

Contract. The written agreement between the Commission and the contractor covering the performance of the work for the proposed construction. The contract will include all contract documents. The contract may cover a single project or a combination of projects awarded as a single unit.

Contract Bond. The form of security approved by the Commission, furnished by the contractor and surety or sureties, guaranteeing complete performance of the contract and the payment of all legal debts pertaining to the construction of the project, or arising from the contract and the duties thereunder, and conditioned as may be required by the laws of the State of Missouri.

Contract Documents. Notice to Contractors, all Bidding Documents, Contract Bond, Contract Agreement, Acknowledgment, Contractor Questionnaire, Notice to Proceed, and all Change Orders.

Contract Time or Completion Date. The number of working days or calendar days shown in the bidding document as the time allowed for the completion of the work contemplated in the contract. If a calendar date for completion is shown in the bidding document, the contemplated work shall be completed by that date.

Contractor. The individual, partnership, corporation or joint venture undertaking performance of the work under the terms of the contract, and acting directly or through the contractor or contractor's agents, employees or subcontractors.

Controversy. A dispute or disagreement between a contractor and the Commission related to interpretation of contract documents or the engineer's decision under contracts entered into by the contractor with the Commission made in writing and in compliance with the requirements for resolutions of controversies under the contract, but which is not a claim under the contract, all as provided elsewhere in the contract documents of which these specifications are a part.

Cost. Cost will mean the actual cost incurred, as distinguished from forecasted cost and determined in accordance with prevailing principles applicable to public contracts including *Contract Cost Principles and Procedures*, 48 CFR, Part 31 and *Government Auditing Standards*, as published by the Comptroller General of the United States.

Crashworthy End Terminal. This term will apply to both crashworthy end terminals and crash cushions.

Culvert. A structure not classified as a bridge that provides an opening under any portion of a roadway.

Days. Days as used in the contract documents will mean calendar days, unless specified otherwise.

Delay. Any event, action, force or factor that causes the established contract time to be exceeded for performance of the contract.

(a) Compensable Delay. An excusable delay for which the contractor may be entitled to additional monetary compensation

(b) Excusable Delay. A delay to the contract or milestone completion date that was beyond the contractor's control and not caused by the contractor's fault or negligence and for which a contract or

milestone time extension may be granted.

(c) Noncompensable Delay. An excusable delay for which the contractor may be entitled to an extension of time, but no additional monetary compensation.

(d) Nonexcusable Delay. A delay to the contract or milestone completion date that was reasonably foreseeable and within control of the contractor, for which no monetary compensation or time extension will be granted.

Differing Site Conditions. Subsurface or latent physical conditions at the site differing materially from those indicated in the contract, or unknown physical conditions of an unusual nature differing materially from those ordinarily encountered and generally recognized as inherent in the work

Disadvantaged Business Enterprise, **or DBE.** A contracting firm certified to participate in U.S. Department of Transportation financial assistance programs as a DBE by MoDOT or by the Missouri Unified Certification Program (UCP) pursuant to Title 49 CFR, Part 26, and pursuant to Title 7 CSR Division 10, Chapter 8, governing MoDOT's DBE Program.

Divided Highway. A highway with separated traveled ways for traffic in opposite directions. Traveled ways separated by painted medians will not be considered divided.

Drainage Ditch. An open depression constructed for the purpose of carrying off surface water.

Engineer. The chief engineer or any other authorized representative of the Commission. Where the term chief engineer is used, the term shall mean the chief engineer in person. MoDOT pursues its mission through the functional units defined by law. Where a functional unit is stated in the contract documents, it will mean the engineer of the functional unit or designee.

Equitable Adjustment. An adjustment to the time or price specified in the contract based upon contractor's actual and reasonable costs to perform the work for the reasons and determined by the methods specified elsewhere in the contract documents.

Extent of the Federal Share. The percentage of federal participation in the costs of the project agreed to between USDOT, FHWA and MHTC before the project is awarded. It does not mean, with regard to contract adjustments, an amount of additional federal participation to be provided regarding the project.

Gender Related Terms. No gender restrictions or limitations are intended or suggested by the use of terms "he", "him", "his", "it" or "its" in these specifications.

Highway. A public way for purposes of vehicular travel, including the entire area within the right of way.

Holidays. Missouri public legal holidays are:

January 1 - New Year's Day

Third Monday in January - Martin Luther King Day

February 12 - Lincoln's Birthday

Third Monday in February - President's Day

May 8 - Truman's Birthday

Last Monday in May - Memorial Day

July 4 - Independence Day

First Monday in September - Labor Day

Second Monday in October - Columbus Day

November 11 - Veterans Day

Fourth Thursday in November - Thanksgiving Day

December 25 - Christmas Day

When any of the above holidays fall on a Sunday, the holiday will be observed on the following Monday; when any of the above holidays fall on a Saturday, the holiday will be observed on the immediately preceding Friday.

Laboratory. The Central Laboratory or any other testing laboratory that may be designated by the engineer for inspecting and determining the suitability of material.

Lead Workers. Hourly employees in direct charge of the specific operations on a project. Formerly referred to as the foremen.

Local Traffic. Traffic that has either its origin or its destination at some point within the limits of the project. Local traffic will also include that traffic on all side roads that lead into the project where such traffic does not have a satisfactory outlet over a public road or street.

Major and Minor Items of Work. Any item having an original value in excess of 10 percent of the original contract amount will be considered as a major item or items. All other original contract items will be considered as minor. Where major contract items are not identified, the original contract item of greatest total cost, computed from the original contract price and estimated quantity, and such other original contract items next in sequence of lower total cost, computed in like manner, necessary to show a total cost at original prices and quantities of no less than 60 percent of the original contract cost will be considered as a major item or items.

Median. The portion of a divided highway separating the traveled ways for traffic in opposite directions.

Notice of Bid Opening. The notification provided prospective bidders, containing a description of the proposed work, instructions, information and the reservation of the right of the Commission to reject any and all bids.

Notice to Contractors. The document contained in the bidding document describing the work to be performed and including information and requirements for the submission of bids.

Notice to Proceed. The written notice from the engineer notifying the contractor of the date on or before which prosecution of the work is to begin.

Outer Roadway Or Service Road. A roadway auxiliary to and located on the side of the throughway for service to abutting property and adjacent areas.

Pay Item. An item of work specifically described and for which a price, either unit or lump sum, is provided. It includes the performance of all work and the furnishing of all labor, equipment and material contemplated or described on the plans or in the text of the specification item included in the contract.

Plans. Detailed construction drawings or reproductions thereof, which show the location, character and details of the work. When referenced in the contract documents, plans will include both the project specific drawings and the standard drawings.

Project. The specific section of the highway, including all appurtenances and construction to be performed thereon under the contract.

Request for Bid. The document furnished by the Commission that includes a complete set of bidding forms and appendices, and certain contract terms, which are made a part of the bidding document by reference.

Right of Way. Land acquired by the Commission for the construction and maintenance of a highway.

Roadbed. The graded portion of a highway between the outside shoulder lines, including the base course, surface course, shoulders and median.

Roadway. The portion of the highway within the limits of construction, including bridges and other structures.

Road User Cost. Includes a combination of both road user delay costs and work zone accident costs.

Sec. Refers to sections in the standard and supplemental specifications unless specified otherwise in the contract documents.

Shoulder. The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses.

Shall. When used in the contract documents, states a mandatory duty on the part of the contractor.

Significant Change in the Work. When the character of the work, as altered, (1) differs materially in kind or nature from that involved or included in the original proposed construction or (2) when a major item of work as defined elsewhere in the contract is increased in excess of 125 percent or decreased below 75 percent of the original contract quantity.

Specifications. The compilation of provisions and requirements for the performance of prescribed work.

(a) Standard Specifications. A book of specifications approved for general application and repetitive use.

(b) Supplemental Specifications. Approved additions and revisions to the standard specifications.

(c) Special Provisions. Revisions to the standard and supplemental specifications applicable to an individual project.

State. The State of Missouri, acting by and through the Commission.

Subcontractor. Any individual, partnership, corporation, joint venture or other entity to whom the contractor, with the written consent of the engineer, sublets any part of the work under the contract.

Substructure. That part of a bridge structure below the bearings of simple and continuous spans; all buttresses and piers below the skewbacks of arches; all parts of rigid frames, or integral bents below tops of footings or tops of caissons; and also, all parts of the abutments, backwalls and wingwalls, except handrails and handrail posts.

Superstructure. All parts of a bridge structure not defined as substructure.

Surety. A corporate body duly authorized to do business in the State of Missouri, and which has executed a bid bond with the bidder or a contract bond with the contractor.

Temporary Structures. Structures required for the use of traffic while construction is in progress and not designated to remain a part of the permanent roadway.

Throughway. A general term denoting a highway primarily for through traffic, usually on a continuous route.

Through Traffic. Traffic which has neither its origin nor its destination within the limits of the project.

Traveled Way. The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

Unbalanced Bid, Materially. A bid that generates a reasonable doubt that award to the bidder submitting a mathematically unbalanced bid will result in the lowest ultimate cost to the Commission.

Unbalanced Bid, Mathematically. A bid containing lump sum or unit bid items that do not reflect reasonable actual costs plus a reasonable proportionate share of the bidder's anticipated profit, overhead costs and other indirect costs.

Will. When used in the contract documents, states a mandatory duty on the part of the engineer or department or

on the part of both the engineer or department and the contractor, which is indicated by the context of use.

USA. Any of the 50 states, the District of Columbia, Puerto Rico and any other territories and possessions of the United States of America.

Work. The furnishing of all labor, material, equipment and other incidentals necessary or convenient to the successful completion of the project and the carrying out of all of the duties and obligations imposed by the contract.

Working Drawings. Stress sheets, shop drawings, erection plans, falsework plans, framework plans, cofferdam plans, bending diagrams for reinforcing steel or any other supplementary plans or similar data which the contractor will be required to submit to the engineer for approval.

SECTION 102
BIDDING REQUIREMENTS AND CONDITIONS

102.1 Notice of Bid Opening. After the date is fixed for the receipt of bids, the notice of bid opening will be posted on MoDOT's website and published as required by law. The notice of bid opening will contain a description of the proposed work, instructions and information to the potential bidder regarding bid forms, plans, specifications, combination bids and the reservation of the right of the Commission to reject any and all bids.

102.2 Contractor Questionnaire. Each prospective bidder, including a joint venture, shall file a contractor questionnaire on the form furnished by the Commission, which is available on MoDOT's website. The contractor questionnaire shall be furnished to the Commission as a separate document apart from any other document submitted. A bid will not be opened and read unless a fully responsive contractor questionnaire is on file with the Commission at least seven days prior to the time set for the opening of the bids. A new contractor questionnaire shall be filed annually, except the Commission reserves the right to request a contractor questionnaire from any contractor as of any date if the Commission has shown reason to believe that the contractor's experience data may have changed from that shown on the questionnaire on file. This document shall include a record of the bidder's experience data. The Commission will use this information as an aid to determine in each instance the lowest responsible bidder and nothing contained herein shall be construed as depriving the Commission of the Commission's discretion in the matter of determining the lowest responsible bidder.

102.2.1 At any time prior to award, as a condition of award and for a period of three years after the date of final acceptance, the Commission may request true copies of the bidder's financial data, including the bidder's balance sheet, profit and loss statement and similar financial data, as of the close of the bidder's most recent fiscal year prior to submission of the bid, and for each fiscal year between the contract award and final acceptance of the contract work. Unless specified otherwise by the Commission, financial data shall be prepared by an accountant and audited financial data shall be provided if it is available to the bidder for the fiscal period requested. A bidder who has not closed the first fiscal year prior to the date of the request shall supply the last periodic balance sheet, profit and loss statement and similar data.

102.2.2 The contractor questionnaire contains an affidavit of labor standards compliance. Each prospective bidder shall execute the affidavit, stating that such bidder will fully comply with all written requests by the Missouri Department of Labor and Industrial Relations, Division of Labor Standards, to provide information for the purpose of establishing a prevailing wage.

102.2.3 The prospective bidder, if a corporation, shall submit with the contractor questionnaire, a copy of the bidder's current annual registration report or initial registration report if a new corporation, on file with the Corporation Division of the Missouri Secretary of State's Office. Each corporation that is a party to a joint venture shall submit the same required report with the corporation's joint venture contractor questionnaire.

102.2.4 A prospective bidder doing business in the State of Missouri under a fictitious name shall furnish to or have on file with the Commission a certified copy of the prospective bidder's registration of the fictitious name issued by the Missouri Secretary of State, as an enclosure with the contractor questionnaire. No contract will be executed by the Commission until such a certificate is furnished by the bidder.

102.2.5 All prospective bidders who are corporations organized in states other than Missouri or countries other than the USA shall furnish, at the prospective bidder's cost, a certified copy of a current certificate of authority to do business in Missouri, with said certificate to remain on file with the Commission. Such a certified copy may be secured from the corporation supervisor in the Office of the Secretary of State, Jefferson City, Missouri. The prospective bidder agrees to cause the prospective bidder's authority to do business as a foreign corporation to be continued and extended throughout the life of any contract awarded and until all claims thereon and thereunder shall have been finally settled. All prospective bidders shall have a valid certificate of authority to transact business in Missouri at the time of bid opening as a condition of responsiveness.

102.3 Bidding. All bids shall be submitted electronically using the BidExpress® website. Any bid not submitted electronically will be considered irregular in accordance with Sec 102.8

102.3.1 MoDOT uses the BidExpress® website (www.bidx.com) as the official depository for electronic bid submittals. MoDOT will ensure that this electronic bid depository is available for a two-hour period prior to the

deadline for submission of bids. In the event of disruption of national communications or loss of services by www.bidx.com during this two-hour period, MoDOT will delay the deadline for bid submissions to ensure the ability of potential bidders to submit bids. Notifications and instructions of delay will be communicated to potential bidders.

102.3.2 The Commission will make the bidding documents available to the prospective bidder. The documents will state the location, description and requirements of the contemplated construction and will show the estimate of the various quantities and types of work to be performed or material to be furnished, and will have a schedule of items for which unit bid prices are invited. The bidding documents will state the time in which the work shall be completed, the amount of the bid guaranty and the date, time and place of the opening of bids.

102.3.3 Bidders that submit bids via the internet shall have on file with the Commission an "Electronic Signature Agreement", a copy of which can be found on MoDOT's website. This agreement shall be initiated by the prospective bidder and submitted to the Commission. A bid will not be opened and read unless a fully executed agreement is on file with the Commission at least seven days prior to the time set for the opening of the bids.

102.3.4 The Missouri Standard Specifications for Highway Construction, Missouri Standard Plans for Highway Construction, including all revisions of these documents, and other items referenced in the bidding documents, whether attached or not, will be considered a part of the bid. A prospective bidder will be expected to obtain the current edition of the Missouri Standard Specifications for Highway Construction and the Missouri Standard Plans for Highway Construction, including all revisions of these documents, which can be found on MoDOT's website.

102.3.5 Bidders will be responsible for any additional fees associated with submitting bids using AASHTOWare Project Bids® Electronic Bidding System software and the BidExpress® website.

102.3.6 It will be conclusively presumed that all of the bidding documents are in the bidder's possession and that these documents have been reviewed and used by the bidder in the preparation of any bid submitted. The effective dates of the *General Provisions & Supplemental Specifications* and the *Supplemental Plans for Highway Construction* will be specified in the contract documents. A copy of the latest version of these documents is available on MoDOT's web site.

102.4 Interpretation of Quantities in Bid Schedule. The quantities appearing in the bid schedule are estimated only and are prepared for the comparison of bids. Payment to the contractor will be made only for the actual quantities of work performed and accepted in accordance with the contract, except where final measurements are not made, as hereinafter provided. The quantities of work to be done and material to be furnished may each be increased, decreased or omitted as hereinafter provided.

102.5 Examination of Plans, Specifications, Special Provisions and Site of Work. The engineer will provide plans and specifications to the contractor providing direction on the work required. Conditions indicated on the plans and in the bidding documents represent information available from surveys and studies. The bidder is expected to carefully examine the proposed work site and bidding documents before submitting a bid. Submission of a bid will be considered proof that the bidder has made an examination and is satisfied with the conditions to be encountered in performing the work.

102.5.1 Other documentary information, consisting of boring logs and other factual subsurface information that does not constitute part of the contract or contract documents, will be provided with project plans that contain cross sections, or they will be available from the engineer upon the bidder's written request. This information, used for project design and quantity estimation purposes, was not obtained to determine actual subsurface conditions, actual quantities of subsurface material or appropriate construction methods, nor shall this information be considered a representation of actual conditions to be encountered during construction. Furnishing this information does not relieve a bidder from the responsibility of making an investigation of conditions to be encountered, including but not limited to site visits, and basing the bid on information obtained from these investigations and the professional interpretation and judgment of the bidder. The bidder shall assume the risk of error if the information is used for any purposes for which the information was not intended. The Commission makes no representation as to the accuracy of the logs or other subsurface information, since the accuracy of this information is limited by the equipment used, the personal judgment of the persons making the investigation, and by the limited number of samples taken. Records indicate conditions encountered only at the times and the specific locations shown. Ground water observations are not routinely recorded in all boring

logs. The absence of such data does not mean ground water will not be encountered. An indication of ground water constitutes no representation or warranty as to where ground water will be found, nor its volume or artesian character, during the project work. Any assumptions a bidder may make from this data is at the bidder's risk; none are intended by the Commission.

102.5.2 Certain other documents in the Commission's possession relating to subsurface investigations are not included in the records made available to bidders under Sec 102.5.1. These documents include correspondence and reports containing interpretations, opinions and recommendations that may or may not be factual, accurate or consistent with design decisions. Any such information that does not constitute part of the contract or contract documents is available, at a nominal cost, from the engineer upon specific, written request by the prospective bidder. The bidder is cautioned that any and all such interpretations, conclusions and recommendations are not represented or warranted to be accurate or reliable and the Commission cannot be bound by them, whether or not the Commission may appear to have "relied" on them. These subjective findings, opinions or assumptions have not been confirmed or shown to be reliable and the bidder assumes the sole risk of liability or loss if the bidder does rely on these documentary interpretations and conclusions to its detriment, delay or loss.

102.5.3 The bidder assumes all risks that may be encountered in basing the order of work, equipment or personnel determinations, time of performance, cost of performance, working days needed, item bid prices or any other element of the work, on documents that the bidder obtains from the Commission, which are not expressly warranted.

102.5.4 Unless stated specifically and expressly in the bidding documents, no project involving excavation, which may include either borrow or the disposal of excess material, is represented or warranted to be a "balanced" job or project, regardless of whether the bidding documents use terms such as "balance points" or other terms that could be interpreted to suggest balance. Whether or not such projects involving excavation contain bid items for borrow or disposal of excess material, the bidder should assume that either is possible and investigate those possibilities accordingly in determining a bid.

102.5.5 Utilities are often in the process of relocation at the time a project is bid. Regardless of what utilities are shown in the bidding documents and utility locations listed, the bidder shall contact each area utility to determine the presence and location of utility lines. The bidder shall determine and shall assume the risk as to whether utilities that are to be relocated by the utility companies have in fact been relocated and if not, when the utility company anticipates the relocation shall be completed. The bidder shall independently determine the reliability of the information received from the utility companies and shall make the determination as to the sequence and timing of utility relocations in determining a bid.

102.5.6 The bidder and contractor has an affirmative duty to inquire and obtain from the National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center (NCDC), from the USACE and any other cognizant government agency, historic weather and water stage information which the bidder may consider important as guides for bidding and scheduling the work. Some of that information may be contained among the bidding documents solely as a convenience and is not warranted nor represented to any degree to be complete and accurate historic data. No warranty or representation whatsoever is made or intended by the Commission of future weather conditions during the project. Water stages and depths of water at any place or at any time within the area of the project are acknowledged to be beyond control of the Commission and dependent upon future weather conditions and actions by other governmental bodies, such as the government of the USA or third parties. The Commission makes no representation that other governmental bodies or third parties will not take action during the period of the contract or any extended time of contract performance, which will affect water stages or depths. Bidders are put on notice that the bidder's operations may be affected by water flows, siltation and other causes over which it is acknowledged the Commission has no control

102.6 Sales and Use Taxes. The Commission will issue a sales tax exemption certificate as described in Section 144.062 RSMo to contractors for the Commission. The tax exemption will apply to the prime contractor, any subcontractors, or suppliers for materials and supplies incorporated or consumed during the construction of the Commission project.

102.7 Preparation of Bidding Documents

102.7.1 Bids submitted shall be prepared using the latest version of AASHTOWare Project Bids® and be submitted using the BidExpress® website. Each bidder shall specify in the bid, in figures, a unit price for each of the separate items listed. The bidder shall not enter zero in any "Unit Price" field unless zero is the intended

bid for that item. A unit price left blank will be considered a zero by the Commission. In case of alternate items, unit prices shall be entered for only one alternate, unless otherwise specified in the bidding documents.

102.7.2 A bidder may submit a separate bid on any or all projects, except that bids shall be submitted for all projects in a required combination. Bidders not having the ability to simultaneously execute all contracts for bids submitted during a bid opening may state, in one of the bids, the maximum total value of contract awards the bidder is willing to accept for that bid opening. Only one statement of "Maximum Monetary Value of Awards Accepted this Bid Opening" shall be completed per bid opening. In the event a bidder submits multiple statements of maximum award, the lowest value stated will be used. The Commission reserves the right to select and award the combination of bids, not exceeding this maximum, that will be to the best interest of the State, provided these bids are in conformance with the requests for bids. Any corrected bid that exceeds the lowest specified maximum award may be declared non-responsive.

102.7.3 Bids submitted shall have the digital ID of an individual authorized to sign bids for their respective company. The individual must be identified as an officer for the company on the contractor questionnaire.

102.7.4 The bid by a partnership or joint venture, including individuals doing business under fictitious names or corporations, shall only submit one bid for the partnership or joint venture.

102.7.5 The bid by a corporation, whether acting alone or as a joint venturer, shall show the address and name of the corporation exactly as shown on the contractor questionnaire, and shall include the signature or digital ID and title of a person authorized by its board of directors to bind the corporation.

102.7.6 Each bidder shall submit with each bid a sworn statement, executed by or on behalf of the bidder to whom a contract may be awarded, certifying that the bidder has not, either directly or indirectly, entered into any agreement, participated in any collusion or otherwise taken any action in restraint of free competitive bidding in connection with the bid or any contract that may result from its acceptance.

102.7.7 A bid will not be accepted or considered if the bid is the product of collusion among bidders, if the bidder is disqualified or determined not responsible or if the bid is irregular in accordance with Sec 102.8.

102.7.8 Subcontractor disclosure. For contracts of more than $2,000,000 each bidder shall submit with each bid a disclosure of the subcontracts that have a subcontract value that is equal to or greater than twenty percent of the total project bid or subcontracts that are greater than or equal to $2,000,000. The disclosure of subcontracts must include the name of each subcontractor, the category of work that each subcontractor will perform (e.g. asphalt, concrete, earthwork, bridges…) and the dollar value of each subcontract. The information shall be disclosed on the form provided in the bidding documents. If that information is not available at the time of bid the bidder shall submit the "Subcontractor Disclosure Form" pages with MoDOT on or before 4:00 p.m. of the third business day after the bid opening date, directly to the Design Division, Missouri Department of Transportation, 105 W. Capitol Avenue, P.O. Box 270, Jefferson City, Missouri 65102-0270. Telefax transmittal to MoDOT will be permitted at fax no. 573-522-2281. Failure to disclose this information may result in a bid being declared non-responsive. The complete signed original documents do not need to be mailed to MoDOT, but the bidder shall have it available if requested by the Design Division or the engineer.

102.8 Irregular Bids. Bids that are not completed in accordance with the bidding documents, that show any omissions, false statements or certifications, alterations of form, additions not called for, conditional or alternate bids unless called for, irregularities of any kind, or that are declared non responsive to the request for bids may be rejected. Bids combining or otherwise tying sections or projects not listed in the bidding documents as being in combination will be deemed irregular bids and will be rejected. Any comment in the bid limiting or qualifying the reserved right of the Commission to make awards that will be to the best interest of the State will constitute an irregular bid.

102.8.1 A bid will be considered irregular and may be rejected if any of the unit bid prices are mathematically or materially unbalanced to the detriment of the Commission.

102.9 Bid Guaranty. No bid will be considered unless accompanied by a certified check or cashier's check on any bank or trust company insured by the Federal Deposit Insurance Corporation, payable to the Director of Revenue, Credit State Road Fund, for no less than five percent of the amount of the bid, or by a bid bond secured by an approved surety or sureties in accordance with Secs 103.4.2 and 103.4.3, for no less than five percent of the amount of the bid. Bidders may submit a bid bond for each project bid or an annual bid bond that

would cover all projects bid for a twelve-month period beginning July 1 and ending June 30 of each state fiscal year. Annual bid bond forms shall be submitted by June 15 of each year. Forms delivered by US Mail should be mailed to: Missouri Highways and Transportation Commission, Attention: Annual Bid Bond, PO Box 270, Jefferson City, MO 65102. Forms delivered by parcel delivery services, (such as UPS, Fed Ex, DHL etc) should be shipped to Missouri Highways and Transportation Commission, Attention: Annual Bid Bond, 105 West Capitol Avenue, Jefferson City, MO 65102. The Commission will notify the bidder by letter that the annual bid bond form is approved.. Bid bonds shall be submitted on forms furnished by the Commission, which are available on MoDOT's website. Bid bond forms will be furnished to the prospective bidder upon request. Electronically produced copies of the bid bond form may be utilized, however, the exact wording used on the Commission furnished form shall be included in full and without deviation. Bid bond forms shall be complete and correct at the time of submittal or the bid may be considered non-responsive. Only the version of the bid bond form provided with the request for bid shall be submitted, unless the Request for Bid or Notice of Bid Opening authorizes the use of alternate bid bond forms. The bid bond power of attorney shall be an original document, not a facsimile. Bids accompanied by bid guaranties that are not in accordance with this section or accompanied by bid bonds that are not issued by an approved surety will be rejected.

102.9.1 Bidders may choose to submit a paper or electronic bid guaranty in accordance with Sec 102.9.

102.9.1.1 The electronic bid bond shall be part of the digitally signed bid and be verified via digital encryption by the bonding agent.

102.9.1.2 If utilizing an annual bid bond as a bid guaranty, it is the responsibility of the bidder to verify that each bid submittal does not exceed the annual bid bond limit. If a bid security maximum amount is specified for the annual bid bond and the bidder chooses to submit bids exceeding the maximum, it is the responsibility of the bidder to contact the surety for an increased annual bid bond or separate bid bond. The Bidder may choose to submit a project-specific bid bond in addition to an existing annual bid bond already on file with MoDOT.

102.10 Bids shall be submitted via the internet using the latest version of AASHTOWare Project Bids®, and be submitted using the BidExpress® website. All bids shall be filed prior to the time specified in the notice to contractors. BidExpress® will not accept any bids submitted after that time.

102.11 Any request for withdrawal of a bid submitted electronically shall be completed through Bid Express® prior to the time set for opening bids. The bidder may submit multiple electronic bids on the same project, however, the last bid received supersedes all previous submittals.

102.12 Combination Bids. Combination bids for two or more projects may be required or permitted and will be designated as such in the bidding documents.

102.12.1 On required combinations, the bidder shall complete the bid for each project included in the combination.

102.12.2 On permitted combinations, the bidder will be allowed to combine all projects in the combination or bid each project separately. The Commission reserves the right to determine the combination and make awards of the bids, that will be to the best interest of the State, provided they are in conformance with the request for bids and the bids submitted.

102.12.2.1 The bidder shall leave the project's bid items blank for all projects not bid in the permitted combination.

102.12.2.2 To combine all projects in a permitted combination, the bidder shall enter a complete bid for each project and mark the "All or None" box in the Bid. By marking "All or None" and combining all the projects, the bidder will be awarded all the projects in the combination or none of the projects.

102.12.2.3 If the bidder does not combine all of the projects, bids for the individual projects will be considered separately. The bidder shall complete the bid for each project the bidder desires to bid.

102.12.3 Two or more projects awarded in combination will be considered to be covered by a single contract. If during construction an item for which a unit price has not been bid is encountered in one project of a combination, the unit price bid for the same item in another project of the combination will apply, unless there is conclusive proof that conditions are changed significantly to effect a definite increase or decrease in the cost of

the operation.

102.13 Bids will be opened and the bid totals made public.

102.14 Disqualification of Bidders. Any one or more of the following reasons may be considered as being sufficient for the disqualification of a bidder and the rejection of the bid or bids:

(a) More than one bid is received for the same work from an individual, firm or corporation under the same or different name, or from different firms or corporations having common ownership, control or "Principals" that are affiliated, as described in Sec 108.13. However, a bidder may submit a bid as principal and as a subcontractor to some other principal or may submit a bid as a subcontractor to as many other principals as the bidder desires and by so doing will not be liable to disqualification in the intent of this specification.

(b) There is reason for believing that collusion exists among the bidders. Participants in such collusion will receive no recognition as bidders for any future work of the Commission until any such participant has been reinstated.

(c) The bidder or any officer, shareholder, owner or director of the bidder, has been terminated, debarred or suspended as an eligible contractor or bidder by any agency of the USA, the State of Missouri or any other state or any city, county, municipal corporation or other political subdivision.

(d) The Commission has determined or finds that the bidder is not responsible.

(e) The bidder is a person or firm not a resident of Missouri and has failed or refused to comply with the Missouri laws relating to nonresident or transient employers or is prohibited by Section 285.230 RSMo from contracting for or performing labor on a Missouri public works project.

102.15 Right to Reject Bids. The Commission reserves the right to reject any bid and also the right to reject all bids. All bids may be rejected for, without limitation, the following reasons:

(a) If in the opinion of the majority of the members of the Commission, the lowest bid or bids are excessive.

(b) The advertised bidding or contract documents are inadequate, ambiguous or otherwise deficient in any respect.

(c) The construction of all or any part of the project is no longer required.

(d) The bids received indicate that the quality requirements in the bidding or contract documents were overstated.

(e) The bidding and contract documents did not include all of the intended evaluation factors.

(f) The bids were not independently arrived at in open competition.

(g) There are indications that any of the bids were collusive or were submitted in bad faith.

(h) The bids received did not provide sufficient competition to ensure adequate price.

102.16 Opportunity to Partner. The successful bidder may enter into a cooperative partnership agreement with the Commission for the contract. The objective of this agreement will be the effective completion of the work, on time and to the standard of quality that will be a source of pride to both the Commission and the contractor. The "Partnering" agreement will not affect the terms of the contract. The agreement will only establish an environment of cooperation between the parties.

102.16.1 Partnering objectives can be achieved on an informal basis, the preferred method, or if a formal partnering agreement is desired, a initial training session is recommended to initiate the formal partnership agreement. The cost of this training will be borne equally between the Commission and the contractor.

102.16.2 Participation in "Partnering" will be voluntary and will not be required of the contract. The costs associated with "Partnering" shall not be included in the bid.

102.17 Disadvantaged Business Enterprise Program Bidding Requirements. Refer to the General Provisions for DBE Program Requirements.

102.18 Certifications. The bidder makes the following certifications by signing and submitting the bid.

102.18.1 Certification Regarding Affirmative Action and Equal Opportunity. If the bidder does not meet all requirements set forth in sub-paragraphs (a), (b) and (c) of this section, then the bidder shall submit a statement indicating which elements the bidder has complied with and those elements that are not in fact true and correct. The statement shall be on company letterhead, signed by the bidder and inserted inside the submitted bid. The bidder shall provide the following elements:

(a) The bidder has developed and has on file at each of the bidder's establishments affirmative action programs pursuant to 41 CFR Part 60-2.

(b) The bidder has participated in a previous contract or subcontract subject to the equal opportunity clause set forth in 41 CFR 60-1.4 and Executive Order No. 11246.

(c) The bidder has filed with the Joint Reporting Committee, the Director of the Office of Federal Contract Compliance Programs or the Director's designate or the EEO Commission, all reports due under the applicable filing requirements contained in 41 CFR, Part 60-1.

This certification applies to and shall be executed by each bidder or proposed subcontractor if the proposed contract or subcontract on this project will equal or exceed $10,000.00. This certification will also apply to any contractor or subcontractor that has contracts or subcontracts on federally assisted projects in any 12-month period that have or can reasonably be expected to have an aggregate total value exceeding $10,000.00, 41 CFR 60-1.5(a)(1). The prime contractor shall assure that each of the subcontractors that meet the criteria will also execute and submit this certification to the Commission.

102.18.2 Certification Regarding Disbarment, Eligibility, Indictments, Convictions or Civil Judgments. The president or authorized official of the bidder, under penalty of perjury under the laws of the USA, shall certify that, except as noted in the exceptions, the company or any person associated therewith in the capacity of owner, partner, director, officer, principal investor, project director, manager, auditor or any position involving the administration of federal funds:

(a) Is not currently under suspension, debarment, voluntary exclusion or determination of ineligibility by any federal agency.

(b) Has not been suspended, debarred, voluntarily excluded or determined ineligible by any federal agency within the past three years.

(c) Does not have a proposed debarment or suspension pending.

(d) Has not been indicted, convicted or had a civil judgment rendered against any of the listed parties by a court of competent jurisdiction in any matter involving fraud or official misconduct within the past three years.

102.18.2.1 If there are any exceptions, the bidder shall submit the exceptions on company letterhead, signed by the bidder and inserted inside the bid submitted.

102.18.2.2 Exceptions will not necessarily result in denial of award, but will be considered in determining bidder responsibility.

102.18.2.3 For any exception noted, the bidder shall indicate to whom it applies, the initiating agency, and dates of action.

102.18.2.4 Providing false information may result in criminal prosecution or administrative sanctions.

102.18.3 Certification Regarding Anti-Collusion. In accordance with 23 USC 112, the bidder shall certify, under penalty of perjury, that the bidder has not, either directly or indirectly, entered into any agreement, participated in any collusion or otherwise taken any action in restraint of free competitive bidding in connection with this contract.

102.18.4 Certification Regarding Lobbying Activities. In accordance with 31 USC 1352, the bidder shall certify that:

(a) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any federal agency, a member of Congress, an officer or employee of Congress or an employee of a member of Congress in connection with the awarding of any federal contract, the making of any federal grant, the making of any federal loan, the entering into of any cooperative agreement and the extension, continuation, renewal, amendment or modification of any federal contract, grant, loan or cooperative agreement.

(b) If any funds other than federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any federal agency, a member of Congress, an officer or employee of Congress or an employee of a member of Congress in connection with this federal contract, grant, loan or cooperative agreement, the bidder shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with the instructions.

102.18.4.1 This certification shall be a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification shall be a prerequisite for making or entering into this transaction imposed by 31 USC 1352. Any person who fails to file the required certification will be subject to a civil penalty of no less than $10,000 and no more than $100,000 for each such failure.

102.18.4.2 The bidder also agrees by submitting a bid that the bidder shall require that the language of this certification be included in all subcontracts that exceed $100,000, and that all such subrecipients shall certify and disclose any lobbying activities accordingly.

102.18.5 Certification Regarding Missouri Domestic Products Procurement Act. This certification will only apply to state-funded projects as noted on the cover of the Request for Bid. The bidder's attention is directed to Sections 34.350 through 34.359 RSMo 2000, which requires all manufactured goods or commodities used or supplied in the performance of the contract or any subcontract to be manufactured, assembled or produced in the USA. Sections 34.350 through 34.359 RSMo will not apply if the total bid is less than $1,000.00.

102.18.5.1 Section 34.355 RSMo requires the vendor or bidder to certify compliance with Section 34.353 RSMo and, if applicable, Section 34.359 RSMo at the time of bidding and prior to payment. Failure to comply with Section 34.353 RSMo during performance of the contract and to provide certification of compliance prior to payment will result in nonpayment for those goods or commodities.

102.18.5.2 The bidder shall certify that all the specified goods or products for which this bid was solicited are manufactured, assembled or produced in the USA. If there are any exceptions, the bidder shall submit a list of the exceptions on company letterhead, signed by the bidder and attached to the inside of the bid submitted. The list shall include the pay item number and the location where the item is manufactured. The bidder shall identify any of the exceptions in the list that are specified goods or products that are treated as manufactured, assembled or produced in the USA under an existing treaty, law, agreement or regulation of the USA regarding export/import restrictions and international trade.

102.18.5.3 The bidder shall notify the contact listed in the Request for Bid of any specified goods or products that cannot be manufactured, assembled or produced in the USA in sufficient quantities or in time to meet the contract specifications.

102.18.5.4 The bidder shall certify that the bid complies with all provisions of Section 34.350 *et seq* RSMo.

102.19 Preference for Missouri Products. By virtue of statutory authority, a preference will be given, on projects other than federal aid projects, to material, products, supplies, provisions and all other articles produced, manufactured, made or grown within the State of Missouri, where same are of a suitable character and can be obtained at reasonable market prices in the state and are of a quality suited to the purpose intended

and can be secured without additional cost over foreign products or products of other states.

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SECTION 103
AWARD AND EXECUTION OF CONTRACT

103.1 Consideration of Bids. After bids are opened and the bid totals read, the bids will be compared on the basis of the summation of the products of the approximate quantities shown in the bid schedule multiplied by the unit bid prices. The results of such comparisons will be immediately available to the public.

103.2 Award of Contract.

103.2.1 The contract will be awarded by the Commission to the lowest responsible bidder as soon as practical after the opening of the bids. The responsibility of the contractor will be determined by the Commission based on, but not limited to, previous work, financial standing and record for the payment of the contractor's obligations. No contract will be executed by the Commission unless the contractor has on file with the Commission a valid contractor questionnaire in accordance with Sec 102.2. The successful bidder will be notified by letter mailed to the address shown on the bid that the bid has been accepted and the contract has been awarded.

103.2.2 The Commission may make a contingent award to the second lowest responsible bidder. If the low bidder fails to execute the contract in accordance with this section, the contract will be offered to the second lowest responsible bidder in accordance with the contingent award made by the Commission within 25 days after the original award date. The second low bidder shall then be bound by the same requirements as specified for the lowest responsible bidder. The Notice to Proceed may be extended by the number of days between the original Commission award and the day the contract has been mailed to the second lowest responsible bidder. If the contract time for completion of the work is set solely by completion date, then the completion date may be extended by the number of days between the original Commission award and the day the contract was mailed to the second lowest responsible bidder. The new contract will be adjusted to reflect these changes, if appropriate.

103.2.2.1 If the second low bidder is not able to perform the work at the unit prices bid by the second low bidder due solely to the fact that the low bidder is unable to perform as a subcontractor in accordance with Sec 103.6, and the second low bidder based its bid upon an offer by the low bidder to perform subcontract work for the second low bidder, the second low bidder will not be required to forfeit its bid bond, providing the second low bidder submits to the Commission proper documentation that its bid was based on the low bidder's quote. Proper documentation shall include, but is not limited to, a letter to the Commission describing the work that was to be performed by the low bidder as a subcontractor, all quotes the contractor received and all documentation for the work in question.

103.2.2.2 When the second low bidder is required to execute the contract and the low bidder was a DBE firm that was identified on the second low bidder's Identification of Participating DBE's, the second low bidder shall attempt to replace the low bidder with another DBE firm. If the second low bidder is unsuccessful in attaining another DBE firm for that work, the second low bidder shall certify that a good faith effort was made in accordance with 49 CFR 26.53. The DBE goal will be adjusted accordingly.

103.2.3 When the tabulated lowest bids are equal in all respects, including price, the successful bidder will be determined by a formal drawing of lot limited to the tied bidders. Tied bidders will be notified of the location and time of the drawing and have the opportunity to attend, but attendance will not be required.

103.2.4 Alternate Bids. In making the award, if alternate bids have been requested, that alternate that will be in the best interest of the Commission will be used.

103.2.5 Federal Concurrence. If the USA or any agency thereof is paying all or a portion of the cost of construction of the project, the award made by the Commission will be tentative until proper federal concurrence therein has been received.

103.3 Return of Bid Guaranty. The bid guaranty, whether check or bid bond, of the low bidder will be retained until the contract has been executed by the successful bidder, all insurance requirements have been met and a satisfactory contract bond furnished. The check of the low bidder will then be returned. The bid guaranty of the second low bidder will be returned when the Commission has determined that award will not be made to that firm. If errors or irregularities appear in the bid of either of the two lowest bidders that creates doubt as to the status of such a bid, the bid guaranties of other bidders may be retained. When the two lowest bidders have been definitely established, the checks of the other bidders will be returned. Any bid bond furnished as a bid

guaranty will be returned only upon request of the bidder furnishing the bid bond. If an award is not made, all checks will be returned to the bidders.

103.4 Contract Bond Required.

103.4.1 The successful bidder shall, at the time of the execution of the contract, furnish a contract bond in a sum equal to the contract price. The bond shall be to the State of Missouri, in a form and with surety or sureties acceptable to the Commission, to ensure the proper and prompt completion of the work in accordance with the provisions of the contract, the contractor's compliance with all of the terms and conditions of the contract, all obligations on the contractor's part to be performed and payment of all obligations to the Commission by the contractor, including any indebtedness, liquidated or unliquidated, for any reason relating to or arising from the contract, and to ensure payment for all labor performed and material consumed or used in the work. The bond, if executed by a surety that is a corporation organized in a state other than Missouri, shall be signed by an agent or broker licensed by the Missouri Department of Insurance. All bids shall be submitted on the basis of furnishing a contract bond executed by an approved surety or sureties, as herein set out. The surety's liability under the contract bond and contract shall not be limited to the penal sum as set forth in the contract bond. The surety shall be liable and responsible to the Commission for the contractor's entire performance and of all obligations arising under or from the contract, which shall include, but is not limited to any change orders issued under the contract that increase the cost of the contract.

103.4.2 Certificate of Authority. Any surety company that proposes to execute a bond as required by the contract shall have on file with or furnish to the Commission a certified copy of the surety's certificate of authority to transact business in the State of Missouri.

103.4.3 Surety Acceptability. A surety will be acceptable to the Commission if the surety is listed in the current United States Department of the Treasury, Fiscal Service, Department Circular 570, *Companies Holding Certificates of Authority as Acceptable Sureties on Federal Bonds and as Acceptable Reinsuring Companies*. Individual contract bonds may not be in excess of the underwriting limitation listed in the circular.

103.5 Execution of Contract. The individual, partnership, corporation or joint venturer awarded the contract shall return the prescribed copies of the contract and bond, properly executed, to the office of the Commission within 15 days after the unexecuted contract has been mailed to the bidder. No bid shall be considered binding upon the Commission until the contract has been awarded by the Commission, and until the successful bidder has executed and returned the contract and a satisfactory bond. No contract will be effective until the contract has been executed by all parties.

103.6 Failure to Execute Contract. Failure to execute the contract or to file an acceptable contract bond within 15 days after the unexecuted contract has been mailed to the bidder will be just cause for the cancellation of the award and the forfeiture of the bid guaranty. A bidder failing to file an acceptable bid or contract bond from an approved surety or failing to execute the contract within the time provided resulting in a cancellation of the award to that bidder, disqualifies that bidder, and any other firm having common ownership or control with that bidder, from performing any work on the Commission project or projects that are the subject of that bid, as a prime contractor, a subcontractor or a supplier.

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SECTION 104
SCOPE OF WORK

104.1 Intent of Contract. The contractor shall complete the work described and furnish all resources required to complete the work under the contract.

104.2 Differing Site Conditions. If differing site conditions are encountered during the progress of the work, the discovering party shall promptly notify the other party in accordance with Sec 104.4. No further disturbance of the site or performance of the affected work shall be done after the alleged differing site conditions are noted, unless otherwise directed in writing by the engineer.

104.2.1 Upon written notification, the engineer will investigate the conditions, and if it is determined that the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the contract, an adjustment, excluding anticipated profits, will be made and the contract modified in writing accordingly. The engineer will notify the contractor whether or not an adjustment of the contract is warranted.

104.2.2 No contract adjustment that results in a benefit to the contractor will be allowed unless the contractor has provided the required written notice as specified in Sec 104.4.

104.2.3 No contract adjustment will be allowed under this section for any effects caused on unchanged work.

104.2.4 Payment will be determined in accordance with Sec 109.4 and adjustments in contract time will be determined in accordance with Sec 108.14.

104.3 Changes in the Work. When considered necessary to satisfactorily complete the project, the engineer reserves the right to provide written notice to the contractor, at any time during the contract, to change quantities or make other alterations for which there are no provisions included in the contract. Such changes in quantities and alterations in the work will not invalidate the contract, require consent of the surety, nor release the contract surety, and the contractor agrees to perform the work as altered. Alterations of plans or of the nature of the work will not involve work beyond the termini of the proposed construction, except as may be necessary to satisfactorily complete the project.

104.3.1 If the alterations or changes in quantities do not cause a significant change in the work to be performed under the contract, payment for the altered work will be determined in accordance with Sec 109.3 for all work for which a contract unit price exists, and Sec 109.4 for all other work. The basis for the adjustment for work for which no unit price exists shall be agreed upon prior to the performance of the work. If a basis cannot be agreed upon, then an adjustment will be made either for or against the contractor in such amount as the engineer may determine to be fair and equitable. If the directed changes require additional time to complete the contract, adjustments in the contract time will be determined in accordance with Sec 108.7.

104.3.2 If the alterations or changes in quantities cause significant change in the work under the contract as defined in Sec 101, an adjustment will be made to the contract. This adjustment will occur whether such alterations or changes are in themselves a significant change in the work or by affecting other work, causing such other work to become significantly different. Payment will be determined in accordance with Sec 109.3 or Sec 109.4. The basis for the adjustment shall be agreed upon prior to the performance of the work. If a basis cannot be agreed upon, then an adjustment will be made either for or against the contractor in such amount as the engineer may determine to be fair and equitable. If the directed changes require additional time to complete the contract, adjustments in the contract time will be determined in accordance with Secs 108.7 or 108.14, as appropriate.

104.4 Notification of Differing Site Conditions and Changes in the Work. The contractor shall promptly notify the engineer of alleged changes to the contract due to differing site conditions, altered work beyond the scope of the contract, or actions taken by MoDOT that changed the contract terms and conditions. Within five business days of the date the alleged change or action was noted, the contractor shall provide the following information to the engineer in writing:

(a) The date of occurrence and the nature of circumstances of the occurrence.

(b) The name, title and activity of MoDOT personnel having knowledge of the matter.

(c) The identity of any documents and the substance of any oral communications involved.

(d) The basis for a claim of accelerated schedule performance.

(e) The basis for a claim that the work is not required by the contract.

(f) The particular elements of contract performance for which additional compensation, compensable or excusable delay may be sought under this section including:

(1) Pay items that have been or will be affected.

(2) Labor or material, or both, that will be added, deleted or discarded and what equipment will be idled, extended or required on the project.

(3) Delay and disruption in the manner and sequence of performance that has been or will be caused.

(4) Estimated adjustments to contract prices, delivery schedules, staging and contract time.

(5) Estimate of the time within which MoDOT must respond to the notice to minimize cost, delay or disruption of performance.

104.4.1 For good cause the engineer may extend the time for the contractor to provide any part of the above information.

104.4.2 The failure of the contractor to provide notice and other information in accordance with the procedures of Sec 104.4 will constitute a waiver of any and all claims that may arise as a result of the allegations.

104.5 Response to Notification of Differing Site Conditions and Changes in the Work. Following submission of the Sec 104.4 notification to the engineer, the contractor shall continue diligent prosecution of the work not affected by the notification, unless directed otherwise in writing by the engineer. Within ten business days after receipt of notification, the engineer will respond in writing to the contractor to:

(a) Confirm or deny that a change occurred and specify future action to be performed by the contractor and the engineer, or

(b) Advise the contractor that specific additional information is needed and the date the information is to be received by the engineer for further review. For good cause, the engineer may extend the time for the contractor to provide any of the additional information. The engineer will respond within ten days of receipt of additional information from the contractor. Any adjustments made to the contract will not include increased cost or time extensions for delay if the contractor fails to provide the information required in the notice or the requested additional information by the date specified.

104.6 Value Engineering Proposals. A Value Engineering Change Proposal (VECP) shall provide a product of equal or improved quality that will reduce the project cost, improve safety or decrease the time required to complete the project. A Practical Design Value Engineering Change Proposal (PDVECP) may provide a product of lesser value, use an existing item in place. Using an existing item in place may include an underrun of quantities, but in accordance with Sec 105.4.1, the underrun may not be an apparent error or omission in the plans, as determined by the engineer. The PDVECP shall not adversely affect safety or function of the final product. The contractor is encouraged to submit to the engineer, in writing, VECP's and PDVECP's for modifying the plans, specifications or other requirements of the contract. Proposed modifications shall not impair, in any manner, essential functions or characteristics of the project, including but not limited to, service life, economy of operation, ease of maintenance, desired appearance, design or safety standards, and shall not significantly delay the completion of the project. Proposals shall be submitted to the engineer in advance of the work to be performed with sufficient time allowed for review. The Commission will not be liable to the contractor for failure to accept or act upon the proposal nor for any delays to the work attributable to any such proposal.

104.6.1 Submitting Proposals. Value engineering proposals shall be submitted on the proper form, available on

MoDOT's web site, and shall contain the following information:

(a) A description of both the existing contract requirements for performing the work and the proposed changes.

(b) A detailed estimate of the cost of performing the work under the existing contract and under the proposed change.

(c) A statement of the time within which the engineer must make a decision thereon, including the probable effect the proposal will have on the contract completion time.

(d) An itemized list of the contract items of work affected by the proposed changes, including any quantity variation attributable thereto.

(e) A description of any previous use or submission of the same proposal by the contractor, including dates, job numbers, results, and/or outcome of proposal if previously submitted.

104.6.2 Conditions. The engineer will only consider VECP's that meet the following conditions.

104.6.2.1 Contractors may submit value engineering proposals that propose changes in the basic design of a bridge or a pavement, except for pavement and shoulder type. Value engineering proposals will be considered only when the proposal will not significantly delay the completion of the project.

104.6.2.2 The contractor shall continue to perform the work in accordance with the requirements of the contract until a change order incorporating the value engineering proposal has been approved, unless otherwise directed by the engineer. If a change order has not been approved by the date upon which the contractor's value engineering proposal specifies that a decision thereon should be made, the proposal shall be deemed rejected, unless the time allowed for a decision has been extended by mutual agreement of both parties.

104.6.2.3 The Commission expressly reserves the right to adopt a value engineering proposal as standard practice for use on other contracts administered by the Commission. If an accepted value engineering proposal is adopted as design policy, only contractors submitting such a proposal will be eligible for compensation pursuant to this section until the proposal is incorporated into design policy, and in that case, only as to those contracts awarded to the contractor prior to submission of the accepted value engineering proposal. Value engineering proposals identical or similar to previously submitted proposals will be eligible for consideration and compensation under the provisions of Sec 104.6 if the identical or similar previously submitted proposals were not adopted as design policy by the Commission, or included in the present contract. Subject to the provisions contained herein, the state or any other public agency will have the right to use all or any part of any submitted value engineering proposal without obligation or compensation of any kind to the contractor, except as noted in Sec 104.6.2.4.

104.6.2.4 The contractor may request the return of information submitted with a value engineering proposal if the proposal is rejected, provided this request is in writing and submitted with the proposal. If the proposal is accepted, this request will be void, and the Commission may use or disclose in whole or in part any information necessary to utilize the proposal.

104.6.2.5 Prior to approval, it may be necessary for the engineer to modify a proposal, with the concurrence of the contractor, to make the proposal acceptable. If any modification increases or decreases the net savings resulting from the proposal, the contractor's share will be determined on the basis of the proposal as modified.

104.6.2.6 An electronic copy of the complete proposal shall be submitted to the engineer for review. The contractor may submit a conceptual proposal for approval stating the basic proposal and approximate cost savings in order to provide the contractor with the opportunity to submit an idea without large initial development costs if the proposal is rejected. Approval or disapproval of proposals will be granted within ten days of receipt of the proposal.

104.6.2.7 A proposal will be disqualified if additional information is not provided at the request of the engineer. This will include design computations, field investigations, results, surveys, etc.

104.6.2.8 Reimbursement for modifications to the proposal to adjust field or other conditions will be limited to

the total amount of the contract bid prices. Rejection, limitation or reimbursement shall not be a basis for any claim against the Commission.

104.6.2.9 The contractor will have no claim to additional costs or delays, including development costs, loss of anticipated profits, or increased material or labor costs, if the proposal is rejected.

104.6.2.10 The engineer will decide whether or not to consider a proposal. The basis for proposal rejections will include excessive review requirements, evaluation or investigation, or if the proposal is inconsistent with project design policies or criteria.

104.6.3 Payment. Payment will meet the following conditions:

104.6.3.1 The engineer will be the sole judge of the acceptability of a value engineering proposal and of the estimated net difference in construction costs from the adoption of all or any part of such a proposal. The engineer may adjust contract prices if, in the judgment of the engineer, such prices do not represent a fair measure of the value of work to be performed or to be deleted.

104.6.3.2 If the contractor's cost reduction is accepted in whole or in part, such acceptance will be by a change order, which will specifically state that the change order is executed in accordance with Sec 104.6. Such change orders will incorporate the changes in the plans and specifications necessary to permit the value engineering proposal or any part of the proposal that has been accepted, to be put into effect, and will include any conditions upon which the Commission's approval thereof is based, if the approval of the Commission is conditional. The change order will also set forth the price for performing those items of work affected by the change order and the estimated net savings in the cost of performing the work attributable to the value engineering proposal in the change order, and will further provide that the contractor will be paid 50 percent for VECP's or 25 percent for PDVECP's of the actual net savings of the construction costs at the completion of the work affected by the change order. All reasonable documented engineering costs incurred by the contractor to design and develop a value engineering proposal will be reimbursed and subtracted from the savings of the construction costs. All routine internal costs incurred by MoDOT to review and implement the VECP will be at the Commission's expense. Major redesign costs, and design/review costs of any amount charged by a consultant to the Commission, will be deducted from the gross savings.

104.6.3.3 The amount and time specified in the change order will be considered full compensation to the contractor for the value engineering proposal and for the performance of that work.

104.6.3.4 Only the contractor may submit proposals and be reimbursed for savings, however the contractor may submit proposals for any approved subcontractor.

104.7 Maintenance of Traffic Operations During Construction.

104.7.1 The contractor shall maintain the flow of all traffic over the project, at the contractor's expense, unless otherwise specified in the contract. Provisions for local traffic, including bicycle and pedestrian traffic, shall be made by the contractor, at the contractor's expense, at all times during construction, unless otherwise specified in the contract.

104.7.2 If detours for through traffic are to be provided by the Commission at the Commission's expense or designated on the plans to be constructed and maintained by the contractor around the entire project or any major portion of the work during construction, the engineer may open for use by traffic any uncompleted portions of the project, and will have the option either to maintain such portions with Commission forces or to require the contractor to maintain the detours. If the contractor is required to maintain such opened portions, the contractor will be reimbursed for the cost of such maintenance in accordance with Sec 109.4. However, when the time set for completion, including any authorized extension of time, has elapsed, the contractor will be responsible for all further costs of maintaining such opened portions, whether the open portions are maintained by the contractor's forces and equipment or by Commission forces.

104.7.3 If the contractor is required to maintain the flow of traffic over the project, including constructed detours or bypasses, such maintenance shall be construed to mean the satisfactory handling of all traffic to maintain safe and substantially uninterrupted flow. The contractor shall maintain the roadbed substantially free of ruts, holes and detrimental surface deformations. The contractor shall control the height of vegetation for traffic safety, and shall provide and maintain in a safe condition approaches, crossings and intersections with

abutting property to the highway, railroads, trails, roads and streets. Such maintenance shall be performed as necessary from the day the contractor starts construction operations under the contract. Snow removal will not be required of the contractor.

104.7.4 When it is to the advantage of the Commission, projects involving pavement may be opened to traffic as soon as the surface has been sufficiently cured, even though the shoulders and other items of work may not be completed. Such projects or portions of projects will be inspected and a partial acceptance made as to the work completed, and the contractor will be required to complete any remaining construction items under traffic.

104.7.5 When the engineer opens for use by traffic any unfinished portions of the project as provided under Secs 104.7.2 or 104.7.4, the contractor will be compensated in accordance with Sec 109.4 for any documented actual additional costs approved by the engineer. Any documented inefficiencies, delays or other time related effects approved by the engineer will be an excusable delay only as provided by Sec 108.14.

104.8 Surfacing for Temporary Use. Surfacing for the temporary use of traffic shall, when directed by the engineer, be applied to areas necessary to provide satisfactory ingress and egress to private property, across the project or along the roadway. Such surfacing will be authorized if traffic cannot be handled satisfactorily by the contractor maintaining a reasonably smooth and drainable earth surface in accordance with Sec 104.7. The quantity, quality and type of surfacing will be designated by the engineer. Acceptance of the material will be based on visual examination.

104.8.1 Measurement of material furnished for temporary surfacing will be made in accordance with Sec 310.5, excluding any deductions for moisture.

104.8.2 The quantity of surfacing for temporary use authorized and accepted will be paid for at the contract unit price. Regardless of overruns or underruns, no adjustment will be made in the price for this material.

104.8.3 Preparing a subgrade, spreading or laying surfacing for temporary use, maintaining the surfacing, future removal or scarifying, if necessary, shall be at the contractor's expense.

104.9 Rights In and Use of Material Found on the Work. The contractor, with written approval from the engineer, may use in the construction of the project any stone, gravel or sand found in the excavation that conforms to the requirements of the specifications for material. The Commission will not pay for damages or for anticipated profits on account of the expected use of any material shown on the plans as existing and later found to be nonexistent or unfit for use. Payment will be made to cover the removal of such material at the contract unit price for excavation of the classification under which the excavation properly belongs. If such material is used instead of material that was to have been furnished at the expense of the contractor under the terms of the contract, the contractor shall furnish sufficient suitable material, at no additional expense to the Commission, to complete the roadway. Unless authorized in writing by the engineer, the contractor shall not excavate or remove from within the right of way any material that is not within the excavation limits as indicated by the slope and grade lines.

104.10 Mailboxes, Signs and Markers.

104.10.1 Mailboxes. Mailboxes within the limits of the project that will interfere with operations shall be removed by the contractor before work is begun. Mailboxes shall be set temporarily where the mailbox will be accessible to both the carrier and the patron, and shall be properly reset by the contractor at designated locations before final acceptance of the work by the Commission. Mailboxes damaged by the contractor shall be replaced by the contractor at the contractor's expense. All mailbox supports set by the contractor shall be in accordance with AASHTO guidelines. Mailboxes may be reset by the contractor using only approved supports furnished either by the postal patron or by the engineer. No direct payment will be made for the removal, relocation or replacement of mailboxes or supports.

104.10.2 Signs and Markers. Signs and markers within the limits of the project that will interfere with operations shall be removed by the contractor before work is begun. All such signs and markers required for safe control and guidance of traffic shall be temporarily reset, readily visible to traffic, and shall be maintained in a satisfactory condition. If the nature of the work makes temporary relocation impractical, the signs shall be placed on movable supports and maintained in accordance with Sec 616. Stop and yield signs at intersecting roadways shall be maintained where signs are readily visible to traffic at all times. Other individual signs may be moved aside only when signs interfere with actual operations. All required signs and markers shall be

properly located to control traffic at all times. Final removal of signs and markers will be permitted only when permanent signs and markers have been installed. All signs and markers will remain the property of the Commission and shall, after final removal, be delivered without damage to locations within the project limits as directed by the engineer. No direct payment will be made for removal, relocation, temporary supports, maintenance or final removal and delivery of signs and markers.

104.10.3 Right of Way Markers and Plaques. All right of way marker posts or markers damaged by the contractor's operations shall be replaced at the contractors' expense, and installed in accordance with Sec 602 and the standard drawings. Replacements for damaged right of way marker plaques will be furnished by the Commission.

104.11 Final Clean Up.

104.11.1 Before final acceptance, the contractor shall restore to a condition equal to or better than that existing prior to construction all property, both public and private, within, adjacent to and beyond the limits of construction that have been disturbed or damaged by prosecution of the work. Restoration work shall be at the contractor's expense.

104.11.2 When specified in the contract, the contractor shall open and clean all existing channels and culverts from all excess mud or silt, drift, brush or debris of any kind. Any material excavated in cleaning existing channels will be paid for as roadway excavation of like classification. Any material excavated in cleaning out culverts that are used in place will be paid for at the contract price per each structure. However, only the initial excavation will be paid for, and any subsequent cleaning required prior to final acceptance shall be at the contractor's expense.

104.12 Requirements for Projects Involving Work On Railroad Right of Way.

104.12.1 All work on, over or under railroad right of way shall be performed by the contractor without damage to the facilities and property of the railroad or the railroad's lessees, and in strict observance of requirements of the engineer and railroad for the safety of railroad property and operations. The contractor shall maintain the existing or proposed depth and section of the ditches along the tracks of railroads through the limits of construction. Any sediment resulting from new construction shall be promptly removed.

104.12.2 The contractor shall indemnify the railroad for any loss or damage to the railroad property, right of way, tracks and other facilities, hereafter referred to as property, caused by acts or omissions of the contractor, or any of the contractor's subcontractors, in performing work on a project, whether on, over, under or in the vicinity of railroad property. In the event the contractor fails to restore railroad property immediately to a condition acceptable to the railroad when any such loss or damage to railroad property is called to the contractor's attention by the railroad, then the railroad may perform such corrective work at the contractor's cost.

104.12.3 Prior to beginning any work on, over or under railroad right of way, the contractor shall furnish to the railroad's engineer evidence of "Commercial Auto Liability Insurance," "Commercial General Liability Insurance" and "Railroad Protective Liability Insurance" in accordance with the contract documents and special provisions, which will establish the limits of each type of insurance.

104.12.4 The term "loss or damage" as used in Sec 104.12 will include, but not be limited to, the erosion and silting of, water damage to, and the accidental or intentional placing or dropping of objects on railroad property.

104.12.5 Work performed on, over or under railroad right of way will be subject to the inspection of railroad representatives.

104.12.6 The Commission will make provisions for any temporary removal of railroad or railroad lessees' facilities that are to be moved.

104.12.7 The contractor shall in no way hold the Commission liable for delay caused by securing the railroad company's approval of construction features involved in placing any grade separation structure, the removal of any structures over the railroad's right of way, shoring plans that could affect the railroad's facilities or operation or any changes from the design plans that appear desirable during construction.

104.12.8 Construction requirements for projects involving work upon railroad right of way will be as follows.

104.12.8.1 Fiber optic, communications, control systems and other types of cable may be buried on railroad property. Before beginning work, the contractor shall contact the railroad to determine if cable systems are buried on the railroad property to be used by the contractor.

104.12.8.2 The contractor shall provide a minimum construction vertical clearance of 21 feet 6 inches above the top of rails and a minimum construction lateral clearance of 10 feet from the center line of track to the nearest temporary construction falsework. The contractor shall provide the minimum final lateral and vertical clearances as shown on the plans.

104.12.8.3 The contractor shall arrange with the railroad for installation of any temporary crossings.

104.12.8.4 The contractor shall notify the railroad and shall arrange for adequate protection of railroad property and operations under the following situations and conditions:

(a) When performing any work or operations closer to railroad tracks than the minimum construction clearances specified in Sec 104.12.8.2 and set forth in schedule of rates in Sec 104.12.9.

(b) When performing work on those portions of the structure located over or under railroad tracks.

(c) When using any temporary crossing of railroad tracks and right of way.

104.12.8.5 Arrangements for flagging shall be made in accordance with the contract documents and special provisions.

104.12.8.6 When performing work near the railroad tracks, the contractor shall, at the end of each work day, inspect the track area and clean up any debris. When the project is completed, the contractor shall remove any debris or material dropped on the railroad from the railroad right of way.

104.12.9 Requirements for projects involving rates of pay and other related costs for protective services required by the railroad will be as follows.

104.12.9.1 The services of one track foreman or other railroad employees qualified to protect railroad operations in accordance with railroad's rules, will be required during any construction operations involving direct interference with railroad tracks or traffic, the fouling of railroad operating clearances or reasonable probability of accidental hazard to railroad traffic. Services of additional railroad personnel for flagging protection will be required whenever such protection is needed when required by the railroad's authorized railroad representative.

104.12.9.2 The rate of pay per hour for each flagger shall be the prevailing hourly rate for the class of employee used in accordance with labor agreements and schedules in effect at the time the work is performed.

104.12.9.3 One and one-half times current hourly rate shall be paid for overtime, Saturdays and Sundays. Two and one-half times current hourly rate shall be paid for holidays.

104.12.9.4 Wage rates are subject to change at any time by law or by agreement between the railroad and railroad employees, and may be retroactive as a result of negotiations or a ruling of an authorized governmental agency. Additional charges, such as labor surcharges, are also subject to change. If the wage rates or additional charges are changed, the contractor shall pay on the basis of the new rates and new charges.

104.12.10 Requirements for projects involving reimbursement for work upon railroad right of way will be as follows.

104.12.10.1 The contractor shall reimburse the railroad for all costs of installation, maintenance and removal of any temporary crossings.

104.12.10.2 The contractor shall reimburse the railroad for all costs of protective services, such as flaggers, required by the railroad for the protection of railroad property and operations in accordance with Sec 104.12.9. All such costs shall be determined on the basis of rates of pay and other related costs actually in existence at the time protective services are furnished. Payments will be made by deduction of funds from the contractor's

periodic progress payments.

104.12.10.2.1 Reimbursement shall cover the full eight hour day during which any flagger is furnished, unless the flagger can be assigned to other railroad work during a portion of such day, in which event reimbursement will not be required for the portion of the day during which the flagger is engaged in other work.

104.12.10.2.2 Reimbursement will be required for any day not actually worked by said flagger following assignment to work on the project for which the railroad is required to pay the flagger and that could not reasonably be avoided by the railroad by assignment of such flagger to other work, even though the contractor may not be working during such time.

104.12.10.3 The contractor shall reimburse travel expenses to the railroad in addition to the rate of pay indicated in Sec 104.12.9.

104.12.10.4 The railroad shall have the right to bring an action directly against the contractor to recover any loss or damage sustained by the railroad by reason of the contractor's breach of agreements contained in Sec 104.12.

104.12.10.5 In addition to such remedies of the railroad, the Commission will withhold from final payment due to the contractor the amount reasonably necessary to reimburse the railroad for such loss or damage, or for performing such work.

104.12.11 All costs incurred by the contractor in complying with Sec 104.12 will be considered covered by the contract unit price for various items of work included in the contract.

104.13 Warranty of Electrical and Mechanical Equipment.

104.13.1 On all contracts requiring the contractor to furnish and install electronic, electrical or mechanical equipment, the contractor shall obtain, assign and furnish to the Commission written manufacturer's warranties for all such equipment consistent with those provided as customary trade practice. Additionally, a contractor's warranty providing for satisfactory in-service operation shall be provided for a minimum period of six months from the date of project acceptance.

104.13.2 If the equipment fails to perform satisfactorily for the specified length of time, the manufacturer or the contractor shall replace or repair the equipment as necessary to restore required performance. MoDOT labor costs resulting from equipment replacement will not be charged to the manufacturer or the contractor.

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SECTION 105
CONTROL OF WORK

105.1 Authority and Duties of Commission in Contract Administration. The Commission is subject to comply with and to have the power and authority provided in, among others, the following laws in execution of the Commission's authority over all state transportation programs and facilities:

(a) 226.130 RSMo providing for Commission to have supervision of highways and bridges constructed, improved and maintained, in whole or part, by the aid of state monies and of highways constructed in whole or in part by the aid of monies appropriated by the United States government, so far as such supervision is consistent with the acts of Congress relating thereto, to let all contracts for the construction or improvement of state highways;

(b) 226.150 RSMo to comply with acts of Congress and with any of the rules or conditions made by the federal agencies to secure funds allocated to this state;

(c) 227.030 RSMo to have power to make all final decisions affecting the work provided for therein;

(d) 227.100 RSMo, to furnish and prescribe contracts for construction of the work provided for in that Chapter;

(e) 227.107 RSMo to prescribe the form of contracts and make all final decisions concerning the performance of work under a design-build highway project contract including claims for additional time and compensation;

(f) 23 USC §112 to have supervision over construction of certain projects funded in whole or part by monies appropriated by the United States Government;

(g) 23 USC §302 to have adequate powers to discharge to the satisfaction of the Secretary of Transportation of the United States Government the duties required by Title 23 of the United States Code and;

(h) 23 CFR §1.3 providing that the Commission shall be authorized by the laws of the State of Missouri to make all final decisions for the state in all matters relating to contracts and agreements and to take such other actions on behalf of the state as may be necessary to comply with the federal laws and regulations in Part 23 of the CFR.

105.1.1 Authority of the Engineer. The engineer will decide all questions that may arise as to the quality, quantity and acceptability of material furnished and the work performed, and as to the rate of progress of the work; all questions that may arise as to the interpretation of the plans and specifications; all questions as to the acceptable fulfillment of the contract on the part of the contractor; all questions of classification; the proper compensation for the performance or breach of the contract; and all claims or controversies of any character whatsoever in connection with or growing out of the construction, whether claimed under the contract, under force account, under quantum merit or otherwise. The engineer's estimates and decisions shall be final, binding, and conclusive upon all parties to the contract.

105.1.2 Suspension of Work. The engineer may suspend the work wholly or in part in accordance with these provisions. The suspension may be given verbally, but will be followed in writing immediately.

105.1.2.1 The engineer may suspend the work wholly or in part for the contractor's failure to:

(a) Correct conditions unsafe for the project personnel or general public.

(b) Carry out provisions of the contract.

(c) Carry out orders of the engineer.

105.1.2.2 Suspensions in accordance with Sec 105.1.2.1 will be nonexcusable and noncompensable.

105.1.2.3 Work may also be wholly or partially suspended for:

(a) Periods necessary due to unsuitable weather.

(b) Conditions considered unsuitable for the prosecution of the work.

(c) Any condition or reason determined to be in the public interest.

105.1.2.4 Suspensions in accordance with Sec 105.1.2.3 may be excusable and may be compensable as determined by the engineer in accordance with Sec 108.

105.2 Plans and Working Drawings. The plans will be supplemented by such working drawings as are necessary to adequately control the work. Working drawings for structures shall be furnished by the contractor and shall consist of such detailed plans as may be required to adequately control the work and which are not included in the plans furnished by the Commission. Required working drawings must be accepted by the engineer, and such acceptance shall not relieve the contractor of any responsibility under the contract for the successful completion of the work.

105.3 Conformity with Contract Documents. All work performed and all material furnished shall be in accordance with the lines, grades, cross sections, dimensions and material requirements, including tolerances, shown in the contract documents.

105.3.1 If the engineer finds the material or the finished product in which the material was used is not in accordance with the contract documents, but that reasonably acceptable work has been produced, a determination will be made if the work will be accepted and remain in place. In this event, the engineer will document the basis of acceptance by contract modifications that may provide for an appropriate adjustment in the contract price for such work or material as deemed necessary to conform to the determination based on engineering judgment.

105.3.2 If the engineer finds the finished product to be unacceptable as a result of the contractor's method of operation or the use of unacceptable material, the work shall be removed and replaced or otherwise corrected by the contractor at the contractor's expense.

105.4 Coordination of Contract Documents. The contract documents are essential parts of the contract, and a requirement occurring in one shall be as binding as though occurring in all. Contract documents are intended to be complementary and to describe and provide for a complete work. In case of discrepancy among contract documents, the governing ranking will be:

(a) Job Special Provisions

(b) Project Specific Drawings

(c) General Provisions

(d) Supplemental Specifications

(e) Standard Specifications

(f) Standard Drawings

(g) Bid Items or Quantities

In case of discrepancies, calculated dimensions will govern over scaled dimensions.

105.4.1 All contractors, including subcontractors, shall not take advantage of any apparent error or omission in the contract documents. If an error or omission is discovered, the engineer shall be notified promptly so corrections and interpretations necessary to fulfill the intent of the contract can be made. A failure to give notice shall render the effects of any error or omission noncompensable and any delay nonexcusable.

105.5 Cooperation by Contractor. The contractor shall maintain one set of contract documents at the work site at all times.

105.5.1 The contractor shall give the work the constant attention necessary to facilitate the progress thereof and shall cooperate with the engineer and other contractors in every possible way.

105.5.2 The contractor shall have at the work site at all times, as the contractor's agent, a competent individual capable of reading and thoroughly understanding the plans and specifications and thoroughly experienced in the type of work being performed, whom shall receive instructions from the engineer. That individual shall have full authority to execute orders or directions of the engineer without delay and to promptly supply material, equipment, tools, labor and incidentals as may be required.

105.6 Cooperation Between Contractors. The Commission reserves the right at any time to contract for and perform other or additional work on or near the project limits covered by the contract.

105.6.1 If separate contracts are awarded within the limits of any one project, each contractor shall conduct work so as not to interfere with or hinder the progress or completion of the work being performed by other contractors. Full cooperation of the contractors involved, in careful and complete coordination of their respective activities in the area, will be required.

105.6.2 Each contractor and surety involved shall assume all liability, financial or otherwise, in connection with the contract and shall indemnify and save harmless the State, the Commission, and the Commission's agents, employees and assigns from any and all damages or claims that may arise because of inconvenience, delay or loss experienced, caused or contributed to by the contractor because of the presence and operations of other contractors working within the limits of the same project.

105.6.3 The contractor shall schedule and conduct work and shall place and dispose of material being used so as not to interfere with or cause unnecessary inconvenience or delay to the operations of other contractors within the limits of the same project. The contractor shall join work with other contractors as required by the contracts or in a manner acceptable to the engineer and shall perform the work in proper sequence with the work of the other contractors. When necessary for proper prosecution of work, each contractor shall permit the other contractors access through overlapping construction areas and shall permit the use of any access or haul roads.

105.7 Cooperation With Utilities. All utility facilities and appurtenances within the project limits shall be installed or relocated by the utility owner, unless specified otherwise. Utility installation and relocation shall be made in accordance with 7 CSR 10-3, Utility and Private Line Location and Relocation.

105.7.1 The contractor shall cooperate with utility owners and the engineer in the installation and relocation of utility facilities to minimize effects on the contractor's work, interruption to utility service and duplication of work by the utility owners. Facilities or appurtenances that are to remain in place during construction shall be accounted for and protected by the contractor's work procedures.

105.7.2 The contractor shall notify Missouri One Call (800-344-7483) with its intent to excavate, as described in Chapter 319 RSMo. Locations of all utility facilities and appurtenances within the project limits will be provided by utility owners and may not be exact, particularly with regard to underground.

105.7.3 The contractor shall proceed in a safe and prudent manner to prevent damage to all public and private utilities. Repairs to damaged utilities caused by negligent or wrongful acts or omissions on the part of the contractor shall be corrected at the contractor's expense. Damaged facilities shall be restored to a condition similar or equal to that existing before the damage occurred.

105.7.4 In the event of any damage, dislocation or disturbance of any underground facility in connection with any excavation, the contractor shall immediately notify Missouri One Call and cooperate with the utility owners until their facilities have been restored. Work shall not begin around any fire hydrants until provisions for continued service have been made and approved by the local fire authority.

105.7.5 The contractor shall be solely responsible and liable for incidental and consequential damage to any utility facilities or interruption of the service caused by it or its subcontractor's operation. The contractor shall hold and save harmless the Commission from damages to any utility facility's interruption of service by it or its subcontractor's operation.

105.7.6 The contractor agrees that any effects of the presence of the utilities, their relocation, contractor's coordination of work with the utilities and any delay in utility relocation shall not be compensable as a suspension of work, extra work, a change in the work, as a differing site condition or otherwise including but, without limitation, delay, impact, incidental or consequential damages. The contractor's sole remedy for the effects of the presence of utilities, delay in their relocation or any other effects shall be an excusable delay as

provided in Sec 105.7.6.1. The contractor waives, for itself, its subcontractors and suppliers the compensability of the presence of utilities, delay in their relocation and any cost to the contractor, it's subcontractors and suppliers in any claim or action arising out of or in relation to the work under the contract.

105.7.6.1 When the failure of the owners of utility facilities to cooperate and coordinate their work with that of the contractor results in actual delay to the contractor in the overall completion of the contractor's work, such delay will be considered in the count of working days or date specified for completion as contractor's sole compensation from the Commission, provided the contractor notified the engineer in writing of the delay at the time the delay occurred.

105.7.7 Should there be located within the right of way any public or private utility facilities that are to remain in place and that will interfere with the contractor's proposed methods of operation, the contractor, in cooperation with the engineer, shall make all necessary arrangements with the owner for any temporary or permanent removal or relocation of such facilities desired for the contractor's convenience. Any cost involved shall be at the contractor's expense.

105.7.8 If utility facilities or appurtenances are found that are not noted in the contract documents and could not be discovered in accordance with Sec 102.5, the engineer will determine whether relocation of the utility is necessary to accommodate construction. If relocation is necessary, the engineer will make necessary arrangements with the utility owner and the contractor. Compensability and excusability will be determined under Secs 104 and 108.

105.8 Construction Stakes, Lines and Grades. Surveying, project layout and setting of construction stakes will be performed by the contractor in accordance with Sec 627.

105.9 Authority and Duties of Resident Engineer. As the immediate representative of the Commission, the resident engineer has direct charge of the engineering details of each construction project and is delegated commensurate authority for the administration of the project. The resident engineer may reject defective material and suspend and reject any work that is being improperly performed. The resident engineer will have no authority to modify the contract except in accordance with the contract documents or when expressly authorized by the Commission.

105.10 Inspection of Work. All material and each part or detail of the work will be subject to inspection by the engineer. The engineer shall be allowed unlimited access to all parts of the work and shall be furnished with such information and assistance by the contractor as is required to make a complete and detailed inspection.

105.10.1 If requested by the engineer, the contractor, at any time before acceptance of the work, shall remove or uncover such portions of the finished work as may be directed. After examination, the contractor shall restore said portions of the work to the standards required by the contract documents. If the work thus exposed or examined proves acceptable, the uncovering, the removing, recovering or making good the parts removed will be paid for in accordance with Sec 109. If the work so exposed or examined proves unacceptable, the uncovering, removing, recovering or making good the parts removed shall be at the contractor's expense.

105.10.2 Any work done or material used without inspection by an authorized Commission representative may be ordered removed and replaced at the contractor's expense.

105.10.3 If any unit of government or political subdivision pays all or a portion of the cost of the work covered by the contract, the unit's respective representatives shall have the right to inspect the work.

105.10.4 When any work is being done on, over or under railroad right of way or adjustments are being made to any public or privately-owned utility facility, the respective representatives shall have the right to inspect the work.

105.10.5 Inspections authorized in Secs 105.10.3 and 105.10.4 will not make any of these agencies a party to the contract or affect the rights of the parties to the contract.

105.10.6 Adequate provisions for lighting, meeting the prior approval from the engineer, shall be provided by the contractor to permit satisfactory construction and inspection of all work done and material produced.

105.10.7 Final Inspection. Upon presumptive completion of the entire project, the engineer will make an

inspection. If all construction contemplated by the contract has been completed to the engineer's satisfaction, that inspection will constitute the final inspection. The engineer will make the acceptance for maintenance upon completion of the final inspection. The engineer will notify the contractor in writing of acceptance for maintenance as of the date of the final inspection, with the exception of items covered by item specific performance bonds. Final acceptance will take place within a maximum of 30 days of receipt of final documentation from the contractor.

105.10.7.1 Following the final inspection, the contractor, subcontractors and suppliers will be relieved of any new or additional liability to third parties for personal injury, death or property damages which may be alleged to result from the design or construction of the work, unless additional work on the right of way will be required by the engineer.

105.10.7.2 Nothing in Sec 105.10.7 shall be deemed to excuse the contractor of liability or responsibility for any personal injury, death or property damages which may have occurred prior to the final inspection of the work.

105.11 Unauthorized and Defective Work.

105.11.1 All changes in the work or departures from the plans, except those due to reclassification of excavation material, will be considered unauthorized and at the contractor's expense unless, before proceeding with the work, the contractor has a copy of an order record signed by the engineer, or a change order signed by all parties whose signatures are provided for, except the federal engineer. These forms will contain complete detailed instructions regarding the proposed changes. Any departure from the instructions contained in such a written order will be considered unauthorized.

105.11.2 The engineer may order unauthorized work removed and replaced at the contractor's expense.

105.11.3 All construction and materials that have been rejected or declared unsatisfactory shall be remedied or removed and replaced in an acceptable manner by the contractor at the contractor's expense. Upon failure of the contractor to remedy or remove and properly dispose of rejected material or work, or to replace them immediately after receiving written notice from the engineer, the engineer may employ labor to rectify the work, and the cost of rectification will be deducted from any payment due or which may become due the contractor.

105.12 Load Restrictions.

105.12.1 The contractor's movement of equipment and vehicles over bridges and pavements within the limits of the project will be subject to the load limit regulations for highways as prescribed by state statutes in effect when the movement occurs, and the contractor shall acquire special permits from the Commission prior to the movement of any such equipment or vehicles with a gross weight in excess of the load limits permitted by statute. All costs of obtaining special permits shall be at the contractor's expense, unless the special permit will be required by a restriction first imposed after the contractor has submitted the bid on the project. Outside of project limits, width, length, height and weight limitations as prescribed by state statutes shall be adhered to by the contractor during the movement of equipment and vehicles over any part of the state highway system, to include project exceptions, and the contractor shall not move or operate any such equipment or vehicles that exceed any statutory limitation without special permits from the Commission. All costs of obtaining special permits shall be at the contractor's expense. Material receipts issued by the engineer will not indicate compliance with any weight restriction regulations. All permits required for movement over highways other than those that are state owned or maintained shall be obtained by the contractor from the respective authority at the contractor's expense.

105.12.1.1 Special permits will not be required for the movement of construction equipment over any part of a bridge or pavement that is constructed or rehabilitated in the contract.

105.12.1.2 All movement will be subject to the same conditions and regulations established by the Commission for movements under special permits with the following additional requirements:

(a) Bridge decks shall be protected by planking of uniform thickness for the full tread width of track.

(b) All concrete in the bridge shall have achieved design strength.

(c) No more than one unit at a time may be moved over the structure.

(d) Equipment shall be centered on centerline of structure during movement.

(e) Adequate provisions shall be made to prevent marring of the pavement surface or the loss of surface texture.

(f) Portland cement concrete pavement shall have achieved the strength required for opening to all traffic.

(g) Adequate provisions shall be made to assure uniform load distribution at the edges of the pavement.

(h) All movements shall be made under the supervision of the resident engineer.

105.12.1.3 Movement of equipment over bridges or pavement not constructed under the contract, but located within the limits of the contract, will be subject to all requirements of this section, and a special permit will be required.

105.12.2 Track or crawler-type equipment having a gross weight of 40,000 pounds or less, evenly distributed over the treads, may be moved over bridges not posted for lesser loads or over rigid-type pavements without special permits. Such equipment having a gross weight in excess of 40,000 pounds shall have a special permit before moving. Crawler-type equipment having a gross weight in excess of 75,000 pounds will not be permitted on bridges or rigid type pavements unless authorized by the engineer.

105.12.3 Track or crawler-type equipment that is subject to unequal distribution of weight, such as cranes and paving mixers and which have a gross weight in excess of 18,000 pounds but less than 40,000 pounds , may be operated upon bridges not posted for lesser loads and rigid type pavements, provided special precautions satisfactory to the engineer are taken to distribute the weight evenly over the treads. Such equipment in excess of 40,000 pounds will require a special permit from the Commission.

105.12.4 The contractor shall not move or operate any type of equipment of such weight or so loaded that the equipment will cause damage to highway facilities either being constructed or in existence. Equipment and vehicles with steel lugs will not be permitted to operate directly on bridges or pavements at any time.

105.12.5 When it is required that material from roadway or borrow excavation be hauled across existing pavement, the contractor may move the material across the pavement with equipment that results in overweight loading, provided the following requirements are met at the contractor's expense:

(a) The contractor and the engineer shall select the location or locations where the crossing over the existing pavement is to be made. The width of the crossing shall be clearly marked on the pavement by painted lines and the contractor's equipment will be required to operate within the limits of the marked crossing.

(b) The contractor shall obtain written permission, including the description of the location of the crossing, from the engineer prior to movements of overweight loads across the existing pavement.

(c) The existing pavement shall be kept open at all times for highway traffic except for short periods of time when individual pieces of equipment are crossing the pavement. The pavement shall be kept reasonably free from earth or other material during hauling operations and shall be cleaned off and kept clean during periods when no hauling across the pavement is in progress.

(d) The pavement and shoulders within the crossing area shall be maintained by the contractor in a condition satisfactory to the engineer.

(e) The contractor shall provide signs and flaggers to direct traffic when hauling across the pavement.

(f) If any hauling across the pavement is done at night, the contractor shall provide adequate lighting to illuminate the crossing.

(g) If the existing pavement at the crossing is to be used in place after the contract is completed, the contractor shall, upon completion of the hauling operations, remove the existing shoulders, pavement and base between the limits of the crossing and replace the pavement with the same type, width and thickness of shoulders, pavement and base existing prior to the beginning of hauling operations.

(h) The contractor shall construct and maintain all necessary bypasses or temporary connections required for the proper handling of traffic during removal and replacement of the pavement in the crossing area.

105.12.6 The contractor shall not store or stockpile any materials on a bridge without approval from the engineer.

105.12.7 Nothing contained herein or in any special permit will relieve the contractor of liability for any damage caused to highway facilities from the movement or operation of equipment and vehicles over the highway system.

105.13 Maintenance of the Work. The contractor shall maintain the work during construction until the work is accepted. This maintenance shall be prosecuted such that the roadway or structures are kept in satisfactory condition at all times.

105.13.1 In the case of a contract for placing a course upon a course or subgrade previously constructed, the contractor shall maintain the previous course or subgrade during all construction operations.

105.13.2 No direct payment will be made for maintenance of the work before the work is accepted.

105.14 Failure to Maintain Roadway or Structure. If the contractor's performance at any time fails to comply with the provisions of Sec 105.13, the engineer will notify the contractor of such non-compliance. If notice is provided verbally, notice will be promptly confirmed in writing. If the contractor fails to remedy unsatisfactory maintenance within 24 hours after receipt of such notice, the engineer may immediately proceed to maintain the project, and the entire cost of this maintenance will be deducted from monies due or to become due the contractor.

105.15 Acceptance.

105.15.1 Partial Acceptance. The contractor may request that the engineer inspect the following completed sections of work for acceptance at any time during the prosecution of the project:

(a) Any section 0.5 mile or more in length.

(b) Any section 0.5 mile or more in length in one direction of a divided highway.

(c) A complete bridge.

(d) An intersection traffic signal system. Partial acceptance may be made for signal equipment prior to the 30 day testing period though any required performance tests and/or guarantees shall remain applicable.

(e) Devices intended to be used for traffic safety and control. Acceptance of traffic safety devices is limited to guardrail, impact attenuation barriers, traffic signal items, signs, delineators, lighting, concrete barrier walls, concrete bridge parapet, bridge railing, guard cable, crash cushions and fence, which are permanently installed in their final position in accordance with the contract documents.

105.15.1.1 If the contract contains seasonal items, such as sodding, painting or such items as might delay the final completion of the project, a partial acceptance of the completed portion may be made prior to completion of the entire project. If the engineer finds upon inspection that the completed work is in acceptable condition, the contractor will be notified in writing and after such notice has been given, the contractor will be relieved of the duty of maintaining and protecting that work to the extent provided in the notice.

105.15.1.2 Nothing in the contract shall be construed to relieve the contractor of full responsibility for making good any non-latent defect in work or material found on any section of work prior to final acceptance of the entire project, to alter in any manner the method of payment prescribed in the contract or to constitute a waiver of any claim the Commission might have against the contractor on the entire project.

105.15.2 Final Acceptance. Upon receipt by the engineer of all project documentation required by the contract and verification by the engineer that all material incorporated into the work has been properly inspected, the

engineer will make the final acceptance upon completion of the final inspection and acceptance for maintenance in accordance with Sec 105.10.7.

105.15.2.1 When required by the contract, project documentation shall consist of the following: Contractor's Affidavit Regarding Settlement of Claims (Form C-242), Final Change Order, DBE Participation List and Final Verification, Affidavit – Compliance with the Prevailing Wage Law.

105.15.2.2 Final acceptance will not excuse the contractor's liability or responsibility to the Commission for any latent defects in the work or material incorporated into the work, or for claims relating to any work or material incorporated into the work.

105.16 Controversies and Claims for Adjustment.

105.16.1 The contractor shall follow the requirements of Sec 104.4 for written notification of differing site conditions or significant changes in the character of work and Sec 108.15 for suspensions of work directed by the engineer. If, after receiving a written reply from the engineer the contractor considers additional compensation is due, the contractor shall file a written notice of claim for additional compensation within 60 days after completing the work in question. The procedure for filing a claim shall be as described in Secs 105.16.6 through 105.16.8.2.

105.16.2 If the contractor considers additional compensation may be due for work or material not clearly covered in the contract or not ordered in writing by the engineer as change in the work, the contractor shall notify the engineer in writing of the intention to make a claim before beginning the work in question. If notification is not given and the engineer is not afforded proper facilities by the contractor to provide necessary inspection and for keeping strict account of actual costs, the contractor agrees to waive any claims for additional compensation. Notice by the contractor and the fact that the engineer has kept account of the costs shall not be construed as substantiating the validity of the claim. The contractor shall file a written notice of claim for additional compensation within 60 days after completing the work in question. The procedure for filing the claim shall be as described in Secs 105.16.6 through 105.16.8.2.

105.16.3 Claims for additional time or compensation under Sec 104 shall be filed within 60 days after completing the work in question. Claims for additional time or compensation in accordance with Sec 108 shall be filed within 60 days after receipt of the engineer's determination. The procedures for filing and the disposition of the claim or controversy shall be in accordance with Secs 105.16.3 through 105.16.9.

105.16.4 If the contractor has any claim against the Commission arising out of the provisions of the contract or the performance or non-performance thereunder, and is not within the scope of Sec 105.16.1 through 105.16.3, the claim shall be filed within the earlier of:

(a) 90 days after the date of final inspection under Sec 105.10.7.

(b) 60 days after the date of declaration of default or termination of the contract under Sec 108.

(c) As provided in Sec 108 upon a termination of the contract for convenience of the Commission.

105.16.5 If the Commission has a claim against the contractor that in any way arises out of the provisions of the contract or the performance or non-performance thereunder, the claim will be filed within 90 days after the date of final inspection under Sec 105.10.7, except for claims of a differing site condition or defects in work or material under Sec 105.15.2.2.

105.16.6 If the claim is against the Commission, the written claim shall be personally delivered or sent by certified mail to the Office of the Secretary of the Commission in Jefferson City, Missouri. If the claim is against the contractor, the written claim will be personally delivered or sent by certified mail to the contractor at the address shown under the signature on the contract. If the claim is against an assignee, the written claim will be personally delivered or sent by certified mail to the assignee at the address shown on the accepted notice of assignment.

105.16.6.1 This provision shall not extend the claim filing time limits of the contractor or the Commission in the case of a differing site condition or a suspension of the work under Sec 108.

105.16.6.2 This provision will not limit the Commission's claim filing time for defects in work or material not discovered within 90 days after the date of final inspection under Sec 105.10.7 or other claim rights not discovered within 60 days of filing of any claim by the contractor, or as to any work covered by a separate or continuing performance bond specified to survive project final acceptance.

105.16.7 Claim submittals on the contractor's part shall be in sufficient detail, as specified in this section, to enable the engineer to determine the basis for additional time or compensation. The following minimum information shall accompany each claim submitted:

(a) A detailed factual statement of the claim, providing all necessary dates, locations and items of work affected by the claim.

(b) The date actions resulting in the claim occurred or conditions resulting in the claim became evident.

(c) A copy of the notice of claim filed by the contractor for the specific claim.

(d) The name, title and activity of each MoDOT employee knowledgeable about facts that gave rise to such claim.

(e) The name, title and activity of each contractor or subcontractor employee knowledgeable about facts that gave rise to such claim.

(f) The specific provisions of the contract supporting the claim, and a statement why the provisions support the claim.

(g) The identification of any pertinent documents, and the substance and date of any material oral communication relating to the claim.

(h) A statement whether the additional compensation or extension of time is based on the provisions of the contract, including breach of contract, or other basis in law outside the contract, with detailed support of the basis a claim may be made outside the terms of the contract.

(i) If an extension of time is also sought, the specific days for which the extension is sought and the basis for such a claim as determined by an analysis of the construction schedule.

(j) The amount of additional compensation sought with an itemized accounting of that amount.

105.16.8 Required Certification of Claims. The claim submittal shall include the contractor's written certification, under oath, attesting to the following:

(a) The claim is made in good faith.

(b) Supporting data is accurate and complete to the contractor's best knowledge and belief.

(c) The amount requested includes all costs related to the specific claim and that no additional related claims will be submitted.

(d) The amount of the claim accurately reflects the contractor's actual cost incurred. To comply with this requirement, the contractor shall file a notarized statement with the claim, in which the statement includes at least the following:

AFFIDAVIT FOR CLAIM
State of (_____)
ss.
County of (_____)
(Name of the Person Making this Affidavit), the (State Your Title or Position in the Firm) [hereinafter "the Affiant"], of (State the Name of the Firm Submitting the Claim), [hereinafter "the Claimant"], being first duly sworn upon his or her oath, states as follows:

1. This Affidavit is made upon the personal knowledge of the Affiant, and is authorized by the Claimant to be

made in behalf of the Claimant.

2. The Claim being submitted by the Claimant to the Missouri Highways and Transportation Commission at this time on (Route), (County), (Job No.), is made in good faith. The Affiant has the requisite knowledge of the Claim, and the facts and supporting data, to be able to make this Affidavit and accurately attest to the facts herein.

3. The amount requested includes all costs related to the claim or controversy and that no additional claim will be submitted.

4. All documents, records, charts, schedules, computer programs and printouts, and other data of any nature or description, which are submitted in support of this Claim pursuant to Sec 105.16.7 of the *Missouri Standard Specifications for Highway Construction* are accurate and complete in all respects, to the best knowledge and belief of the Affiant and the Claimant.

5. Under all applicable penalties of state or federal law for perjury, submitting a false affidavit or statement, fraud, stealing or other falsification, the Affiant hereby certifies that this Claim for extra compensation and time, if any, submitted herewith by the Claimant for work performed on this contract, is a true and accurate statement of the Claimant's actual costs incurred and time sought in performing the contract work, and is fully documented and supported under and pursuant to the contract described above between the Claimant and the Missouri Highways and Transportation Commission.

6. This Affidavit is given in compliance with Sec 105.16 of the *Missouri Standard Specifications for Highway Construction*, which forms a part of that contract.

_____
(Type or Print Name of the Claimant)
By:_____
(Affiant's Legal Signature)
Subscribed and sworn to before me, a notary public, on this day of , (year).

_____
Notary Public
My commission expires: _____

105.16.8.1 The person signing the claim and affidavit under oath shall be the owner if the contractor is a sole proprietorship, shall be a general partner if the contractor is a partnership, shall be an authorized agent if the contractor is a limited liability company or joint venture, or shall be an authorized officer or member of the board if the contractor is a corporation.

105.16.8.2 No claim shall be deemed filed under the contract by a contractor until:

(a) Every item of information provided for in Sec 105.16.7 has been provided or the contractor makes an affirmative, unequivocal statement as part of its claim that no record, document or information provided for by a specific provision of that section exists, and

(b) The sworn certification precisely as set forth in Sec 105.16.8 has been made and delivered to the Secretary of Commission.

105.16.9 Duty to Supply Records and Information Regarding a Claim or Controversy. The Commission is subject to a legal duty to pay no additional sum to a contractor after a contract has been entered into and performed in whole or part, or any claim under any agreement or contract made without express authority of law. The Commission is under the further legal duty to pay only those claims that are supported, which have a basis in the terms of the contract and applicable state law as fairly construed and which are in accordance with prevailing principles of public contract law. The Commission is obligated by law to set forth both the contractual basis and the cost data, supported by audit, of actual costs incurred by the contractor to substantiate any amount paid.

105.16.9.1 Record Retention. From and after the date the contractor determines a cause has occurred for a possible contract adjustment, and notwithstanding any policy the contractor may have regarding record retention, the contractor shall retain all files, records and data, in whatever form, that relate to the contractor's bid and performance of the contract relevant to the possible contract adjustment.

105.16.9.2 Duty to Supply Information. During the review of the claim, the contractor and the contractor's subcontractors and suppliers shall cooperate with MoDOT and shall provide, if requested, access to the documents that contain the below information, to the extent requested by MoDOT and MoDOT's attorneys or consultants. Request for some, but not all, of the following information will not preclude MoDOT's right to request the same or additional information at another time:

(a) Job site superintendent and foreman diaries, daily time sheets and daily reports of all types.

(b) Any union agreements applicable to the work, including any amendments.

(c) Insurance, welfare and benefits records.

(d) Earnings records of salaried and hourly personnel charged as costs of the work.

(e) Payroll tax and withholding returns.

(f) Material invoices, purchase orders, and all material and supply acquisition contracts.

(g) Material cost distribution worksheets.

(h) Records for all equipment whose use was included either in the bid or which was charged to the project. This should include internal equipment rates used for both purposes, as well as equipment leased from third parties and from affiliates and related parties. All lease or rental agreements shall be provided.

(i) Vendor rental agreements and contracts with subcontractors and suppliers.

(j) Payment records and invoices for subcontracted work.

(k) Canceled checks (payroll and vendors).

(l) Job cost reports, both periodic and final, and both the summary and supporting reports, for all costs charged to the contract and for any changes to the work, including any reports that compare estimated with actual costs.

(m) General ledger, general journal (if used) and all subsidiary ledgers and journals, including all supporting documentation pertinent to entries made in these ledgers and journals, whether paper or computer-maintained.

(n) Financial statements with all footnotes and attachments for all years in which the contractor performed work on the project.

(o) Depreciation records on all company equipment, and all documents used to develop the actual cost of owning and operating equipment used in the work.

(p) All documents that reflect the contractor's actual profit and overhead during the time the work was being performed, and for each of the two years prior to the beginning of the project.

(q) All bid records related to the preparation of the contractor's bid, including the final calculations on which the bid was determined.

(r) Worksheets, working papers and all other records used in or the product of preparation of the claim. This includes those showing the cost components claimed and how the amounts claimed were computed. Without limitation, this is intended to include personnel and equipment production analysis, schedule analysis, all data inputs used or developed for computer analysis or generation of the claim.

(s) Projected and actual personnel and equipment loading plans.

(t) Any internal budget for the project.

105.16.9.3 Confidentiality of Records. The contractor and, if applicable, the contractor's subcontractors and suppliers, shall deliver to MoDOT and MoDOT's attorneys or consultants, all information and documents

requested, notwithstanding any claim of confidentiality or proprietary interest in the records. MoDOT and MoDOT's attorneys and consultants will affirmatively act to protect the records and information from disclosure beyond those persons having a need to know the information for the purpose of making a decision regarding the claim, or for law enforcement purposes. The contractor shall identify and segregate any documents or information that the contractor considers particularly sensitive.

105.16.10 On any claim for additional compensation for work on the project, whether claimed under the contract, for a differing site condition, as a change in the work, for breach of the contract, for a positive representation by which the contract was induced or otherwise, the following items shall never be allowable or claimed directly or indirectly:

(a) Attorney fees, consultant or claims preparation costs, or costs related to litigation.

(b) Any item that would not be eligible for federal-aid participation under the provisions of 23 CFR 635.124, regardless of whether the project is one approved by the FHWA.

(c) Any item that would be an expressly unallowable cost under the provisions of 48 CFR Part 31, Subparts 31.1 and 31.2, or as it may be amended, superseded or replaced during the life of the contract.

105.16.11 Any claim, controversy or item of any claim or controversy not included in the writings required to be filed in Sec 105.16, or any claim included but not clearly defined and specifically set out, itemized and supported, or any notice or claim not filed within the time and in the manner provided in Sec 105.16, shall be forever waived, and shall neither constitute the basis of nor be included in any legal action, counterclaim, defense, set-off, arbitration or other alternative dispute resolution procedure mutually agreed upon between the parties.

105.16.11.1 The omission of any claim or of the detail required to be in a claim in accordance with Sec 105.16.7 will not be subject to cure by making the claim or supplying the details in any later court or alternative dispute resolution proceeding.

105.16.11.2 MoDOT has established a written procedure for handling contractor claims and controversies that provides the process for resolution of all claims and the engineer's final decision. The completion of that process and the engineer's final decision will be a condition precedent to any legal action, counterclaim, defense, set-off or arbitration concerning the matters claimed. Any claim or controversy, or any portion thereof that has not been presented for handling in accordance with MoDOT's contractor claims and controversies procedure will not be subject to resolution in an alternate dispute resolution process.

105.16.12 MoDOT's review of a claim pursuant to Sec 105.16 will be in addition to the right or duty of MoDOT or the Commission to conduct audits or other reviews of a claim or contractor's books of account or operations otherwise provided by federal or state laws or the rules of civil procedure.

105.17 Venue. Any action concerning any matter, thing or dispute arising out of or relating to the terms, performance, non-performance or otherwise of the agreement, shall be filed in the Circuit Court of Cole County, Missouri. The parties agree that the contract is entered into at Jefferson City, Missouri, and substantial elements of the contract's performance will take place or be delivered at Jefferson City, Missouri, by reason of which the contractor consents to venue of any action by or against the contractor in Cole County, Missouri. The contractor shall cause this provision to be incorporated in all of the contractor's agreements with, and to be binding upon, all subcontractors in the performance of this agreement.

105.18 Arbitration.

105.18.1. Purpose. By adoption of 226.096 RSMo (L. 2003, HB 668), certain controversies or claims to which the Missouri Department of Transportation is a party that arises out of or relates to a contract awarded pursuant to subdivision (9) of subsection 1 of 226.130 (RSMo) subject to certain limits and preconditions are subject to, "be settled (sic) by arbitration administered by the American Arbitration Association under its Construction Industry Arbitration Rules, except as provided, in 226.096". Under the provisions of Chap. 435 RSMo arbitration is the subject of agreement between the parties to a contract. This section provides for incorporation of the, American Arbitration Association's, Construction Industry Arbitration Rules and Mediation Procedures (AAA Rules), amended and effective on the date arbitration is demanded and for their modification and revisions as permitted by the AAA Rules and Chap. 435 RSMo.

105.18.2. Incorporation. The AAA Rules are incorporated as part of the contract except as amended or excluded. The AAA Rules are further expressly amended or excluded as provided herein and as provided directly or indirectly by 226.096 RSMo (L. 2003, HB 668) and Chap. 435 RSMo.

105.18.3 Regular Track Procedures. The AAA Construction Industry Arbitration Rules, Regular Track Procedures, October 1, 2009 are amended as follows:

105.18.3.1 R-1. Agreement of Parties and Designation of Applicable AAA Rules. Not revised.

105.18.3.2 R-2. AAA and Delegation of Duties. Not revised.

105.18.3.3 R-3. National Panel of Construction Neutrals. Shall be replaced with the following:

In cooperation with the National Construction Dispute Resolution Committee the AAA shall establish and maintain a National Roster of Construction Arbitrators ("National Roster") and shall appoint arbitrators as provided first by the provisions of Missouri law, including 7 CSR 10-26, and then as provided in these rules. The term "arbitrator" in these rules refers to the arbitration panel, constituted for a particular case, whether composed of one or more arbitrators, or to an individual arbitrator, as the context requires.

105.18.3.4 R-4. Filing Requirements Under an Arbitration Agreement in a Contract. Not revised.

105.18.3.5 R-5. Filing Requirements under a Submission Agreement. Not revised.

105.18.3.6 R-6. Changes of Claim or Counterclaim. Shall be replaced with the following:

The contract between the parties provides for a Notice of Controversy or a Claim for adjustment to the contract prior to any demand for arbitration. Arbitration demands, issues, nature or amount of relief sought, shall not differ or be additional to that in the Notice of Controversy or Claim for contract adjustment provided for in the contract. There may not be a revision of the issues, nature of relief sought or increase in relief during or by way of any presentation of evidence during the arbitration. No award may be upon different issues or basis of relief or provide relief different in nature or greater in amount than contained in the Notice of Controversy or Claim given under the contract and stated in the demand for arbitration. No new or different controversy, claim or counterclaim may be submitted to the arbitrator except with the consent of both parties and the arbitrator and any consent must be clearly expressed, written and signed by the parties. There will be no amendments by implication.

105.18.3.7 R-7. Consolidation or Joinder. Shall be replaced with the following:

If Commission expressly agrees in writing with regard to multiple disputes arising under a particular contract, multiple demands may be consolidated so long as the relief sought in total does not exceed $409,123 in the principal relief sought, as adjusted on an annual basis effective January first of each year in accordance with the Implicit Price Deflator for Personal Consumption Expenditures as calculated pursuant to subsection 5 of section 537.610, RSMo. See http://insurance.mo.gov/industry/sovimmunity.php. Demands to which Commission is not a party in direct privity of contract will never be joined. The issue of consolidation of claims and joinder of parties will not be arbitrable. Nothing in this section shall prohibit more than one demand for arbitration pursuant to the same contract, provided that each demand for arbitration arises from a separate claim based upon facts supporting a separate right of relief, filed with the Department and accepted by the department under the Missouri Department of Transportation's "Contractor Claims and Controversies Procedures". Neither shall a prime contractor be prohibited from filing a demand for arbitration arising from work, which was subcontracted provided that; (a) the claim was initially accepted by the department under "Contractor Claims and Controversies Procedures." and (b) would provide a right to contract adjustment separate from any claimed or which could be claimed by the prime contractor for its sole benefit. However, subcontractors shall have no right to file a demand for arbitration with the Commission.

105.18.3.8 R-8. Interpretation and Application of Rules.

105.18.3.9 R-9. Jurisdiction. Not revised.

105.18.3.10 R-10. Mediation. Not revised.

105.18.3.11 R-11. Administrative Conference. Not revised.

105.18.3.12 R-12. Fixing of Locale. Not revised.

105.18.3.13 R-13. Date, Time and Place of Hearing. Not revised.

105.18.3.14 R-14. Arbitrators Appointment from National Construction Panel. Delete paragraphs (a), (b), (c), (d) and (e) and replace with the following:

Arbitrators will be selected and appointed in accordance with 7 CSR 10-26.

105.18.3.15 R-15. Direct Appointment by a Party. Not revised.

105.18.3.16 R-16. Appointment by a Chairperson by Party-Appointed Arbitrators or Parties. Not revised.

105.18.3.17 R-17. Nationality of Arbitrator in International Arbitration. Not revised.

105.18.3.18 R-18. Number of Arbitrators. Not revised.

105.18.3.19 R-19. Disclosure. Not revised.

105.18.3.20 R-20. Disqualification of Arbitrator. Not revised.

105.18.3.21 R-21. Communication with Arbitrator and the AAA. Not revised.

105.18.3.22 R-22. Vacancies. Not revised.

105.18.3.23 R-23. Preliminary Management Hearing. Not revised.

105.18.3.24 R-24. Exchange of Information. Not revised.

105.18.3.25 R-25. Attendance at Hearings. Not revised.

105.18.3.26 R-26. Representation. Not revised.

105.18.3.27 R-27. Oaths. Not revised.

105.18.3.28 R-28. Stenographic Record. Not revised.

105.18.3.29 R-29. Interpreters. Not revised.

105.18.3.30 R-30. Postponements of Hearings. Not revised.

105.18.3.31 R-31. Arbitration in the Absence of a Party or Representative. Not revised.

105.18.3.32 R-32. Conduct of Proceedings. Not revised.

105.18.3.33 R-33. Evidence. Not revised.

105.18.3.34 R-34. Evidence by Affidavit and Posthearing Filing of Documents or Other Evidence. Not revised.

105.18.3.35 R-35. Inspection or Investigation. Not revised.

105.18.3.36 R-36. Interim Measures. Not revised.

105.18.3.37 R-37. Closing of Hearing. Not revised.

105.18.3.38 R-38. Reopening of Hearing. Not revised.

105.18.3.39 R-39. Waiver of Rules. Not revised.

105.18.3.40 R-40. Extensions of Time. Not revised.

105.18.3.41 R-41. Serving of Notice. Paragraphs (a) and (b) shall be replaced with the following:

(a)Any papers, notices, or process necessary or proper for the initiation or continuation of an arbitration under these rules; for any court action in connection therewith, or for the entry of judgment on any award made under these rules, may be served on a party by mail addressed to the party or its representative at the last known address with return receipt or by personal service, in or outside the state where the arbitration is to be held, provided that reasonable opportunity to be heard with regard thereto has been granted to the party.

(b)The AAA, the arbitrator and the parties may also use overnight delivery with return receipt or electronic facsimile transmission (fax) to give the notices required by these rules. Facsimile transmission must require an acknowledgment that an entire legible transmission was received. Where all parties and the arbitrator agree, notices may be transmitted by electronic mail (email), or other methods of communication.

(c) Not revised

105.18.3.42 R-42. Majority Decision. Not revised.

105.18.3.43 R-43. Time of Award. Not revised.

105.18.3.44 R-44. Form of Award. Paragraph (b) shall be replaced with the following:

(a) Not revised.

(b) The arbitrator shall provide a concise, written breakdown of the basis of the award and a written explanation and justification for the awarded amount.

(c) Not revised.

105.18.3.45 R-45. Scope of Award. Not revised.

105.18.3.46 R-46. Award upon Settlement. Not revised.

105.18.3.47 R-47. Delivery of Award to Parties. Not revised.

105.18.3.48 R-48. Modification of Award. Not revised.

105.18.3.49 R-49. Release of Documents. Not revised.

105.18.3.50 R-50. Withdrawal of Claims or Counterclaims.

105.18.3.51 R-51. Applications to Court and Exclusion of Liability. Paragraph (c) shall be replaced with the following:

(a) Not revised.

(b) Not revised.

(c) Parties to these rules shall be deemed to have consented that judgment upon the arbitration award shall be entered as provided by 226.096, RSMo (L. 2003, HB 668).

(d) Not revised.

(e) Not. revised.

105.18.3.52 R-52. Administrative Fees. Not revised.

105.18.3.53 R-53. Expenses. Not revised.

105.18.3.54 R-54. Neutral Arbitrator's Compensation. Not revised.

105.18.3.55 R-55. Deposits. Not revised.

105.18.3.56 R-56. Remedies for Nonpayment. Not revised.

105.18.4 Fast Track Procedures. The AAA Construction Industry Arbitration Rules, Fast Track Procedures, October 1, 2009 are amended as follows:

105.18.4.1 F-1. Fast Track Applicability. Not revised.

105.18.4.2 F-2. Answers and Counterclaims. Not revised.

105.18.4.3 F-3. Limitation on Extensions. Not revised.

105.18.4.4 F-4. Changes of Claim or Counterclaim - Shall be replaced with the following:

The contract between the parties provides for a Notice of Controversy or a Claim for adjustment to the contract prior to any demand for arbitration. Arbitration demands, issues, nature or amount of relief sought, shall not differ or be additional to that in the Notice of Controversy or Claim for contract adjustment provided for in the contract. There may not be a revision of the issues, nature of relief sought or increase in relief during or by way of any presentation of evidence during the arbitration. No award may be upon different issues or basis of relief or provide relief different in nature or greater in amount than contained in the Notice of Controversy or Claim given under the contract and stated in the demand for arbitration. No new or different controversy, claim or counterclaim may be submitted to the arbitrator except with the consent of both parties and the arbitrator and any consent must be clearly expressed, written and signed by the parties. There will be no amendments by implication.

105.18.4.5 F-5. Appointment and Qualification of Arbitrator. Shall be replaced with the following:

The provisions of 7 CSR 10-26 and the procedures for regular track arbitrator selection, apply to fast track procedure arbitrations.

105.18.4.6 F-6. Serving of Notice for Hearing – Shall be replaced with the following:

(a) Any papers, notices, or process necessary or proper for the initiation or continuation of an arbitration under these rules; for any court action in connection therewith, or for the entry of judgment on any award made under these rules, may be served on a party by mail addressed to the party or its representative at the last known address with return receipt or by personal service, in or outside the state where the arbitration is to be held, provided that reasonable opportunity to be heard with regard thereto has been granted to the party.

(b) The AAA, the arbitrator and the parties may also use overnight delivery with return receipt or electronic facsimile transmission (fax) to give the notices required by these rules. Facsimile transmission must require an acknowledgment that an entire legible transmission was received. Where all parties and the arbitrator agree, notices may be transmitted by electronic mail (email), or other methods of communication.

105.18.4.7 F-7. Preliminary Telephone Management Hearing. Not revised.

105.18.4.8 F-8. Exchange of Information. Not revised.

105.18.4.9 F-9. Discovery. Not revised.

105.18.4.10 F-10. Date, Time, and Place of Hearing. Not revised.

105.18.4.11 F-11. The Hearing. Not revised.

105.18.4.12 F-12. Time Standards. Not revised.

105.18.4.13 F-13. Time of Award. Not revised.

105.18.4.14 F-14. Neutral Arbitrator's Compensation. Not revised.

105.18.5 Form of Award – Shall be added as follows:

The arbitrator shall provide a concise, written breakdown of the basis of the award and a written explanation and justification for the awarded amount.

105.19 Electronic Signatures. The contractor may utilize a verifiable electronic signature to sign contract documents. The electronic signature shall be verified by a recognized independent third party or the Construction and Materials Divisions.

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SECTION 106
CONTROL OF MATERIAL

106.1 Source of Supply and Quality Requirements.

106.1.1 All material needed in the work shall be furnished by the contractor, unless otherwise stated in the contract. The contractor shall assume full responsibility for ordering material of the required quality and quantity. The contractor shall be responsible for the delivered costs of all material ordered.

106.1.2 The material used in the work shall meet all quality requirements of the contract, and shall be obtained from supply sources that meet the approval of the engineer. If a uniform product is not being furnished from a supply source or if for any reason, the product from any source at any time proves to be unsatisfactory, the contractor may be required to furnish approved material from other sources. The engineer may reject the entire output of any source where it is impractical to secure a continuous flow of uniformly satisfactory material.

106.1.3 Any work incorporating material having no prior approval from the engineer shall be performed at the contractor's risk and may be considered unacceptable and unauthorized and, if so considered, will not be paid for. If a change in source will affect the control or appearance of the work, the use of any one kind or class of material for a specific project from more than one source will be prohibited, except as approved by the engineer. If approved, the engineer will set forth the conditions under which the change may be made.

106.1.4 Material will be subject to inspection or test at any time during production or manufacture or at any subsequent time prior to or after incorporation into the work. The points of inspection will be determined by the engineer. Material for sampling will be selected by the engineer. Material provided by the source solely as a sample of that material for testing verification will not be permitted. Initial inspection, testing and approval or rejection will be made as early as practical. The engineer may waive any of the requirements regarding determination of quality and accept material on certification or visual inspection if, in the judgment of the engineer, the quantity involved is too small or the material use is not sufficiently important to warrant tests.

106.1.5 To expedite the inspection and testing of material, the contractor shall submit a list of proposed sources of material to the engineer at the pre-construction conference or two weeks prior to beginning work, whichever is earlier. The list shall be in a format acceptable to the engineer. At the option of the engineer, material may be approved at the source of supply before delivery is started.

106.2 Local Material Sources.

106.2.1 Designated Sources. The Commission may acquire the right and make available to the contractor the right to take material from sources designated on the plans or described in the contract including the right to use designated property if so specified, for plant site, stockpiles and haul roads. In general, the quality of material contained in such sources will be considered acceptable, but the contractor shall determine the method of operation, equipment and work required to produce a material meeting the specifications from the source. Designation of a source for material will not be a representation of the quantity of acceptable material obtainable or the method, equipment or work required to obtain material from the source. It is not feasible to ascertain from samples the limits for an entire deposit, and variations will be considered as usual and are to be expected. The engineer may order procurement of material from any portion of a deposit and may reject portions of the deposit as unacceptable.

106.2.2 Contractor Furnished Sources. If sources of material are not designated on the plans or described in the contract, or if the contractor desires to use material from sources other than those designated, the contractor shall acquire the necessary rights to take material from the sources and shall pay all costs related thereto, including any that may result from an increase in length of haul. All costs of exploring, meeting environmental requirements and developing such other sources shall be at the contractor's expense. Environmental compliance documentation shall follow MoDOT requirements for contractor furnished borrow, as described in Sec 203.3, and shall be submitted to the engineer for review and approval. The use of material from other than designated sources will not be permitted until representative samples taken by the contractor in the presence of the engineer have been approved and written authority is issued for the use thereof. If sources of material or material deposits are provided by the contractor, the engineer will test the samples and determine the suitability of the material.

106.2.3 Operation of Sources. Whether sources of material are acquired and made available by the Commission or are furnished by the contractor, activities shall be in compliance with all federal and state laws

and the areas shall be excavated or worked in such a manner to comply with the current MoDOT Pollution Prevention Plan and minimize siltation of streams, lakes, ponds and reservoirs.

106.2.4 Final Condition of Sources. Unless otherwise permitted, pits and quarries shall be excavated such that water will not collect and stand therein. Sites from which material has been removed shall be left in such a condition to avoid or minimize siltation of streams, lakes, ponds and reservoirs, and shall be left in a neat and presentable condition upon completion of the work.

106.3 Samples, Tests and Cited Specifications. Samples for tests will be taken and shipped to the laboratory in accordance with MoDOT's *Engineering Policy Guide (EPG) 106.3.1*. There shall be no direct charge to the Commission for material taken as samples, either for field tests or for laboratory tests. If a specification of a recognized national standard agency (AASHTO, ASTM, AWS, AWWA, etc.) is designated, the material shall meet either the designated specification if a date is indicated or the latest revision thereof in effect at the time of bid opening. Tests of samples of material will be conducted by the engineer in accordance with the methods specified in the contract or in accordance with the latest methods in effect at the time of bid opening, as prescribed by the national standard agency. Such national standard specifications and methods of tests will include those designated as tentative, interim or amended and officially approved and published by the sponsoring agency. If appropriate methods have not been so prescribed, tests shall be performed in a manner determined by the engineer.

106.4 Plant Inspection. The engineer may inspect material at the source. If plant inspection is undertaken the following conditions shall be met.

106.4.1 The engineer shall have the cooperation and assistance of the contractor and the producer of the material.

106.4.2 The engineer shall be permitted unlimited access to all parts of the plant as required for adequate inspection of the plant equipment and for selection of samples. Facilities shall be furnished for the procurement of samples, performance of the tests and for the protection of testing equipment and supplies when tests are conducted at the source of production.

106.4.3 If bituminous shipments are considered by the engineer to justify testing at the source, laboratory facilities and testing equipment meeting requirements of the prescribed methods shall be provided by the supplier. The space and equipment shall be adequate for the orderly and proper testing of material without interference to or by the refinery personnel.

106.4.4 When requested, a Type 1 field laboratory shall be furnished at the aggregate source in accordance with Sec 601.

106.4.5 The Commission will refuse to provide plant inspection at sources where adequate safety measures are not provided and maintained.

106.4.6 The Commission reserves the right to inspect plant equipment and to retest all material prior to or after incorporation into the work and to reject all material which, when retested, do not meet the requirements of the specifications.

106.5 Storage of Material. The contractor shall be responsible for proper storage and handling of all material to ensure preservation of required quality and shall be arranged such as to facilitate inspection.

106.6 Handling Material. All material shall be handled in such a manner as to preserve the material's quality and fitness for the work. Aggregate shall be transported from the storage site to the work in tight vehicles constructed to prevent loss or segregation of material after loading and measuring.

106.7 Unacceptable Material. All material not in accordance with the specifications, when initially inspected and tested, will be considered defective, and all such material, whether in place or not, will be rejected and unless remedied, shall be removed from the site of the work. Any approved material that, in the judgment of the engineer, is no longer specification compliant will be rejected. Defective material, including any material furnished by the Commission that has been damaged by the contractor after delivery, shall be replaced or reconditioned by the contractor at the contractor's expense. Rejected material that has been reconditioned or corrected such that the material satisfactorily meets the specifications shall not be used without the engineer's

written approval.

106.8 Material Furnished by the Commission. If any material is to be furnished by the Commission, special provisions designating such material will be included in the contract documents. The cost of handling and placing such material after delivery to the contractor will be considered as part of the contract price for that material or work. The contractor shall be responsible for all material upon receipt, and deductions will be made from any monies due to the contractor to make good any shortages and deficiencies, from any cause whatsoever, for any damage that may occur after such delivery and for any demurrage charges.

106.9 Buy America Requirement. On all federal-aid projects, the contractor's attention is directed to Title 23 CFR 635.410 *Buy America Requirements*. Where steel or iron products are to be permanently incorporated into the contract work, steel and iron material shall be manufactured in the USA except for "minor usage" as described herein. Furthermore, any coating process of the steel or iron shall be performed in the USA. The use of pig iron and processed, pelletized and reduced iron ore manufactured outside of the USA will be permitted in the domestic manufacturing process for steel or iron material.

106.9.1 Any sources other than the USA as defined will be considered foreign. The required domestic manufacturing process shall include formation of ingots and any subsequent process. Coatings shall include any surface finish that protects or adds value to the product.

106.9.2 "Minor usage" of foreign steel, iron or coating processes will be permitted, provided the cost of such products does not exceed 1/10 of one percent of the total contract cost or $2,500.00, whichever is greater. If foreign steel, iron or coating processes are used, invoices to document the cost of the foreign portion, as delivered to the project, shall be provided and the engineer's written approval obtained prior to placing the material in any work.

106.9.3 Buy America requirements include a step certification for all fabrication processes of all steel or iron materials that are accepted per Sec 1000.

106.9.3.1 Items designated as Category 1 will consist of steel girders, piling, and reinforcing steel installed on site. Category 1 items require supporting documentation prior to incorporation into the project showing all steps of manufacturing, including coating, as being completed in the United States and in accordance with CFR Title 23 Section 635.410 Buy America Requirements. This includes the Mill Test Report from the original producing steel mill and certifications documenting the manufacturing process for all subsequent fabrication, including coatings. The certification shall include language that certifies the following. That all steel and iron materials permanently incorporated in this project was procured and processed domestically and all manufacturing processes, including coating, as being completed in the United States and in accordance with CFR Title 23 Section 635.410.

106.9.3.2 Items designated as Category 2 will include all other steel or iron products not in Category 1 and permanently incorporated in the project. Category 2 items shall consist of, but not be limited to items such as fencing, guardrail, signing, lighting and signal supports. The prime contractor is required to submit a material of origin form certification prior to incorporation into the project from the fabricator for each item that the product is domestic. The Certificate of Materials Origin form (link to certificate form) from the fabricator must show all steps of manufacturing, including coating, as being completed in the United States and in accordance with CFR Title 23 Section 635.410 Buy America Requirements and be signed by a fabricator representative. The Engineer reserves the right to request additional information and documentation to verify that all Buy America requirements have been satisfied. These documents shall be submitted upon request by the Engineer and retained for a period of 3 years after the last reimbursement of the material.

106.9.3.3 Any minor miscellaneous steel or iron items that are not included in the materials specifications shall be certified by the prime contractor as being procured domestically. Examples of these items would be bolts for sign posts, anchorage inserts, etc. The certification shall read "I certify that all steel and iron materials permanently incorporated in this project during all manufacturing processes, including coating, as being completed in the United States and in accordance with CFR Title 23 Section 635.410 Buy America Requirements procured and processed domestically in accordance with CFR Title 23 Section 635.410 Buy America Requirements. Any foreign steel used was submitted and accepted under minor usage". The certification shall be signed by an authorized representative of the prime contractor.

106.9.4 When permitted in the contract, alternate bids may be submitted for foreign steel and iron products. The

award of the contract when alternate bids are permitted will be based on the lowest total bid of the contract based on furnishing domestic steel or iron products or 125 percent of the lowest total bid based on furnishing foreign steel or iron products. If foreign steel or iron products are awarded the contract, domestic steel or iron products may be used; however, payment will be at the contract unit price for foreign steel or iron products.

106.10 Missouri Domestic Products Requirement. For state funded projects, as noted on the cover of the contract, material shall be in accordance with Sec 102.18.5.

106.11 Units.

106.11.1 Equipment. Equipment such as scales, concrete and asphalt plants, and placement equipment shall be scaled in or measured in English units. Equipment requiring calibration will be calibrated using the equipment's "as manufactured" units.

106.11.2 Material. All material shall be furnished quantified in the specified units of measure for dimensions and other physical aspects. Any cost of re-design due to use of material with units of measure other than as specified by the contract shall be at the contractor's expense.

106.11.3 Project Documentation. All project tickets, paperwork for measurement, certifications or reporting of material shall be in English units.

106.12 Pre-Acceptance List of Material and Sources.

106.12.1 Pre-Acceptance List Description. A PAL will indicate material products or sources that have complied with all pre-approval requirements for a specific material and indicates a source has committed to continued compliance with applicable contract requirements.

106.12.1.1 Pre-Acceptance List Material. For material acceptance based on PAL approval, Sec 106.12 will govern over all other applicable specifications. All material shall be in full compliance with Sec 106 and all other applicable contract documents, and shall be certified as such by the source of the material. Random sampling of the material will be conducted by the engineer to verify that the material is in compliance with the applicable specifications. Material on a PAL may be used on a project by the contractor prior to the engineer receiving random sample test results.

106.12.1.2 Unavailable PAL Material. If there are no PAL materials or suppliers for a specific PAL listing, or during the transition of a material to the PAL, the material may be accepted following sampling, testing and documentation review of each shipment in accordance with the specifications for that material.

106.12.2 Definition of Terms. The following definitions will apply only to Sec 106.12 and subsections:

(a) **Source.** The manufacturer, supplier, fabricator, source or any other entity that is listed on a PAL as the provider of that specific material or product.

(b)**Intermediate Agent.** A supplier of a PAL material, but who is not listed as the source of that specific material or product on the PAL.

106.12.3 Application for Placement on the PAL. A source may propose a material for PAL inclusion by submitting the information required in these specifications and other applicable contract documents, along with any required samples to Construction and Materials. Consideration of a material for PAL inclusion will be based on compliance with this specification or other applicable contract documents, the material's history and any other applicable criteria. Submittal of a request for PAL inclusion will not guarantee approval. The application shall include the following in a written document with attachments as needed:

(a) A completed, original Product Listing/New Product Evaluation Request Form (M-PAL Form).

(b) A completed, original PAL Program Inclusion Certification and Guarantee Statement Form (M-STMNT Form).

(c) A complete description of the material and how the material may be identified.

(d) A list of all MoDOT specifications applicable to the material.

(e) All documentation required by applicable MoDOT specifications or any other contract document.

106.12.4 Material Term on a PAL. Upon approval, the material will remain on a PAL for three years, provided the material's name, formulation and properties have not changed, the specification requirements have not changed, or the material or source has not been removed from the PAL for non-compliance reasons.

106.12.4.1 Material Reapplication on a PAL. During the last 12 months of a material's term on a PAL, the source shall reapply for placement on the PAL in accordance with Sec 106.12.3. No term expiration notification will be sent to the source, and the source shall be responsible for initiating reapplication.

106.12.4.2 Material Updates. Any name, source, or physical or chemical property changes to the material shall be submitted in writing and approved by Construction and Materials prior to use of the revised material. All physical or chemical changes to a material required to meet new or updated specifications shall be accompanied by identifiable name or identification changes, including revisions of any pertinent product information and certifications affected by the change. This information shall be provided in addition to the documentation required under Sec 106.12.3. When an update is properly submitted and approved, the update will be considered the same as a PAL reapplication, and the expiration date will be extended for three years from the date the changes were approved.

106.12.5 Material Removal from a PAL. Any material proposed for use after removal from a PAL, including use on existing contracts, will not be accepted by PAL methods. Unless stated otherwise, material removed from a PAL for reasons other than failure to re-apply will not be considered for reinstatement until one year after the date of removal. A material may be removed from a PAL for any of the following reasons.

106.12.5.1 Material and sources may be removed immediately from a PAL based on the discretion of Construction and Materials, for reasons including, but not limited to, failure of material to meet specifications, falsification of documentation, not providing required documentation or notification, lack of response to engineers' inquiries by the material's approved source, unsatisfactory performance in the field or other reasons indicating lack of consistent material quality or suitability.

106.12.5.2 Material that fails more than one random sample test in any 12-month period, for whatever reason, including improper manufacture, improper sampling, or improper supplier or contractor handling, will be subject to removal immediately from the PAL without recourse.

106.12.5.3 If a reapplication in accordance with Sec 106.12.4.1, as determined by postmark, is not received prior to the material's termination date, the material will automatically be removed from the PAL at the end of the material's term. For reinstatement of these materials to a PAL, the source shall submit an application in accordance with Sec 106.12.3.

106.12.5.4 Material that has not been documented as being used on MoDOT projects in any three consecutive years will be removed from a PAL. Once removed, a material will not be reinstated until substantial evidence of recent satisfactory use is provided and specific intended use on MoDOT work is established. No other time suspension will apply for considering reinstatement of these requests.

106.12.5.5 Any material or source removed from a PAL twice for any reason in any two-year period will be subject to permanent removal, with a minimum suspension of three years.

106.12.5.6 If a source has more than two materials removed from a PAL in any three-year period, all material from that source may be subject to removal from all PALs.

106.12.6 Reinstatement of a Material on a PAL. Consideration for reinstatement of a material once removed from a PAL will be no sooner than specified under Sec 106.12.5, will require a written document from the source stating the reasons for removal of the material from a PAL, the action taken to correct those deficiencies, written concurrence from Construction and Materials that the cause has been suitably addressed, followed by an application in accordance with Sec 106.12.3 for PAL approval.

106.12.7 Source Certification and Guarantee. Material to be accepted by the engineer under PAL approval shall include a source's certification, which may include certified test results, and a guarantee in accordance

with the applicable material specification in the contract documents. The written documentation shall also certify that the material provided is similar in all aspects to the material originally approved and placed on the PAL, and shall indicate the specific date of approval. An intermediate agent shall furnish a manufacturer and supplier's certification identifying the material, and stating that the material meets all contract document requirements for the specified intended use. Required documentation shall be retained by the manufacturer and each intermediate agent for a period of two years from the date of shipment of the material. The documentation shall be traceable to the destination or destination project and shall be immediately available to the engineer when requested.

106.12.8 Notification of PAL Material Delivery. Prior to delivery to the job site, the source, intermediate agent, shipper or contractor's representative shall notify Construction and Materials by mail, fax or electronically of the impending shipment of PAL material. The source shall ensure that any intermediate agent of the source's approved PAL material carries out the required notification. This notification shall include, at minimum, the following:

(a) The specific contract number.

(b) Line number for which the material will be used.

(c) Type and quantity of material.

(d) Date of expected delivery to the job site.

(e) Brand and manufacturer name of the material.

106.12.8.1 All of the above information shall have been received by Construction and Materials five working days prior to delivery of the material to the job site. Additional material may be considered part of the original shipment when the ordered quantity was underestimated or material was lost or damaged. Construction and Materials shall be notified prior to the shipment of additional material. No material shall be used on a project until Construction and Materials approves such use.

106.12.8.2 PAL Identification. Upon approval, the entity providing the notification of material delivery will be informed that the material was approved and an identification number for that specific material will be provided. This identification number shall be written on a tag or label and shall be attached to all the material prior to presentation for use at the job site. Material without the identification number attached will not be permitted for use on a project.

106.12.9 Sampling of Material. The source for a material shall ensure all users are adequately informed and monitored to ensure proper material sampling and usage. The source shall provide instructions for proper sampling of the material, and sampling shall be performed under the observation of the engineer. The source shall be solely responsible for proper sampling, unless stated otherwise by Construction and Materials.

106.12.9.1 Additional material may be requested by the engineer at the time of shipment to allow random sampling of the material at the project site without creating a material shortage.

106.12.9.2 Sample size and sampling frequency will be at the discretion of the engineer.

106.12.10 Intermediate Agent Responsibilities.

106.12.10.1 Any intermediate agent supplying PAL material to a supplier or contractor shall be responsible for proper handling, storage, sampling (if required to be performed by the agent) and delivery in accordance with applicable specifications and the source's recommendations, including notification of PAL material in accordance with Sec 106.12.8. If the intermediate agent is negligent in performing any of these specified tasks, the intermediate agent may be immediately denied as an intermediate agent for the PAL material without recourse and may be held responsible for material failure in accordance with Sec 106.12.13. If an intermediate agent is disapproved by Construction and Materials, that agent will not be reconsidered as an intermediate agent of any PAL material until one year after the date of removal as an intermediate agent of PAL material. Reinstatement will require a written document from the intermediate agent stating the reasons for removal as an intermediate agent for PAL material, the action taken to correct those deficiencies, and written concurrence from Construction and Materials that the problem has been suitably addressed and that the agent is approved as an

intermediate agent of PAL material.

106.12.10.2 An intermediate agent will be allowed to request PAL inclusion for a product manufactured by a separate company that does not have substantial business interest in applying for PAL or for a product that is only used in small quantities. If PAL inclusion is granted, the intermediate agent shall be responsible for any material provided that does not meet the applicable specifications. The intermediate agent shall assume all penalties for non-compliant material, including removal from a PAL in accordance with Sec 106.12.5.

106.12.11 Contractor PAL Use. The source for PAL material shall be listed on the PAL at the time the material is incorporated into the project. The contractor bears the risk that material on the PAL at the time of bidding is no longer on the PAL at the time of incorporation. The contractor may obtain a list of PAL material by contacting Construction and Materials or from MoDOT's website. Use of PAL material shall not relieve the contractor or supplier of any responsibility to provide an inspected and approved material meeting all requirements of the contract documents.

106.12.12 Testing of Material. Test results from any sample will be considered representative of the material, and a final determination of specification compliance will be made on the basis of that sample.

106.12.13 Responsibility for Material Failure. When material has been incorporated into the project and fails any specified tests, Sec 106.7 will apply. The use of this material on all other projects shall be suspended until notified otherwise by Construction and Materials.

106.13 Quality Control/Quality Assurance. For material or work governed by QC/QA specifications, quality control performed by the contractor will determine acceptance of the material when test results are confirmed by the engineer's sampling, testing and assessment. When the engineer's sampling, testing or assessment do not support the contractor's results, work shall be suspended and any material in place will be subject to rejection following a review by the engineer. Final acceptance of the material, work or process will be based on the engineer's sampling, testing and assessment.

106.13.1 Access to Contractor QC Testing. The engineer shall be allowed to witness contractor QC testing at any time.

106.14 Proprietary Items. In the event a proprietary item included in a contract becomes unavailable during the term of the contract, the contractor shall promptly provide documentation to the engineer substantiating that the proprietary item is unavailable. Price or credit terms demanded of the contractor by the supplier will not constitute sufficient reason to substitute for the specified proprietary item. As part of the documentation, the contractor shall propose an alternative source or item that meets the performance requirements of the original proprietary item included in the contract. Any adjustment in the contract unit price shall be made in accordance with Sec 109.4. If an acceptable alternative item cannot be located, the proprietary item and any associated work may be underrun from the contract.

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SECTION 107
LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC

107.1 Laws to be Observed. The contractor shall know, observe and comply with all federal and state laws, local laws, codes, ordinances, orders, decrees and regulations existing at the time of or enacted subsequent to the execution of the contract that in any manner affect the prosecution of the work, except as specified in the contract or as directed by the engineer. The Contractor shall also ensure that any subcontractor know, observe and comply with all federal and state laws, local laws, codes, ordinances, orders, decrees and regulations as outlined above. The contractor and surety shall indemnify and save harmless the State, the Commission, the Commission's agents, employees and assigns from any claim or liability arising from or based on the violation of any such law, code, ordinance, regulation, order or decree, except any local regulations, decrees, orders, codes or ordinances that the contract or the engineer has specifically directed that the contractor need not obey.

107.1.1 Contract and Legal Inconsistency. The engineer shall be notified immediately in writing if any discrepancy or inconsistency is discovered between the contract and any law, ordinance, regulation, order or decree.

107.1.2 Local Building and Zoning Codes or Ordinances. The projects of the Commission are not typically subject to local building or zoning codes or ordinances. Therefore, the contractor usually need not obtain a local building or zoning permit or variance for work done exclusively as the Commission's contractor on the Commission's project and the Commission's right of way. Other local codes or ordinances may not apply to the Commission, and thus to the contractor as well. If any questions arise concerning whether the contractor shall comply with a local code, ordinance, decree or order of any type, the contractor shall advise the engineer of the problem immediately, for resolution by the engineer. This provision will not exempt the contractor from the requirement of thoroughly researching and determining, before submitting a bid on the contract and from complying with, all federal, state or local laws, regulations, codes, ordinances, decrees or orders that may apply to the contract work. The Commission will not be responsible for the contractor's failure to be informed before bidding as to the federal, state and local laws, regulations, codes, ordinances, decrees or orders that may govern the contract work, or for the contractor's failure to determine before bidding which of these do not govern the contract work.

107.1.3 Authentication of Certain Documents. If plans, plats, detailed drawings or specifications for falsework, cofferdams or any other work are required to be submitted to the engineer, the documents shall be signed, sealed and stamped in accordance with the laws relating to the practice of architecture and professional engineering in the State of Missouri (Chapter 327, RSMo).

107.2 Permits, Licenses and Taxes. Except as otherwise provided in the contract, the contractor shall procure all permits and licenses, shall pay all charges, fees and taxes, and shall give all notices necessary and incidental to the due and lawful prosecution of the work. No direct payment will be made for the cost of complying with this requirement.

107.3 Patented or Copyrighted Devices, Material and Processes. If the contractor is required or desires to use any design, device, material or process covered by letters, patent, copyright, service or trademark, the contractor shall arrange and provide for such use by suitable agreement with the patentee or owner, and a copy of the agreement may be required by the Commission. The contractor and surety shall indemnify and save harmless the State, the Commission, the Commission's agents, employees and assigns from any suits, claims or damages arising from the infringement upon or use of any patented, copyrighted or registered design, device, material, process or mark.

107.4 Safety and Sanitary Provisions. The contractor shall at all times take necessary precautions to protect the life and health of all persons employed on the project or, who at the direction of the contractor are present on the right of way. The contractor shall be familiar with the latest accepted accident prevention methods and shall provide necessary safety devices and safeguards accordingly. The Commission will refuse to provide inspection services at plants or work sites where adequate safety measures are not provided and maintained.

107.4.1 Apparel. All workers within highway right of way shall wear approved ANSI/ISEA 107 Performance Class 2 or 3 safety apparel and more specifically as follows:

107.4.1.1 During daytime activities, flaggers shall wear a high visibility hard hat, safety glasses, a Performance

Class 3 top OR a Performance Class 2 top, and safety footwear. Hard hats other than high visibility orange or green shall be covered with a high visibility covering.

107.4.1.2 During daytime activities, workers shall wear a hard hat, safety glasses, a Performance Class 3 top OR a Performance Class 2 top, and safety footwear.

107.4.1.3 During nighttime activities, flaggers shall wear a high visibility/reflective hard hat, safety glasses, a Performance Class 3 top AND Class E bottoms, OR Performance Class 2 top AND Class E bottoms, and safety footwear. Hard hats shall be reflective or covered with a high visibility covering.

107.4.1.4 During nighttime activities, workers shall wear a hard hat, safety glasses, a Performance Class 3 top OR Performance Class 2 top AND Class E bottoms, and safety footwear.

107.4.2 The contractor shall provide and maintain in a neat and sanitary condition, such accommodations for the use of employees as may be necessary to comply with the requirements and regulations of any agency having jurisdiction over public health and sanitation. The contractor shall permit no public or private nuisance.

107.4.3 All sanitary facilities and safety devices shall be furnished free to employees and no direct payment will be made for such facilities or devices.

107.5 Public Convenience and Safety. The contractor shall conduct the work in a manner that will ensure, as far as practical, the least obstruction to traffic and shall provide for the convenience and safety of the general public and residents along and adjacent to the highway in an adequate and satisfactory manner.

107.5.1 Obstructions Prohibited. Fire hydrants on and adjacent to the highway shall be kept accessible to fire fighting apparatus at all times, and no obstruction shall be placed within 15 feet of any such hydrant. Footways, gutters, sewers, outlets, inlets and portions of highways adjoining the work under construction shall not be obstructed. Pavements over which hauling is performed shall be kept clean of spilled or tracked-on material at all times when in use by traffic.

107.5.2 Objects Potentially Affecting Navigable Airspace. The contractor shall comply with all federal regulations pertaining to constructing, erecting or installing any object, temporary or permanent, which could potentially affect navigable airspace.

107.5.3 Material and Equipment. During construction hours, equipment, material and vehicles utilized in construction of the project will only be permitted on shoulders, medians or pavements where the locations are closed to traffic, properly signed and occupied by ongoing construction operations, unless otherwise approved by the engineer. Except in cases of emergency, construction equipment, material and vehicles will not be permitted on pavements or shoulders being utilized by traffic. If the contract specifies time periods the contractor will not be permitted to perform work, construction equipment or vehicles shall not enter or leave the construction area via the pavements handling traffic nor be operated on the pavements handling traffic within the construction area during the restricted time periods. During non-construction hours, construction equipment, material and vehicles will not be permitted within 30 feet of the edge of the pavement or shoulders carrying traffic unless the equipment, material and vehicles are located in a properly protected area, an off-site storage area or as otherwise directed by the engineer.

107.6 Bridges over Navigable Waters. All work on navigable waters shall be conducted such that free navigation of the waterways will not be interfered with and that existing navigable depths will not be impaired except as allowed by permit issued by the USCG or the USACE.

107.7 Use of Explosives. All blasting operations shall be conducted under the direct supervision of a licensed blaster as required by the Missouri Blasting Safety Act. When explosives are used in the prosecution of the work, the contractor shall use the utmost care to prevent bodily injury and property damage. The contractor shall be responsible for damage resulting from the use of explosives. The engineer will have the authority to suspend any unsafe blasting operation. The contractor shall be familiar and comply with the rules and regulations of any city, county, state or federal agency or any other agency that may have jurisdiction in the handling, loading, transporting, storage and use of explosives. All places used for explosives storage shall be marked clearly **"DANGEROUS EXPLOSIVES".**

107.7.1 Before beginning work, the contractor shall furnish the engineer letters of approval for the proposed

operation from the appropriate regulating agencies. The contractor shall notify in writing the appropriate fire protection jurisdiction of the intent to store, transport or use explosives and shall provide proof of notice to the engineer. The contractor shall provide the engineer with copies of all permits, blasting logs and seismic monitoring data.

107.7.2 The contractor shall notify in advance each property owner, tenant and public utility company having structures or facilities close to the work of any intention to use explosives.

107.7.3 Removal of any item or material of any nature by blasting shall be done in such a manner and at such time as to avoid damage affecting the integrity of the design and to avoid damage to any new or existing structure, whether on Commission right of way or private property, included in or adjacent to the work. Unless the contract documents or the engineer restricts such operation, the contractor shall be responsible for determining a method of operation to ensure the desired results and the integrity of the completed work.

107.7.4 The contractor and surety shall indemnify and save harmless the State, the Commission, the Commission's agents, employees and assigns from any claim related to the possession, transportation, storage or use of explosives.

107.8 Preservation of Monuments and Artifacts.

107.8.1 Monuments. The contractor shall not disturb or damage any land monument or property landmark unless authorized by the engineer.

107.8.2 Human and Archaeological Remains. The contractor shall report to the engineer the discovery of human remains, artifacts, fossils and other items of historical, archaeological or geological significance discovered within the right of way during construction. Such items will remain in the Commission's custody and shall not be removed from the site unless directed by the engineer. The preservation and handling of such items shall be in accordance with Sec 203.4.8.

107.9 Forest and Park Protection. Environmental and sanitary laws and regulations regarding the performance of work within or adjacent to state or national forests or parks shall be obeyed. The contractor shall keep the project site in an orderly condition, dispose of all refuse, obtain permits for the construction and maintenance of all construction camps, stores, warehouses, residences, latrines, cesspools, septic tanks and other structures in accordance with the regulations and instructions issued by the forest or park supervisor. The contractor shall require employees and subcontractors, independently, and at the request of forest officials, to prevent and suppress forest fires, and to notify a forest official of the location and extent of any fire.

107.10 Environmental Protection. The contractor shall comply with all federal, state and local laws and regulations controlling pollution of the environment. Pollution of streams, lakes, ponds and reservoirs with fuels, oils, bitumens, chemicals or other harmful material and pollution of the atmosphere from particulate and gaseous matter shall be avoided.

107.10.1 Fording of streams and fill for temporary work not specified on design plans will not be permitted unless the plan for such operation is authorized by the Corps of Engineers, meets the approval of the engineer, complies with the current MoDOT Pollution Plan and results in minimum siltation to the stream. Temporary stream crossings shall not be constructed unless specifically designated as a condition of the Corps of Engineers Section 404 permit or a permit is obtained, and the temporary stream crossing is in accordance with Sec 806.

107.10.2 When work areas or pits are located in or adjacent to streams, the areas shall be separated from the main stream by a dike or barrier to keep sediment from entering the stream. Care shall be taken during the construction and removal of such barriers to minimize siltation of the stream.

107.10.3 Disposal of Portland cement concrete residue and wash water, water from aggregate washing, or other operations producing sediment laden runoff shall be treated in accordance with Sec 806.

107.10.4 Oil distributors or tanker trucks used for the transport or application of any petroleum-based products, and that have a capacity greater than 1,320 gallons, shall not be left unattended on MoDOT right of way within the project limits during non-construction hours unless secondary containment is deployed as per the Spill Prevention Control and Countermeasure rule. Parking of these vehicles on MoDOT right of way outside of the project limits, or on any MoDOT owned property, shall not be allowed without the aforementioned secondary

containment and prior authorization from the engineer.

107.11 Responsibility for Claims for Damage or Injury. The contractor and insurance company shall indemnify and save harmless the State, the Commission, the Commission's agents, employees and assigns from all claims or suits made or brought for bodily injury, death or property damage, arising from performance of the work to the extent of:

(a) The negligent acts or omissions of the contractor, subcontractors, suppliers or their respective officers, agents or employees.

(b) The creation or maintenance of a dangerous condition of or on the Commission's property or right of way, which condition occurred due to the acts or omissions of the contractor, subcontractors, suppliers or their respective officers, agents or employees or for which the contractor had knowledge of or could have had knowledge of the condition in time to warn of or repair said condition.

(c) The failure of the contractor, subcontractors, suppliers or their respective officers, agents or employees, to perform the work in accordance with the plans and specifications.

107.11.1 The contractor will not be required to defend, indemnify or hold harmless any other person, including the State, the Commission, or the Commission's agents, employees or assigns for any acts, omissions or negligence of other persons.

107.11.2 Neither the Commission nor the contractor, by execution of a contract, shall intend to or create a new or enlarge an existing cause of action in any third party. This provision shall not be interpreted to create any new liability that does not exist under the statutory limited waiver of sovereign immunity, or to waive or extinguish any defense that either party to this contract or their respective agents and employees may have to an action or suit by a third party.

107.12 Contractor's Responsibility for Work. From the earlier of the date of commencement of the work or the effective date of the notice to proceed, and until any work is accepted by the engineer, the work shall be in the custody and under the charge and care of the contractor. Issuance of a payment estimate on any part of the work done will not be considered as final acceptance of any work completed up to that time.

107.12.1 Damages to any portion of the work before the work is completed and accepted, caused by the action of the elements or from any other reason, shall be repaired or replaced at the contractor's expense. The contractor, at the contractor's option, may insure against any such damages. The Commission may, in its discretion, make such a payment, determined in accordance with Sec 109.4, for damage to the work due to unforeseeable causes beyond the control of, and without fault or negligence on the part of the contractor, unless the contractor has been reimbursed for such damages by the contractor's insurer. Prior to reimbursement, the contractor shall furnish documentary evidence of all efforts to recover such repair costs.

107.12.2 The contractor shall immediately give written notice to the engineer of any pedestrian or vehicular accident. The contractor may be directed by the engineer to repair permanent Commission facilities that have been damaged by events that are beyond the control of the contractor. Reimbursement will be provided by the Commission, determined in accordance with Sec 109.4, for the actual direct cost of labor, equipment and material, exclusive of overhead, indirect or consequential costs of profit. The Commission may elect to make such repairs in lieu of the contractor.

107.13 Insurance Requirements. The contractor shall procure and maintain at the contractor's expense until acceptance of the project by the engineer, insurance for all damages and losses imposed by law and assumed under the contract, of the kinds and in the amounts specified in Secs 107.13.1 through 107.13.4. Before the contractor begins the work, the contractor shall require the insurance company or companies to furnish to the engineer evidence of such insurance showing compliance with these specifications. All insurance required in Sec 107.13 shall be occurrence policies in a form acceptable to the engineer, and shall remain in force until all work required to be performed under the terms of the contract is satisfactorily completed as evidenced by formal acceptance by the engineer. Each policy or policy's declaration pages shall provide that the policy shall not be materially changed or canceled until the engineer has been given at least 30 days advance notice in writing. If any policy is canceled before the contract work is complete, a satisfactory replacement policy shall be in force, with notice and evidence of insurance submitted to the engineer, prior to the effective date of cancellation of the former policy. All evidence of insurance and notices shall be submitted to: Construction and Materials,

MoDOT, 105 W. Capitol Avenue, P.O. Box 270, Jefferson City, Missouri 65102-0270. Upon request, the contractor shall promptly furnish the engineer with a complete copy of the policy. Failure to furnish evidence of proper insurance, or complete insurance policies when requested, will result in the temporary suspension of work as provided in Sec 108, and may result in other claims or actions for breach of contract or otherwise, as may be recognized at law or in equity.

107.13.1 Workers' Compensation Insurance. The contractor shall furnish evidence to the engineer that, with respect to the operations the contractor performs, the contractor carries workers' compensation insurance, or is qualified by the Missouri Division of Workers' Compensation as self-insured, and carries insurance for employer's liability sufficient to comply with all obligations under state laws relating to workers' compensation and employer's liability. The contractor shall require each subcontractor on the project to furnish the same evidence to the engineer. This evidence shall be furnished to and approved by the engineer prior to the time the contractor or subcontractor commences work on the site of the project.

107.13.2 Contractor's Liability Insurance with Additional Insured Parties.

107.13.2.1 Commercial Liability Insurance. The contractor shall carry commercial general liability insurance and commercial automobile liability insurance from a company authorized to issue insurance in Missouri. Each such policy shall name the Commission, and the Missouri Department of Transportation and its employees, as additional named insureds, in amounts sufficient to cover the sovereign immunity limits for Missouri public entities as calculated by the Missouri Department of Insurance, Financial Institutions and Professional Registration, and published annually in the Missouri Register pursuant to Section 537.610, RSMo. Each policy shall be endorsed to cover liability arising from blasting if applicable, other inherently dangerous activities, and underground property damage. Each policy shall be endorsed to include broad form general liability, contractual liability and completed operations coverage.

107.13.2.2 Annual Updates. The contractor shall cause the insurer to update the contractor's liability insurance coverage minimums annually to correspond to the statutory limits as adjusted on an annual basis effective January 1st, and published in the Missouri Register as provided for in section 537.610 RSMo. If a statutory limit of liability for a type of liability specified in this section is repealed or does not exist, the Commission shall set reasonable limits for that insurance coverage which shall be subject to adjustment periodically, in a written notice from the Commission to the Contractor.

107.13.2.3 Subcontractor's Coverage. If any part of the contract is subcontracted, each subcontractor, or the contractor on behalf of that subcontractor, shall obtain the same commercial general liability insurance and commercial automobile liability insurance coverage. The commercial general liability insurance shall name the same entities specified in Sec 107.13.2.3 as additional insureds, and shall have the same separation of insureds conditions.

107.13.3 Navigable Waters Insurance Protection.

107.13.3.1 Description. Any contractor performing contract work on or adjacent to the Missouri and Mississippi rivers, and any other waters classified as "navigable waters of the United States" by the USACE, shall obtain insurance coverage in accordance with these specifications. The contractor may also obtain this insurance coverage for any subcontractor who will perform contract work under that contract. Employees of contractors or subcontractors that perform marine construction work on or near a waterway that is a navigable water of the United States may be subject to maritime law liability for injuries to employees working from vessels in waterways or working from nearby facilities in relation to construction on or over such waterways. Contractors and subcontractors for such work on these navigable waters of the United States shall purchase coverages as required in
Secs 107.13.3.2.1 and 107.13.3.2.2.

107.13.3.2 Insurance Requirements. Jones Act Insurance, Longshore and Harbor Workers' Compensation Act Insurance, and Maritime Law Liability Insurance will apply as provided in Secs 107.13.3.2.1 and 107.13.3.2.2.

107.13.3.2.1 Jones Act Insurance. Insurance shall be purchased by any contractor or subcontractor performing work on or near the Missouri or Mississippi Rivers, or any other navigable waters of the United States, for exposures under the Jones Act, 46 USC, with a minimum limit of $2,000,000 per occurrence and in the aggregate, or as may be specified by law, whichever amount is higher. The contractor or subcontractor may obtain insurance covering employees under the Jones Act for any other project for which the contractor's insurer

deems there is exposure. Insurance under this section covers any employee deemed by the courts as masters or members of crews of vessels who are entitled to seek recovery as "seamen" for injury or death under the Jones Act, or general maritime law. Such coverage may be provided through appropriate endorsements to the contractor's or subcontractor's workers' compensation policy.

107.13.3.2.2 US Longshore and Harbor Workers' Compensation Act Insurance. Insurance shall be purchased by any contractor or subcontractor performing work on or near the Missouri or Mississippi Rivers, or any other navigable waters of the United States, for exposures under the US Longshore and Harbor Workers' Compensation Act, USC, Title 33, with a minimum limit of $2,000,000 per occurrence, and in the aggregate, or as may be specified by law, whichever amount is higher. The contractor or subcontractor may obtain insurance covering employees under the US Longshore and Harbor Worker's Act as defined in this section for any other project for which the contractor's insurer deems there is exposure. Insurance under this section covers any employees who do not qualify as masters or members of a crew of a vessel, but perform work in loading or unloading vessels or work from docks, barges or other platforms, and who may be deemed by the courts as entitled to seek compensation for injury or death under the US Longshore and Harbor Workers' Compensation Act. Such coverage may be provided through appropriate endorsements to the contractor's or subcontractor's workers' compensation policy.

107.13.4 Railroad Protective Liability Insurance. In addition to other forms of required insurance, the contractor shall carry railroad protective liability insurance when any of the contractor's work is to be performed within any railroad right of way. The policy shall be written using one of the following combinations of Insurance Services Office ("ISO") Form Numbers: CG 00 35 01 96 and CG 28 31 10 93, or CG 00 35 07 98 and CG 28 31 07 98. The name or names of the railroad companies to be insured will be specified in each contract. The minimum limits of the insurance will be established in the contract documents and provided to the contractors prior to the opening of bids. The contractor shall submit the original policy in its entirety and one duplicate to the Commission for review and transmittal to the railroad. No work will be permitted within any railroad's right of way until the railroad involved has reviewed and approved the insurance policy. Any day upon which the contractor cannot perform work due to such a policy not being approved by the railroad will not be counted as a working day under Sec 108.7. Subcontractors for any part of the work that is sublet will not be required to obtain railroad protective liability insurance or provide evidence thereof, if the contractor's insurance for that purpose covers subcontractors.

107.13.5 Insurance with Other Than Missouri Companies. Any insurance policy required as specified above, if written by an insurance company organized in a state other than Missouri, shall be signed by an agent or broker licensed by the State of Missouri. In the case of policies written by companies organized in a state other than Missouri, the evidence of insurance submitted as authorized in the contract shall be signed by an agent or broker licensed by the State of Missouri. Nothing in this provision limits or waives the requirement that each insurance policy shall be issued by a company authorized to issue such insurance in Missouri.

107.13.6 Combinations. Employer's liability insurance, commercial general liability insurance and commercial auto liability insurance and insurance under the Jones Act or Longshore and Harbor Workers Compensation Act or Maritime Law Liability requirements, as required by this section, may be arranged under a single policy for the full limits required or by a combination of underlying policies and an excess liability policy, or "umbrella" coverage, which follows the form of the underlying policy.

107.14 Third Party Liability. Neither the State of Missouri, including the Commission, nor the contractor, by execution of the contract including these specifications, intend to create a right of action in a third party beneficiary, except as specifically set out in these specifications and the contract. It is not intended by any required contractual liability in the contract or in these specifications that any third party beneficiary has a cause of action arising out of the condition of the project when completed in accordance with the plans and accepted by the Commission.

107.15 Personal Liability of Public Officials. There shall be no personal liability upon the Chief Engineer, or any member, employee or agent of the Commission in carrying out any of the provisions of the contract or in exercising any power or authority granted to the individual, it being understood that in such matters the individual acts as an agent and representative of the State, with official and public duty doctrine immunity. If any provision of the contract appears to impose a duty on such an individual, the duty will remain exclusively that of the Commission and will not be a personal duty or obligation of the individual.

107.16 Contractors That Are Not Resident In Missouri. Any contractor that is not a permanent resident of or

domiciled in Missouri shall provide to the Commission proof of compliance with the Missouri "nonresident employers" financial assurance laws at
Sections 285.230 to 285.234, RSMo, before the contractor performs any work on a project.

107.16.1 A nonresident contractor that is a "transient employer" as that term is defined in Section 285.230.1, RSMo, and 12 CSR 10-2.017(1)(A), shall file with the Commission a photocopy of the contractor's current transient employer's certificate of registration issued by the Missouri Department of Revenue before performing any work on a project. A nonresident contractor that is not classified by the Missouri Department of Revenue as a "transient employer" because the nonresident contractor has properly registered with the Missouri Department of Revenue and the Missouri Division of Employment Security, and has filed and paid Missouri state income taxes for more than 24 consecutive months, shall file with the Commission a photocopy of the contractor's certificate of registration, issued by the Missouri Department of Revenue, that it is not a "transient employer" before performing any work on a project.

107.16.2 The contractor shall require a nonresident subcontractor to file with the Commission a photocopy of the subcontractor's current transient employer's or alternate certificate of registration, as issued by the Missouri Department of Revenue, before that subcontractor performs any work on a project.

107.16.3 Any nonresident contractor or subcontractor that fails to file the financial assurance forms with the Missouri Department of Revenue as required by Missouri law will be prohibited from contracting for or performing labor on any project for a period of one year.

107.17 Basis of Payment. No direct payment will be made for compliance with Sec 107, except as provided by Sec 618.

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SECTION 108
PROSECUTION AND PROGRESS

108.1 Subletting of Contract.

108.1.1 The contractor shall not sublet, sell, transfer, assign or otherwise dispose of the contract or contracts or any portion thereof, or of any right, title, or interest therein, without written consent of the engineer. Requests for permission to sublet, assign or otherwise dispose of any portion of the contract shall be in writing and accompanied by evidence that the organization that will perform the work is particularly experienced and equipped for such work. In case such consent is given, the contractor will be permitted to sublet a portion thereof, but the contractor's organization shall perform work amounting to no less than 40 percent of the total contract cost. Certification or classification of a contractor by type of work performed or consent to a subcontract shall not constitute the Commission's endorsement of the qualifications of the subcontractor or that the particular subcontractor's work will constitute compliance with any other provisions of the contract.

108.1.2 The value of the work sublet will be the amount designated in the contractual agreement between the contractor and the subcontractor. The subcontractor shall perform the work described in the subcontract agreement. No subcontracts, or transfer of contract, will in any case release the contractor's liability under the contract and bonds. Consent to a subcontract will not create a direct contractual relationship between the subcontractor and the Commission.

108.1.3 The contractor shall furnish to the Commission a complete copy of the signed subcontract, and all revisions upon request.

108.1.4 A contractor, at the discretion of the engineer, may make a substitution for a subcontract that was disclosed with the bid in accordance with Sec 102.7 or may add a subcontract that would have required disclosure in accordance with Sec 102.7. The contractor shall submit the name of the new subcontractor, the category of work, the dollar value of each subcontract and the reason for the substitution or addition in writing to the engineer for consideration.

108.2 Notice to Proceed. The notice to proceed will stipulate the date the contractor is expected to begin work. The Commission will issue the notice to proceed by stipulating the date on the notice of award sent to all successful bidders, or on a separate form for this purpose. Prior to the stipulated date, the contractor shall execute and file the prescribed number of copies of the contract and bond and shall furnish to the Commission satisfactory evidence of having complied with insurance requirements.

108.3 Prosecution of Work. The contractor will be expected to start work on the date stipulated by the notice to proceed. If all contract requirements have been met in accordance with Sec 108.2 the contractor may start work before the date stipulated by the notice to proceed, provided the engineer is notified in writing at least three days prior to the date on which the contractor expects to begin.

108.3.1 The contractor shall continuously and diligently prosecute the work in such order and manner as will ensure the completion of the work within the specified time, and the contractor shall be fully responsible for the prosecution and coordination of all work being performed under the contract.

108.3.2 The work in progress shall receive the personal attention either of the contractor or of a competent and reliable representative of the contractor who shall have full and final authority to act for the contractor. If authority is delegated to a representative of the contractor, the contractor shall notify the engineer in writing, stating the name of the person authorized to act as the contractor's representative, and stating the name or names of persons authorized to sign the various documents such as weekly reports, change orders, force account statements, labor payrolls and any other documents that may be required during the progress of the work. If progress at any time is not adequate to meet the contractor's schedule and the contract completion time, the contractor shall take all steps necessary to complete the work in the time and manner specified in the contract.

108.3.3 Prior to beginning any work on contracts involving a joint venture, the joint venturers shall appoint and maintain a single representative having full and final authority to act for the joint venture. The engineer shall be notified in writing of the name of this representative and of any replacements.

108.4 Progress Schedules. The contractor shall submit a progress schedule to the engineer for review prior to or at the pre-construction conference. The progress schedule shall be used to establish construction operations and

to monitor the progress of the work, although the engineer's determination of the then major operation or controlling item of work will always prevail. The progress schedule shall be in the form specified in Sec 108.4.1, unless the contract contains different requirements. The progress schedule shall be based on the number of working days, calendar days or other increments as set forth in the contract that the contractor expects to require in completing the project, recognizing the capabilities of labor, equipment, arrangements for material, mobilization, shop drawing preparation and approvals, and other relevant items. If an electronic computer software program is used to generate the schedule, the initial and any revised schedules shall be accompanied by a disk containing the schedule files in the native format of the software program used to create the schedule. The disk shall be labeled with the contract ID, route, county, date of revision, and the name of the software program used. The contractor will not be required to provide any copies of the software program.

108.4.1 Form and Contents of Progress Schedule. The progress schedule shall contain an activities schedule bar chart and may, at the contractor's option, include a written narrative that breaks down into detail the time in working days, calendar days or completion date involved in performing all construction activities for the duration of the project, and which is in a suitable scale as to indicate the percentage of work scheduled for completion at any time. The schedule shall indicate all interdependencies between activities. The progress schedule shall also clearly outline the intended maintenance of traffic, work phasing provided by the contract and such other information, as required by the contract.

108.4.2 Preparation of Initial Schedule. The contractor shall complete development of a progress schedule and present a copy to the engineer prior to or at the pre-construction conference.

108.4.2.1 The construction time, as indicated by the progress schedule, for the entire project or any milestone, shall not exceed the specified contract time. If any milestone date or contract completion date is exceeded in the schedule, time estimates on the progress schedule shall be revised. The controlling activity shall be clearly shown for each day of the schedule. A controlling activity will be defined as that part of a progress-controlling item or items that must be performed before the next progress-controlling item of work can be started. Following a review of the progress schedule by the engineer, the engineer and contractor will meet for a joint review, correction and adjustment of the schedule, if necessary.

108.4.2.2 If necessary this process will be repeated. However, the schedule shall be finalized by the contractor within seven days after request for correction and adjustment to the schedule.

108.4.3 Cost and Intent of Progress Schedules. The review by the engineer of any progress schedule will not constitute a determination that the schedule is reasonable, that following the schedule will result in timely completion, or that deviation will result in a delayed completion. The progress schedule, and any updates provided, is not a part of the contract. If the schedule reflects a completion date different than that specified in the contract, that does not void the completion date or working days specified in the contract. If any schedule reflects a completion time earlier than that specified in the contract, the contractor specifically understands that no claim for additional contract time or compensation will lie against the Commission if the work is not completed by the earlier time shown on the schedule. It will be the contractor's responsibility to determine the most feasible order of work consistent with the requirements of the contract.

108.4.3.1 No direct payment will be made for furnishing progress schedules or revisions.

108.4.3.2 If the contractor fails to comply with the requirement to supply an initial or any revised progress schedule, the engineer may withhold progress payments until a schedule has been submitted and reviewed.

108.4.4 Revised Progress Schedules. The contractor shall provide a revised progress schedule, which will then become the current progress schedule:

(a) When departure from the existing progress schedule makes it apparent to the engineer or the contractor that the project will not be completed in the time provided in the contract.

(b) When the engineer or the contractor determines that the progress schedule requires revisions for any reason.

108.5 Labor, Methods and Equipment. The contractor shall at all times employ sufficient labor, methods and equipment for prosecuting the work to full completion in the time and manner required by the contract.

108.5.1 All workers shall have sufficient skill and experience to properly perform work assigned. The engineer may demand the dismissal of any person employed by the contractor in, about or upon the work, who engages in misconduct, is incompetent or negligent in the due and proper performance of assigned duties, or who neglects or refuses to comply with any proper directions given. Such a person shall not again be employed thereon without the written consent of the engineer. Should the contractor continue to employ or re-employ any such person, the engineer may suspend the work until the contractor complies with such orders.

108.5.2 All equipment used on the work shall be of sufficient size and in such mechanical condition to meet requirements of the work and to produce satisfactory work. The condition or use of equipment on any portion of the project shall not cause damage to the roadway, adjacent property or other highways, or injury to any person.

108.5.3 The intent of the contract is to provide performance-type specifications to the extent consistent with producing finished work meeting the intent of the contract documents. Therefore, the methods and equipment to be used by the contractor in accomplishing the work will not be prescribed in the contract, and the contractor is free to use any method or equipment that will accomplish the contract work in conformity with the requirements of the contract. The failure of the engineer to object to contractor's equipment or methods will never constitute agreement that the equipment or methods used are appropriate.

108.5.4 If the contract specifies that the construction be performed by the use of certain methods and equipment, such methods and equipment shall be used unless otherwise authorized by the engineer. If the contractor desires to use a method or type of equipment other than those specified in the contract, authority shall be requested from the engineer. The request shall be in writing, including a full description of the proposed methods and equipment to be used and an explanation of the reasons for making the change. If approval is given, the contractor shall be fully responsible for producing work in conformity with the contract. If the engineer determines that the work produced does not meet contract requirements after use of the substitute method or equipment, the contractor shall discontinue the use of the substitute method or equipment and shall complete the remaining construction with the methods and equipment specified in the contract. The contractor shall remove deficient work and replace the work as specified in the contract, or take such other corrective action as directed by the engineer. Except as provided in Sec 104, no change will be made in the basis of payment for the construction items involved or in contract time as a result of approving any method or equipment change.

108.6 Temporary Suspension of Work. The engineer has authority to suspend any or all of the work in accordance with Sec 105 for such time as necessary. If it becomes necessary to stop work for an indefinite period, the contractor shall store all material in a manner that will protect the material from theft or damage, shall not unnecessarily obstruct traffic, shall take every precaution to prevent damage to or deterioration of work performed, shall provide suitable drainage of the roadway by opening ditches, shoulder drains, etc. and shall erect temporary structures where necessary. The contractor may suspend work for reasonable cause upon written approval from the engineer. During such a period in which work is suspended, liquidated damages will not accrue unless such suspension is due to the contractor's failure to comply with the contract. If work has been suspended, the contractor shall notify the engineer in writing at least 48 hours before resuming operations.

108.7 Contract Time for Completion of the Work. The time for the completion of the work is specified by calendar days, calendar date or working days in the contract. Time is an essential element of the contract, and it is therefore important that the work be pursued vigorously to completion.

108.7.1 Completion by Calendar Days or Calendar Date. Any computation of time by calendar days or calendar date will be based on the seasonal importance of days on the basis of weighted time tables on file in the Office of the Secretary of the Commission and available on the MoDOT website. If a change in the work is directed by the engineer, the contractor will be allowed an extension of contract time based on the weighted time tables and the ratio of the cost of such additional work to the contract price, unless it can be established that the additional work required more time than is indicated. In such cases, the actual time required, as determined by the engineer, may be allowed.

108.7.1.1 If the notice to proceed is not issued and effective within 35 days after the award or the later date specified in the contract due to any failure of the Commission, the contractor will be given an extension of contract time equal to the number of calendar days after the 35th day or the later date specified in the contract, until the notice to proceed is effective. Such a delay in the effective date of the notice to proceed will be an excusable, noncompensable delay.

108.7.1.2 The contractor will not be entitled to any extension of contract time because of unsuitable weather

conditions or the effects of weather conditions unless authorized in writing by the engineer as an excusable, noncompensable delay under Sec 108.14.1.

108.7.2 Completion by Working Days. If the time for the completion of the work is based on working days, this time will be specified in the contract. A working day will be defined as any day when, in the judgment of the engineer, soil and weather conditions would permit the major operation of the project for six hours or more, unless other unavoidable conditions prevent the contractor's operations. If conditions require the contractor to stop work in less than six hours, the day will not be counted as a working day.

108.7.2.1 December 15 to March 15, both dates inclusive and Saturdays, Sundays, and holidays established by law will not be counted as working days.

108.7.2.2 The count of working days will start on the date the contractor starts construction operations, or the effective date of the notice to proceed, whichever is earlier. The engineer will determine when a working day is to be charged. The engineer may make allowance for working days lost due to causes justifying their elimination from the count of working days. No allowance will be made for delay or suspension of the prosecution of the work due to fault of the contractor. On each contractor pay estimate the engineer will give the contractor written notice of the number of working days charged since the preceding pay estimate. Any objection by the contractor to the number of working days so charged shall be made in writing within five days, setting forth the contractor's objections and specifying the reasons therefore, or those objections shall be forever waived and will not constitute the basis for an excusable or compensable delay.

108.7.2.2.1 Where projects specify signal or lighting equipment as the major work items, working days will not begin until 104 calendar days after the date of the Notice to Proceed or until such time as the signal or lighting equipment is available to the contractor, or until the contractor begins work, whichever date is the earliest, to allow time for the fabrication and delivery of signal posts and lighting poles.

108.7.2.3 In case the final value of all work performed exceeds the original contract amount, an extension in the working days will be granted the contractor. The extension will be made by increasing the contract time by the ratio of the total final cost of all work performed under the contract to the total amount of the original contract. Incentive/disincentive, bonus or deduction adjustments will not be used in this computation. For a combination of projects awarded as a single contract, the extension will be made in a similar manner. If it can be established that the extra work required more time than indicated, the actual number of working days required, as determined by the engineer, may be allowed.

108.8 Liquidated Damages for Failure or Delay in Completing Work on Time.

108.8.1 If the contractor or, in case of default, the surety fails to complete the work within the time specified in the contract, or within such extra time as may be allowed in the preceding sections, a deduction of an amount specified in the contract will be made for each day that the contract remains incomplete after the time allowed for completion. The amount specified in the contract is agreed upon, not as a penalty, but as liquidated damages for loss to the Commission and the public. This amount will be deducted from any money due the contractor. The contractor and surety will be liable for all liquidated damages. Permitting the contractor to continue the work after the expiration of the specified time or any extension of time will not constitute a waiver by the Commission of any contractual rights.

108.8.1.1 The liquidated damages shown in the contract will be listed separately as contract administrative costs and project road user costs. A combination of projects awarded as a single contract will be considered as one unit for the determination and assessment of the administrative liquidated damages. The road user costs will be specified independently for each project in the contract and will be assessed independently for each project not completed within the time specified in the contract.

108.8.1.2 The Commission may waive the road user cost as may accrue if the work is deemed to be significantly complete. A project will be considered significantly complete when all necessary signing, pavement markings in accordance with Sec 620, guardrail, signals, all permanent traffic control devices and other safety appurtenances have been installed and are operational. At a minimum, traffic must have complete use of the roadways and shoulders, with no delays due to construction activity. The suspension of the road user cost by the engineer will not constitute a waiver by the Commission of any contractual rights, and its application will be contingent upon the discretion of the engineer in completing the remaining items of work.

108.8.1.3 Regardless of the method used to specify contract time for completion of the work, liquidated damages will not be charged as follows:

(a) From December 15 through March 15, both dates inclusive.

(b) For Saturdays, Sundays, and holidays established by law.

(c) During any period of sod maintenance, as specified in Sec 803, if such maintenance is the only work remaining and the contractor can perform the maintenance without inconveniencing the traveling public.

(d) During the final 15 consecutive day test period for a signal system, as specified in Sec 902, provided all other work has been completed.

108.8.2 The Commission will not be required to file a claim or counterclaim under Sec 105.16.5 or any other provision, to assess or retain liquidated damages.

108.8.3 The contractor and surety shall be liable for liquidated damages chargeable under the contract when the work is completed after default of the contract, unless the delay is caused by the Commission. A delay in the work or the final completion of the project caused by the Commission shall not void the provisions of the contract as to liquidated damages and will be considered an excusable, noncompensable delay.

108.9 Signal and Lighting Malfunctions. If the engineer invokes the option under Secs 901, 902 or 903 to have MoDOT personnel or a third party correct a lighting, signal or sign lighting malfunction, the contractor will be charged for the service. If MoDOT personnel make the correction, the charge will be computed as five times the cost for all replacement parts, equipment rental, salaries and fringe benefits. If a third party makes the correction, the contractor will be charged 1.2 times the charges billed the Commission by the third party. However, in no case will the charge be less than $100.

108.10 Default of Contract. After notice and an opportunity to remedy, the engineer may declare the contractor in default, if the contractor:

(a) Fails to begin the work under the contract within the time specified to begin work.

(b) Fails to perform the work with sufficient resources to assure the timely completion of the work.

(c) Fails to perform the work in accordance with the contract requirements, or neglects or refuses to remove and replace rejected material or unacceptable work.

(d) Discontinues the prosecution of the work.

(e) Fails to resume work that has been discontinued within a reasonable time after notice to do so.

(f) Becomes insolvent, is declared bankrupt or commits any act of bankruptcy or insolvency, allows any final judgment to remain unsatisfied or makes an assignment for the benefit of creditors.

(g) Fails to comply with contract requirements regarding prevailing wage payments, DBE or EEO requirements.

(h) Is a party to fraud.

108.10.1 The engineer will give notice in writing to the contractor and surety of the condition described in Sec 108.10, and advise the contractor and surety of the actions required for remedy. If the contractor does not proceed to remedy the condition within ten days of receipt of this notice, the engineer may declare the contractor in default. The declaration of default will be made in writing to the contractor and the surety.

108.10.2 If within ten days after receipt of the declaration of default, the surety does not proceed to assume the contract for completion under the direction of the engineer, the Commission has full power and authority, without impairing the obligation of the contract or the bond:

(a) To take over the completion of the work.

(b) To appropriate or use any or all project material and equipment that is suitable and acceptable.

(c) To enter into agreements with others.

(d) To use such other methods as in its judgment may be required for the completion of the contract in an acceptable manner.

108.10.3 Liability for Costs. The contractor and surety shall be liable for all costs and expenses incurred in completing the work, and for all liquidated damages in conformity with the contract. The contractor and surety are obligated to comply with all change orders and directives of the engineer to the same extent, and for the same compensation, if any, as the contractor would have been in the absence of default. In case the sum of such liquidated damages and the expense so incurred is less than the sum that would have been payable under the contract if the work had been completed by the contractor, the contractor or surety will be entitled to receive the difference. If the sum of such expense and such liquidated damages exceeds the sum that would have been payable under the contract, the contractor and surety will be liable and shall pay the amount of such excess. This provision will apply regardless of whether the surety or the Commission completes the contract work. The contractor and surety will solely be liable for the costs and expenses of a completing contractor, laborers and suppliers with which either has contracted.

108.10.4 If it is determined after termination of the contractor's right to proceed that the contractor was not in default, the rights and obligations of the parties will be the same as if the termination had been issued for the convenience of the Commission under Sec 108.11. Sums to which a contractor may be entitled as a result of the contract termination will be limited to amounts determined under Sec 108.11.

108.10.5 Sureties' Continued Acceptability. A surety failing to proceed within ten days after the written declaration of default by the engineer under Sec 108.10 may be required to show cause to the Commission why the surety should continue to be accepted for future bonds.

108.11 Termination of Contract for Convenience of the Commission. The Commission may terminate the entire contract, or any portion thereof, if the engineer determines that a termination is in the Commission's best interest. The engineer will deliver to the contractor and surety a notice of termination specifying the extent of termination and the effective date. A termination of the contract for convenience may be directed at any time after the Commission has made a determination to award a contract. The bidding documents may provide for a termination of the contract for convenience under this section upon the occurrence or nonoccurrence of a specified event after bid opening.

108.11.1 Submittals and Procedures. After receipt of a notice of termination, the contractor shall immediately proceed with the following obligations:

(a) Stop work as specified in the notice.

(b) Place no further subcontracts or orders for material, supplies, services or facilities, except as necessary to complete the portion of the contract that has not been terminated.

(c) Terminate all subcontracts to the extent they relate to the work terminated.

(d) Settle with subcontractors and suppliers all outstanding liabilities arising from the termination.

(e) Transfer title and deliver to the Commission, work in progress, completed work, supplies and other material produced or acquired for the work terminated, and completed or partially completed plans, drawings, information and other property that, if the contract had been completed, would be required to be furnished to the Commission.

(f) Complete performance of the work not terminated.

(g) Take any action that the engineer directs to protect and preserve contract-related property that is in the possession of the contractor in which the Commission has or may acquire an interest.

108.11.2 Settlement Provisions. When the Commission orders termination of all or a part of the contract effective on a certain date, completed items of work as of that date will be paid for at the contract unit price. Payment for partially completed work will be made either at agreed prices or under the provisions below. When items are eliminated in their entirety by such termination, the contractor will be paid for actual work done and actual costs incurred before notification, including mobilization of equipment or material.

108.11.2.1 Additional Costs. Within 60 days of the effective termination date, the contractor shall submit any request for additional damages or costs not covered in Sec 108.11 or elsewhere in the contract. Such a request may include only such cost items as: mobilization, overhead expenses proven to be attributable to the project or the part terminated and not paid for under work not terminated, subcontractor costs not otherwise paid for, actual idle equipment and idle labor cost only for any time the work is stopped in advance of the termination date, guaranteed payments for private land usage as part of the original contract, and any other actual cost for which the contractor feels reimbursement should be made.

108.11.2.1.1 Anticipated profits, including anticipated earnings on usage of owned equipment, and impact, delay or other direct or indirect costs resulting from this termination that are not expressly authorized, will not be compensable as part of any settlement.

108.11.2.1.2 The contractor and the engineer may agree upon the whole or any part of the amount to be paid because of the termination. The amount may include a reasonable allowance for profit on work done. The agreed amount may not exceed the total contract price as reduced by the amount of payments previously made and the contract price of work not terminated. The contract will be amended and the contractor paid the agreed amount.

108.11.2.2 Additional Cost Review. If the contractor and the engineer fail to agree on the whole amount to be paid the contractor because of the termination of work, the Commission will pay the amounts determined as follows, but without duplication of any amounts agreed upon in Sec 108.11.2.1:

(a) For contract work performed before the effective date of termination, the total, without duplication of any items of:

(1) The actual cost of work performed.

(2) The cost of settling and paying termination settlements under terminated subcontracts that are properly chargeable to the terminated portion of the contract if not included in Sec 108.11.2.1.

(3) A sum for profit on the actual cost of work performed as determined by the engineer to be fair and reasonable. The engineer will allow no profit under this section if the contractor's costs incurred on work performed exceed the contract prices paid.

(b) The reasonable costs to settle the work terminated, including:

(1) Internal accounting and clerical expenses reasonably necessary for the preparation of termination settlement proposals and support data, including expenses for termination and settlement of subcontracts.

(2) Storage, transportation and other costs incurred, reasonably necessary for the preservation, protection or disposition of the termination inventory.

(c) For normal spoilage and to the extent that the engineer expressly accepts the risk of loss. The engineer will exclude the fair value of property that is destroyed, lost, stolen or damaged so as to become undeliverable to the Commission or to the buyer.

108.11.2.2.1 In arriving at the amount due the contractor under this clause, there will be deducted:

(a) All advanced payments for mobilization, services or facilities, or other payments to the contractor under the terminated portion of the contract.

(b) Any claim that the Commission has against the contractor under the contract.

(c) The agreed price for or the proceeds from the sale of material, supplies or other items acquired and sold by the contractor, and not recovered by or credited to the Commission.

(d) Any costs saved as a result of the termination.

108.11.2.2.2 If the termination is partial, the contractor may file a proposal with the engineer for an equitable adjustment of the price or prices of the continued portion of the contract. The engineer will make any equitable adjustment agreed upon. Any proposal for an equitable adjustment under this clause shall be requested within 60 days from the effective date of termination unless extended in writing by the engineer.

108.11.2.2.3 The contractor shall maintain and make available all project cost records to the engineer for audit to the extent necessary to determine the validity and amount for each item requested. This will include, but is not limited to, all items described in Sec 105.16. These records and documents shall be made available to the engineer at the contractor's office at all reasonable times, without any direct charge. If approved by the engineer, photographs, microphotographs or other authentic reproductions may be maintained instead of original records and documents.

108.11.3 Effect of Termination. Termination of the contract or portion thereof will not relieve the contractor of contractual responsibilities for the work completed, nor will termination relieve the surety of the surety's obligation for and concerning that part of the contract not terminated or any just claim arising out of the work performed.

108.12 Notice to Contractor and Surety. Notice to the contractor, in case of default or termination of the contract, shall be deemed to be served when delivered to the person in charge of any office used by the contractor, the contractor's representative at or near the work or by certified mail addressed to the contractor's last known place of business. Notice to the surety shall be deemed served when mailed to the surety's address as shown in the contract by certified mail.

108.13 Termination of Contract for Misconduct. For the purposes of the following provision, "state" will include the State of Missouri and any other state, commonwealth or territory of the United States. The Commission may declare the contract to be terminated at any time after the contract is awarded and prior to final acceptance of the project, for any one or more of the acts set forth below, if the act occurred after the bid opening or within two years immediately preceding the date of the bid opening, unless the act is a basis for an adverse action under 49 CFR, Part 29 in which case the time limit will not apply, on any Commission or other federal, state or local government or privately awarded contract:

(a) Receiving or giving any currency or item of value in order to influence the competitive bidding process or the award of a competitively bid contract; bid-rigging, collusion or any similar act or communication with any person or firm in restraint of competitive bidding on a contract; or to obtain or grant an advantage in obtaining the award of such a contract.

(b) Fraud, dishonesty or a material misrepresentation or omission of fact in any request for proposal or bid submitted to a private firm or governmental agency, or in any contract documents submitted to such a firm or agency.

(c) Making or receiving kickbacks or payments of currency or any item of value in order to obtain or retain any contract or payment thereunder, or in return for an agreement to make or for the making of any false statements or material misrepresentations or omissions of fact to any federal, state or local governmental agency or private firm relevant to contract compliance.

(d) Suspension, debarment or other disqualification of the contractor, or determination that the contractor is not a responsible bidder for public contracting purposes, by any federal, state or local governmental agency, regardless of whether the sanction is still in effect at the time of the bid or contract award by the Commission.

(e) Conviction or adjudication of guilt in any criminal proceeding in a federal or state court, regardless of whether sentence was suspended or executed, for any act an element of which is fraud, dishonesty or moral turpitude, which conduct is relevant to a determination of the responsibility of the contractor.

(f) Commission of any act or failure to act, such that the contractor is subject to the determination that the contractor is not a responsible bidder under the contract or under applicable Missouri or federal law.

108.13.1 The acts, omissions and liabilities of persons or firms affiliated with the contractor or of persons that are principals of the contractor, are those of the contractor, unless the circumstances clearly negate that conclusion. Persons or firms are "affiliates" of each other if, directly or indirectly, either one controls or has the power to control the other or a third person controls or has the power to control both. Examples of control include, but are not limited to: interlocking management or ownership, identity of interests among family members, shared facilities and equipment, common use of employees on projects or a new business entity organized following the determination of ineligibility or non-responsibility of a person or firm which has the same or similar management, ownership or principal employees as the ineligible person. A "principal" will be defined as an officer, director, owner, partner or other natural person within a firm with primary management, supervisory or contracting responsibilities.

108.13.2 The Commission will not declare the contract terminated pursuant to this section if the contractor made a full and complete disclosure of the acts and circumstances described in Sec 108.13 to the Commission in the bid or in writings submitted with the bid and the Commission did not determine the contractor to be non-responsible prior to making the award of the contract. The Commission will not be precluded from terminating the contract under this section if the information provided by the contractor did not constitute a full and complete disclosure of all facts and circumstances pertinent to the issue of the responsibility and integrity of the contractor.

108.13.3 The procedures for notice of the proposed termination of the contract and the contractor's right to be heard regarding that proposed action will be those in accordance with a proposed disqualification or suspension under the provisions of 7 CSR 10-18. After notice and an opportunity to be heard, upon a finding of the existence of a basis to terminate a contract under this section, the Commission may terminate the contract immediately or at the occurrence of some specific date or event in the future, prior to project completion, upon delivery of a written notice to the contractor by actual service or by certified mail, return receipt requested, sent to the address of record of the contractor. Effective with the contract termination date, the contractor shall discontinue further work on the project and shall instruct subcontractors and suppliers to do the same, other than to remove promptly the contractor's personnel, equipment and supplies from the project site. The contractor will be paid for all completed work to that date at the contract price. At the option of the engineer, the Commission may assume the possession and cost of any specially fabricated material or supplies for the project that have been ordered prior to notice of termination, but have not been installed on the date of termination. The contractor and surety will be liable to the Commission for all costs and expenses incurred by the Commission in completing the project, including, but not limited to, the Commission's costs to redraft and rebid the project, which costs and expenses exceed the total of the contractor's bid price plus additional expenses allowed by the engineer during the contractor's work on the project, less the amount paid to the contractor by the Commission. The Commission will not be liable for damages for breach of contract or in any other action or respect for declaring a default if one exists under this section and for terminating the contract prior to completion by the contractor.

108.13.4 The satisfactory performance of a contract, prior to the notice to the contractor of the intent to terminate the contract for misconduct, will not be a basis to determine whether the contract may be terminated for misconduct under this section.

108.13.5 The contractor shall file any claim the contractor has against the Commission within 60 days after the effective date of termination, pursuant to the procedures of Sec 105. The Commission will file any claim the Commission has against the contractor or surety within
60 days of the date of final acceptance of the project, whether or not it is renumbered or redesigned, and whether completed by the surety, by a successor contractor retained by the Commission, or by the Commission itself. Any Commission claim will be filed pursuant to the procedures of Sec 105.

108.14 Determination of Compensation and Contract Time Extension for Excusable, Noncompensable and Compensable Delays. An extension of the contract time may be granted under the following conditions provided documentation has been given to the engineer in accordance with Secs 108.14.3 through 108.14.5. Strict adherence to the provisions of this section will be a condition precedent to the contractor's entitlement to an extension of contract time or compensation because of project delays.

108.14.1 Excusable or Noncompensable Delay. Contract time allowed for the performance of the work may be extended for delays caused by acts of God, acts of the public enemy, fires, floods, earthquakes, epidemics, quarantine restrictions, strikes, freight embargoes, unusually severe weather or other delays not caused by the contractor's fault or negligence.

108.14.2 Compensable Delay. Contract time allowed for performance of the work may be extended for delays caused by the Commission. The contractor may be granted an extension of time and additional compensation only as provided by Sec 109.

108.14.3 Notification of Delay. Within seven days of the occurrence of a delay to the prosecution of any phase of the work, the contractor shall notify the engineer in writing of such a delay and indicate that a request for delay consideration will be filed. Delay costs incurred prior to notifying the engineer that operations have been delayed will be noncompensable.

108.14.4 Procedures Following a Delay. The contractor shall keep daily records of all non-salaried labor, material costs and equipment expenses for all operations affected by the delay.

108.14.4.1 The contractor shall maintain a daily record of each operation affected by the delay and the station location of the operations affected. Daily records of the operations and stations will also be maintained by the engineer. Each Monday, the contractor shall compare the previous week's daily records with the records kept by the engineer. The contractor shall also prepare and submit written reports to the engineer each Monday containing the following information:

(a) Number of days behind schedule due to the delay.

(b) A summary of all operations that have been delayed or will be delayed.

(c) In the case of a claimed compensable delay, the contractor shall explain how the Commission's act or omission delayed each operation and estimate the amount of time required to complete the project.

(d) An itemized list of all extra costs incurred, including:

(1) How the extra costs relate to the delay and how the costs are being calculated and measured.

(2) The identification of all non-salaried project employees for whom costs are being compiled.

(3) A summary of time charges for equipment, identified by manufacturer's year and model and the contractor's number, for which costs are being compiled.

108.14.4.2 The contractor shall provide written notice to the engineer within seven days of the results of the comparison of the detailed reports performed each Monday and shall define any disagreements between specific records.

108.14.4.3 Failure to meet to review the engineer's records or to report disagreements between the records will be considered conclusive evidence that the engineer's records are accurate.

108.14.5 Procedures Following Completion of Work Allegedly Delayed. Within the earlier of 15 days of completion of any phase of work allegedly delayed, or of project completion, the contractor shall submit a report to the engineer containing the following information:

(a) A description of the operations that were delayed and the documentation and explanation of the reason for the delay, including all reports prepared by or for the contractor.

(b) An as-built chart or other graphic depiction of how the operations were delayed based on the contractor's most recent progress schedule prior to the delay event.

(c) An item by item measurement and explanation of extra costs requested for reimbursement due to the delay.

108.14.5.1 All costs shown in the report submitted to the engineer must be directly caused by the delay event and shall reflect the actual costs incurred as shown on the contractor's project cost records kept in the ordinary course of business.

108.14.5.2 The engineer will review the contractor's submission and any reports prepared for the engineer. A written decision will be provided to the contractor within 60 days of the receipt of the complete contractor's submission. This time may be extended if the engineer requires additional information. The contractor shall state affirmatively in writing when the contractor has made a complete submission of information regarding a delay event.

108.14.5.3 In the case of compensable delays, if the engineer determines that the Commission is responsible for delays to the contractor's operations, the engineer's written decision will reflect the nature and extent of any resulting equitable adjustment to the contract in accordance with Sec 109.

108.15 Suspension of Work Directed by the Engineer.

108.15.1 If the performance of all or any portion of the work is suspended or delayed by the engineer for an unreasonable period of time not originally anticipated, customary or inherent to the construction industry, and the contractor believes that additional compensation or contract time is due as a result of such suspension or delay, the contractor shall submit to the engineer in writing a request for adjustment within seven days of receipt of the notice to resume work. The request shall set forth the reasons and support for such an adjustment. The procedures of Secs 108.14.4 and 108.14.5 will apply to requests for additional compensation or time claimed by the contractor as a result of a suspension of work directed by the engineer under this section.

108.15.2 Upon receipt, the engineer will evaluate the contractor's request. If the engineer agrees that the cost or time required for the performance of the contract has increased as a result of such a suspension and the suspension was caused by conditions beyond the control of and not the fault of the contractor, suppliers or subcontractors, and not caused by weather, the engineer will make an adjustment, excluding profit, and modify the contract in writing accordingly. The engineer will notify the contractor of the engineer's determination whether or not an adjustment of the contract is warranted.

108.15.3 No contract adjustment will be made unless the contractor has submitted the request for adjustment within the time prescribed.

108.15.4 No contract adjustment will be allowed under this clause to the extent that performance would have been suspended or delayed by any other cause, or an adjustment is provided for or excluded under any other term or condition of the contract.

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SECTION 109
MEASUREMENT AND PAYMENT

109.1 Measurement of Quantities. All work completed under the contract will be measured by the engineer according to United States standard measure or will be paid for on a contract quantity basis as set out elsewhere in these specifications. The method of measurement and basis of payment will be made to the nearest whole number unless specified otherwise. When the contract quantity of any item is found to include appreciable errors, or when an authorized revision of the plans is made, the quantity will be corrected before making final payment. The method of measurement and computations to be used in determination of quantities of material furnished and of work performed under the contract will be those methods generally recognized as conforming to good engineering practice.

109.2 Scope of Payment.

109.2.1 Compensation. The contractor shall receive and accept compensation provided for in the contract as full payment for performing all work under the contract in a complete and acceptable manner, and for all risk, loss, damage or expense arising from the work or the prosecution thereof subject to Sec 109.8.

109.2.2 Completed Improvements. The payment of any current or final estimate, or the acceptance of any portion of the work as provided in the specifications, will not affect the obligation of the contractor to submit for final acceptance a completed improvement in accordance with the contract.

109.3 Compensation for Altered Quantities. When the accepted quantities of work vary from the quantities in the contract, the contractor shall accept payment at the original contract unit prices for the accepted quantities of work done. No allowance will be made for any increased cost, except as provided in Sec 104 and Sec 108.

109.4 Differing Site Conditions and Changes in the Work. Contract adjustments to compensate for changes in the work or extra work caused by differing site conditions or changes in the work performed in accordance with Sec 104 will be determined by use of one of the following methods, in order of precedence

109.4.1 Contract Unit Prices. Where contract unit prices exist, the contract unit price will always be applied without deviation, unless the effect of a differing site condition or a significant change in the character of the work requires an equitable adjustment to a contract unit price under the terms of this contract. Equitable adjustments will exclude any anticipated profits.

109.4.2 Unit Prices or Lump Sum Amount Agreed Upon in the Change Order Authorizing the Work. Where contract unit prices do not exist for the work to be done, the parties may agree to such unit prices or a lump sum price for that work. Where an equitable adjustment to a unit price is required, the parties may agree to the adjustment to be made to the contract unit price, excluding any anticipated profits. Prior to agreeing upon such unit or lump sum prices, the engineer may require from the contractor any information to which the engineer is authorized under Sec 104.

109.4.3 Equitable Adjustment. In all other cases, except work ordered to be performed under force account, the engineer will make an equitable adjustment to or determination of the affected contract prices for the work, based on the contractor's actual costs to perform the work. This determination will be consistent with the contractor's other proven costs to perform the contract work, as shown in the contractor's bid computations and project cost records, produced and kept in the ordinary course of business. Prior to making an equitable adjustment, the engineer may require from the contractor any information relevant to that determination, including the information authorized under Sec 104. The condition precedent to determination of contractor entitlement and amount of any contract adjustment and Commission liability will be that the adjustment:

(a) Is supported by demonstrated actual excess costs incurred, including by an audit of the actual costs, unless expressly waived by FHWA on federal aid projects.;

(b) Has a basis in the terms of the contract;

(c) Has a basis in terms of applicable Missouri law and;

(d) Is in accordance with prevailing principles of public contract law.

109.4.4 Application of Force Account. Force account, as computed under Sec 109.5, will apply to determine the amount of compensation for a contract adjustment under Sec 109.4 only when expressly directed to be used in writing by the engineer and in no other instance whatsoever for any determination of contract adjustments for any work performed on the project, whether claimed under the contract, for breach of the contract, arising from a claimed representation by which the contract was induced or any other basis.

109.5 Force Account Computation.

109.5.1 Labor. For all lead workers and laborers, the contractor will receive the rate of wage paid for each hour that said lead workers and laborers are engaged in the force account work.

109.5.1.1 The contractor will receive the actual costs paid to, or on behalf of, employees for subsistence and travel allowances, health and welfare benefits, pension fund benefits or other benefits, if such amounts are required by the collective bargaining agreement or employment contract applicable to the classes of labor employed on the work.

109.5.1.2 An amount equal to 20 percent (5 percent profit and 15 percent overhead) of the sum of the above items will also be paid the contractor.

109.5.2 Insurance and Taxes. For property damage, liability and worker's compensation insurance premiums, unemployment insurance contributions and social security taxes on the force account work, the contractor will receive the actual cost paid, to which 20 percent (5 percent profit and 15 percent overhead) will be added.

109.5.3 Material. For material accepted by the engineer and used, the contractor will receive the actual cost of such material delivered on the work, including transportation charges paid (exclusive of equipment rentals as hereinafter set forth), to which cost 20 percent (5 percent profit and 15 percent overhead) will be added. For all material used in connection with, but not entering permanently into the work, reasonable depreciation will be allowed.

109.5.4 Equipment. The Contractor will be reimbursed for its costs for providing equipment at the rates listed in “Cost Recovery” as posted by EquipmentWatch™, hereafter referred to as the Rental Rate Blue Book, for contractor-owned equipment necessary to accomplish the force account work, including all fuel and lubricants, tires and repairs. The contractor will be allowed an hourly rate equal to the monthly rental rate divided by 176 hours as set out in the Rental Rate Blue Book http://equipmentwatch.com/blue-book-cost-recovery/ at the time the force account is ordered. The allowed rates will be the rate adjustment factor multiplied by the bare hourly rates multiplied by the regional adjustment factor, plus the estimated operating cost per hour. The allowed time will be the actual operating time on the work. For the time required to move the equipment to and from the site of the work and any authorized standby time, the rate will be 50 percent of the hourly rate after the actual operating costs have been deducted. All allowed time shall fall within the authorized working hours for such extra work. No payment will be allowed for time elapsed while equipment is broken down or being replaced. The hourly rental rates will apply only to equipment that is already on the job. If the actual unit of equipment to be used is not listed in the schedule, the rate listed for similar equipment with the approximate same initial cost shall be used. Equipment to be used and all prices shall be agreed upon in writing before such equipment is used. An amount equal to 20 percent (5 percent profit and 15 percent overhead) of the sum of these items will also be paid to the contractor. Whenever it is necessary for the contractor to rent equipment, the rental and transportation costs of the equipment plus five percent for overhead will be paid. In no case shall the rental rates exceed those of established distributors or equipment rental agencies. All prices shall be agreed upon in writing before such equipment is used.

109.5.5 Miscellaneous. No additional allowance will be made for general superintendence, the use of small tools or other costs for which no specific allowance is herein provided. Jobsite and home office overhead expenses shall be considered fully compensated by the payments provided in Sec 109.5.

109.5.6 Subcontracted Work. For administration and all overhead costs in connection with approved subcontract work, the Prime contractor will receive an amount equal to five percent of the actual cost of the subcontracted work. The engineer has the authority to require alterations in the equipment and labor force assigned to force account work, to limit authorization of overtime work to that normally used on a project for work of similar nature or to require overtime work when an emergency exists, and to require the cessation of force account work when adverse conditions seriously limit productivity.

109.5.7 Statements. No payment will be made for work performed on a force account basis until the contractor has furnished the engineer with duplicate itemized statements of the cost of such force account work detailed as follows:

(a) Name, classification, date, daily hours, total hours, rate and extension for each laborer and foreman.

(b) Designation, dates, daily hours, total hours, rental rate and extension for each unit of machinery and equipment.

(c) Quantities of material, prices and extensions.

(d) Transportation of material.

(e) Cost of property damage, liability and worker's compensation insurance premiums, unemployment insurance contributions and social security.

109.5.7.1 Statements shall be accompanied and supported by receipted invoices for all rental equipment, material used and transportation charges.

109.5.7.2 If material used on the force account work is not specifically purchased for such work but is taken from the contractor's stock, then in lieu of the invoices, the contractor shall furnish an affidavit certifying that such material was taken from contractor's stock, that the quantity claimed was actually used, and that the price and transportation claimed represent the actual cost to the contractor.

109.5.8 Compensation. Each day the contractor's representative and the engineer shall compare records of the cost of work done as ordered on a force account basis. Two copies of these records will be made by the engineer on forms provided by the Commission, and the copies shall be signed at the end of each day by both the engineer and the contractor, one copy to be retained by the engineer, and one copy to be retained by the contractor. The total payment made, as provided in Sec 109.5, shall constitute full compensation for such work.

109.6 Method of Payment. Payment to the contractor for furnishing all material and performing all work under the contract will be deposited electronically in an account number and financial institution designated by the contractor on form MO 300-1278.

109.7 Partial Payments.

109.7.1 Payment Estimates. The engineer will make semi-monthly payment estimates in writing for the material in place and the work performed during the semi-monthly interval and the value thereof at the contract unit bid prices. For partially complete items, the proper percentage with relation to completion will be allowed.

109.7.2 Material Allowance. The engineer may, in any payment estimate, include the value of any non-perishable material that will be finally incorporated in the completed work. The material shall be in conformity with the plans and specifications in the contract, and shall not have been used at the time of such estimate. The value of such material in a single submission from one supplier shall be no less than $10,000.00. The material shall be delivered to the project or other location that is approved by the engineer. Any storage area not within the right of way shall be leased at the contractor's expense with provisions for right of entry by the engineer during the period of storage. Invoices for material payment shall be submitted to the engineer at least four days prior to the estimate date. Receipted invoices for all material payments previously allowed on the estimate shall be submitted to the engineer within 42 days of the date of the estimate on which material allowance was made or such material allowance will be deducted from future payments. The amounts paid for such material shall reduce the amount of other partial or final payments due the contractor for the work performed as the materials are fabricated or incorporated in the completed work.

109.7.2.1 No partial payment will be made for living or perishable plant material until planted.

109.7.2.2 The engineer may also, on contracts containing 100 tons or more of structural steel, include in the estimate prepared for partial payment, the value of structural carbon steel or structural low alloy steel, or both, which is to form a part of the completed work and which has been produced and delivered by the steel mill to the fabricator.

109.7.2.2.1 The required receipted mill invoice, billing, title or assignment documents or other documents furnished by the contractor shall include certified mill test reports as described in Sec 1080, containing complete material description, identification, weights, dimensions, heat and unit numbers, and cost data.

109.7.2.2.2 The structural steel shall be stored separately and used only for the fabricated structural steel in the contract.

109.7.2.2.3 The weight of the structural steel considered for partial payment shall not exceed the contract quantity.

109.7.2.3 The engineer may also include in any payment estimate an amount not to exceed 90 percent of the invoice value of any inspected and accepted fabricated structural steel items, fabricated structural aluminum sign trusses, structural precast items and permanent highway signs providing the total invoice value of these items is no less than $25,000 for each storage location for each project.

109.7.2.4 All material furnished for the work as noted in these specifications will be subject to shop inspection by the engineer.

109.8 Final Acceptance and Payment. When the project has been accepted as provided in Sec 105, the engineer will prepare the final tabulation of the quantities of work performed. All prior partial estimates and payments will be subject to correction in the final tabulation and payment. The contractor will be paid the entire sum found to be due after deducting all previous payments and all amounts to be retained or deducted under the provisions of the contract. The contractor shall submit the following for file with the Commission:

(a) An affidavit, on the form prescribed by the Commission, to the effect that all payments have been made and all claims have been released for all material, labor and other items covered by the contract bond.

(b) The written consent of the surety to such payment is required if retainage was held.

(c) Any other documents that may be required by the contract.

109.8.1 Final Payment and Claims. If said affidavit regarding subcontractor and third party debts and claims cannot be given because of a dispute as to the amount or legality of a claim, the engineer, with the consent of the surety, may consent to and make payment of all of the final amounts due the contractor if:

(a) The engineer is of the opinion that the claim has not been paid solely because the contractor is, in good faith, questioning the legality of said claim or its amount.

(b) The engineer is further satisfied that there is good and sufficient bond to fully protect said claimant.

(c) The contractor's affidavit clearly sets out the facts as to the name and address of the unpaid claimant or claimants, the amount of the disputed claim, and a brief statement of the cause of the dispute.

109.8.2 Corrections. Final acceptance will not prevent the Commission from correcting any measurement, estimate or certificate made before or after completion of the contract. The Commission will not be prevented from recovering, from the contractor or surety, or both, overpayments made or costs sustained by the Commission for failure of the contractor to fulfill the obligations under the contract. A waiver on the part of the Commission of any breach of any part of the contract shall not be held to be a waiver of any other or subsequent breach.

109.8.3 Defects. The contractor and surety shall be liable to the Commission for latent defects, fraud or such gross mistakes as may amount to fraud, or as regards the Commission's rights under any warranty or guaranty without prejudice to the terms of the contract.

109.9 Retained Percentage.

109.9.1 Withholding of Retained Percentage.

109.9.1.1 Retainage may be initiated during contract performance if the engineer determines that certain events

have occurred, including:

(a) Events where federal or state law applicable to the contract require payments be withheld to enforce a contract obligation.

(b) Events where the contract otherwise specifically provides for withholding payments to secure performance.

(c) The occurrence of a cause for withholding payment specified in the Missouri Prompt Pay Act, 34.057 RSMo. Retainage withheld under these circumstances will be as allowed by that statute.

(d) When projects are being charged liquidated damages or when it is determined by the engineer that assessment of liquidated damages is probable and imminent.

109.9.1.2 If retainage is initiated during contract performance, then the greater of the amount allowed under 34.057 RSMo or five percent will be deducted from the total amount of remaining work items of each estimate. The retained percentage will be released as provided in these specifications. The net amount due on the estimate will be certified to the Commission for payment. This method of retained percentage will not apply to Sec 808.6.

109.9.2 Release of Retained Percentage. As soon as practical after final acceptance of the work, and after final quantities have been computed or computations have reached a point where final quantities may be closely estimated, the retained percentage will be paid to the contractor. A portion of any retained percentage may be released after the project is open to all through traffic, or the work has been essentially completed. Prior to release of any retained percentage the contractor shall file with the Commission:

(a) An affidavit, on the form prescribed by the Commission, to the effect that all payments have been made and all claims have been released for all material, labor and other items covered by the contract bond.

(b) The written consent of the surety to such payment.

(c) Any other documents which may be required by the contract.

109.9.3 Release with Pending Claims. If said affidavit cannot be given because of a dispute as to the amount or legality of a claim, the engineer, with the consent of the surety, may consent to and make payment of all of final amounts and percentage due the contractor if:

(a) The engineer is of the opinion that the claim has not been paid solely because the contractor is, in good faith, questioning the legality of said claim or its amount.

(b) The engineer is further satisfied that there is good and sufficient bond to fully protect said claimant.

(c) The contractor's affidavit clearly sets out the facts as to the name and address of the unpaid claimant or claimants, the amount of the disputed claim, and a brief statement of the cause of the dispute.

109.10 Assignments. Neither the contract, nor any duties or obligations or rights of the contractor or the contractor's surety arising under, from or relating to the contract, or to be performed as required by the contract, and whether present or prospective, including, without limitation, money due at any time or any claim of any character arising from or relating to performance or nonperformance of the contract, whether for breach or otherwise, shall be assigned or transferred to any other person so as to bind or affect the Commission absent the express written consent of the surety and the Commission and upon a written request and compliance with such requirements as the engineer or Commission may provide.

109.11 Compensation for Project Delays. This provision will apply to and will control all contract adjustments, change orders and claims for additional compensation that are time related, resulting from compensable project delays, inefficiency, standby, extended performance or described in any other term.

109.11.1 Only the actual and documented additional costs associated with the following items will be

recoverable by the contractor as an equitable adjustment for delay.

(a) Non-salaried labor expenses.

(b) Material costs.

(c) Equipment costs.

(d) Costs of extended job-site overhead.

(e) An additional ten percent of the total of items (a), (b), (c) and (d) for home office overhead and every other cost for which no specific allowance is provided.

109.11.2 All costs claimed shall be adequately documented when measuring additional equipment expenses (i.e. ownership expenses) arising as a direct result of a delay caused by MoDOT. Actual records kept in the usual course of business, measuring actual increased ownership expenses pursuant to generally accepted accounting principles, may be required at the discretion of the engineer for determining equipment costs. For delays that the engineer determines to be short-term, or when the engineer determines this method acceptable, equipment costs shall be calculated using the provisions for authorized standby time in Sec 109.5.4, except that no increase for overhead or profit will be allowed in excess of what is established in Sec 109.11.1.

109.11.3 The parties agree that, in any adjustment for delay costs, MoDOT will have no liability for the following items of damages or expense.

(a) Profit in excess of that provided herein.

(b) Loss of profit.

(c) Labor inefficiencies.

(d) Equipment inefficiencies or reduced production.

(e) Home office overhead in excess of that provided in the percentage allowance in Sec 109.11.1 or herein if none of those percentages applies.

(f) Consequential damages, including but not limited to loss of bonding capacity, loss of bidding opportunities and insolvency.

(g) Indirect costs or expenses of any nature.

(h) Attorney's fees, claims preparation expenses or costs of litigation.

109.12 Change Orders. Except as otherwise provided for in the change order, an adjustment of the contract price or time of contract performance in a change order constitutes compensation in full to the contractor, subcontractors and suppliers for all costs and time effects directly or indirectly attributable to the matter described in the change order, for all delays related thereto, for all impact, cumulative impacts and for performance of the change within the time stated. The surety's liability under the contract bond and contract shall not be limited to the penal sum as set forth in the contract bond. The surety shall be liable and responsible to the Commission for the contractor's entire performance and of all obligations arising under or from the contract, which shall include, but not be limited to, any change orders issued under the contract that increase the cost of the contract.

109.13 Prompt Payment to Subcontractors and Suppliers. The requirements set forth in this section will apply to all contracts where the federal government is participating in the cost of construction.

109.13.1 When the contractor receives any payment from the Commission, the contractor shall, within the earlier of fifteen days of receipt of that payment, or the date provided by the subcontract or purchase order, pay each subcontractor or supplier a sum, less only any retention provided by the subcontractor or purchase order or sum withheld as allowed by Sec 109.13.3, equal to one of the following:

(a) The value of that subcontractor's work, services or material included on the contractor payment estimate applicable to that payment.

(b) The amount of any material allowance under Sec 109.7.

(c) Such greater sum as provided by the subcontract or purchase order for work included on the contractor payment estimate.

109.13.2 Notwithstanding any conflicting provision in a subcontract or purchase order and subject only to the requirements of Sec 109.13.3, the contractor shall make final payment of the balance of all sums under a subcontract or purchase order, including any retention, within 30 days of the satisfactory completion of the subcontractor's work or services, or a supplier's final delivery of materials to be provided.

109.13.3 The contractor may withhold periodic payment or final payment to a subcontractor or supplier only for the following causes and only if that subcontractor or supplier is directly involved:

(a) The engineer has rejected specific areas or items of work or materials as not conforming to the contract or such areas or items of work or materials are deemed not suitable for payment.

(b) Unsatisfactory job progress.

(c) Defective construction work or materials not remedied.

(d) Disputed work, but only the disputed amount.

(e) Failure to comply with other material provisions of the contract.

(f) Third party claims filed, or reasonable evidence that a claim will be filed, but not claims covered by a subcontractor or supplier's insurance required by Sec 107.

(g) Substantial evidence of the subcontractor or supplier's failure to make timely payments for labor, equipment or materials; damage to the contractor or another subcontractor or material supplier, but not such damage as is covered by a subcontractor or supplier's insurance required by Sec 107.13.2.3.

(h) Substantial evidence that the subcontractor or supplier's work cannot be completed for the unpaid balance of the subcontract or purchase order sum, or a reasonable amount for retention.

109.14 Price Adjustment for Fuel. If the contractor accepts the option for fuel adjustment in the bid proposal, the method of price adjustment for the fuel used on the items of work specified herein will be based on "Fuel Usage Factors" The following table specifies the fuel usage factors for Production and On-Road Hauling. The On-Road Hauling Factor is based on an average 30-mile round trip and will be used regardless of the actual haul distance.

Item of Work	Unit	Fuel Usage Factor for Production	Fuel Usage Factor for On-Road Hauling	Total Fuel Usage Factor
Class A Excavation	gal/yd^3	0.20	n/a	0.20
Unclassified Excavation	gal/yd^3	0.30	n/a	0.30
Class C Excavation (Includes Sandstone and Igneous Rock Excavation)	gal/yd^3	0.40	n/a	0.40
Embankment in Place	gal/yd^3	0.35	n/a	0.35
Bituminous Construction on Roadways, Shoulders and Entrances. Includes both full depth asphalt and overlays. Includes all asphalt mixes under Secs 401, 402 and 403, as well as Ultrathin	gal/ton of total asphalt	2.65	0.67	3.32

Bonded Asphalt Wearing Surface (UBAWS). Asphalt mixes paid by SY will be converted to equivalent tons using a factor of 1.98 tons/yd^3.	mix			
Concrete Pavement Construction on Roadways, Shoulders and Entrances. Includes both full depth concrete and overlays. Includes roller compacted concrete. Round to nearest 1 in. increment. (e.g. if 7.5" pavement use 8 in. factor). If less than 6 in., use 6 in. factor. Concrete paid by CY will be converted to equivalent thickness.	gal/yd^2			
	6 in.	0.27	0.22	0.49
	7 in.	0.29	0.26	0.55
	8 in.	0.31	0.29	0.60
	9 in.	0.33	0.33	0.66
	10 in.	0.35	0.37	0.72
	11 in.	0.36	0.41	0.77
	12 in.	0.39	0.44	0.83
	13 in.	0.41	0.48	0.89
	14 in.	0.42	0.52	0.94
Aggregate Base Construction[a] on Roadways, Shoulders and Entrances.	gal/yd^2			
	3in.	n/a	0.11	0.11
	4 in.	n/a	0.15	0.15
	5 in.	n/a	0.19	0.19
	6 in.	n/a	0.23	0.23
	7 in.	n/a	0.26	0.26
	8 in.	n/a	0.30	0.30
	9 in.	n/a	0.34	0.34
	gal/ton	n/a	0.67	0.67
	gal/yd^3	n/a	1.35	1.35

[a] Includes all base in Secs 302 and 304, when hauled to the project, but does not include material in Secs 303 or 310. Does not include any base produced within project limits or adjacent to the project. Includes base shown in pay limits for optional shoulder designs (e.g. A3 shoulder), but not the portion identified as incidental base.

109.14.1 The first day of each month (excluding Saturdays, Sundays, and holidays) in which the project is bid will be used to establish the "Starting Fuel Index" for the duration of the project. The "Starting Fuel Index" will be the average of the values given for No. 2 fuel as reported by Platt's Oilgram - PAD 2 - St. Louis Area.

109.14.2 The pay items and unit prices in the contract will not change. The Commission will, on the first day of each month (excluding Saturdays, Sundays and holidays), determine the "Monthly Fuel Index" of No. 2 fuel from the price index as reported by Platt's Oilgram - PAD 2 - St. Louis Area, which will apply to all payment estimates during that month regardless of the type fuel used.

109.14.3 The quantities of completed work for the payment period will be determined by the engineer and included in the payment estimate. These same quantities will be used to determine the fuel usage for any price adjustment.

109.14.4 The difference (±) between the "Monthly Fuel Index" and the "Starting Fuel Index" will be the "Monthly Fuel Index Adjustment Factor". This "Monthly Fuel Index Adjustment Factor", along with the "Fuel Usage Factor" and quantities of completed work for which payment is made will determine the fuel adjustment payment or deduction.

109.14.5 If adjustments are made in the contract quantities, the contractor shall accept the fuel adjustment as full compensation for increases or decreases in the price of fuel regardless of the amounts of overrun or underrun.

109.14.6 The fuel adjustment will be computed each pay period work is performed, for the usage of fuel by the following procedure:
Fuel Adjustment = (Fuel Usage Factor) x (Monthly Fuel Index Adjustment Factor) x (Units of Work included in the payment estimate)

109.14.7 Payments or deductions for the fuel adjustments on the various items of work will be made on the estimate as one "Fuel Adjustment". No change order will be required.

109.14.8 If the bidder wishes to be bound by these specifications, the bidder shall execute the acceptance form in the proposal. Failure by the bidder to execute the acceptance form will be interpreted to mean election to not participate in the price adjustment for fuel.

109.15 Price Adjustment for Asphalt Cement.

109.15.1 Asphalt Cement Price Index. Adjustments will be made to the payments due the Contractor for any plant mix bituminous base, plant mix bituminous pavement, plant mix bituminous surface leveling, asphaltic concrete pavement and ultrathin bonded asphalt wearing surface that contains performance graded (PG) asphalt binder when it has been determined that the Monthly Asphalt Index for the month prior to placement of the asphalt mixture has fluctuated from the Monthly Asphalt Index for the month the project was let. The Monthly Asphalt Index shall be established for each calendar month as the average of the midpoint selling prices of PG64-22 for St. Louis and Kansas City, Missouri areas, as published by Poten and Partners Inc. in the Asphalt Weekly Monitor®, on the first Monday preceding the date of the normal monthly MoDOT letting. For months when there is no normal monthly letting, the published price on the third Monday of that month shall be used for the Monthly Asphalt Index. Special lettings shall have no effect on determining the Monthly Asphalt Index. The asphalt base index shall be the Monthly Asphalt Index for the month of the bid opening. For calculation of the price adjustment, any asphalt placed on the first day of a month will be included with the asphalt placed the previous month in order to keep price adjustments in sync with the payment estimate period schedule.

109.15.1.1 The price adjustment will be applied to the actual amount of virgin PG asphalt binder used by the Contractor for all asphalt items specified in Sec 109.15.1. For asphalt mixtures that are paid for by the square yard, the price adjustments will be made for applicable equivalent tons, as calculated by the engineer, based upon the plan square yard quantity and thickness converted to tons, excluding the 1:1 wedge. The price adjustment will be applied to all Job Order Contract projects for all quantities of the wet ton and square yard asphalt mix. The percentage of virgin PG asphalt binder as shown in the job mix formula, in accordance with Sec 401, Sec 403 and Sec 413, will be the basis for price adjustments for any asphalt mix type placed on the project. The effective asphalt binder obtained from the use of Recycled Asphalt Pavement (RAP) and/or Recycled Asphalt Shingles (RAS) will not be eligible for adjustment. The Monthly Asphalt Index for PG64-22 will be applied to the asphalt mix for mixes using any PG asphalt binder.

109.15.1.2 Price Adjustment Calculated. To determine the price adjustment for any asphalt mix specified in this provision, the following formula will be used.

$$A = (B \times C/100) \times (D-E)$$

Where: A = Dollar value adjustment for mix placed during the payment estimate period
B = Tons of asphalt mixture placed during the payment estimate period
C = Percent of virgin PG asphalt binder as listed in the job mix formula in use
D = The Monthly Asphalt Index for the month prior to the month the asphalt mix was placed
E = The asphalt base index = the Monthly Asphalt Index for the month the project was let

109.15.1.3 The engineer will apply the price adjustments, as determined by the price adjustment calculation established herein, for each payment estimate period in which asphalt is placed, except for any asphalt placed after the allowable contract time period as defined in Sec 108. For asphalt placed after the contract completion time limit, the "D" value used for the price adjustment calculated shall be either the last "D" value prior to the date that contract time was exceeded, or the current monthly "D" value, whichever is lower.

109.15.1.4 Optional. This provision is optional. If the bidder wishes to be bound by this provision, the bidder shall execute the acceptance form in the Bid. Failure by the bidder to execute the acceptance form will be interpreted to mean election to not participate in the Asphalt Cement Price Index. If the Asphalt Cement Price Index is accepted, PG asphalt binder for the project will not be eligible for a material allowance as described in Sec 109.

109.15.2 Seal Coat Price Index. Adjustments will be made to the payments due the contractor for Seal Coat placed in accordance with Sec 409. Adjustments will be calculated in accordance with Sec 109.15.1 Asphalt Cement Price Index, except as defined herein.

109.15.2.1 Basis of Payment. To determine the adjustment for any material specified in this provision the

following formula will be used.

A = B X (0.68 X 8.58/2000) X (D – E)

Where: A = adjustment for Seal Coat placed during the index period
B = gallons of seal coat placed during the index period
D = average index price at the beginning of the period
E = average index price at the time of bid
0.68 = factor to reduce volume of emulsion to AC only
(use average specific gravity of 1.03 for seal coat)

109.15.2.2 Optional. This provision is optional. If the bidder wishes to be bound by this provision, the bidder shall execute the acceptance form in the Bid for the Seal Coat Price Index. Failure by the bidder to execute the acceptance form will be interpreted to mean election to not participate in the Seal Coat Price Index.

109.15.3 Asphalt Underseal Price Index. Adjustments will be made to the payments due the contractor for Asphalt Underseal placed in accordance with Sec 625. Adjustments will be calculated in accordance with Sec 109.15.1Asphalt Cement Price Index, except as defined herein.

109.15.3.1 Basis of Payment. To determine the adjustment for any material specified in this provision the following formula will be used.

A = B X (8.66/2000) X (D – E)

Where: A = adjustment for asphalt underseal placed during the index period
B = gallons of asphalt underseal placed during the index period
D = average index price at the beginning of the period
E = average index price at the time of bid
(use average specific gravity of 1.04 for underseal)

109.15.3.2 Optional. This provision is optional. If the bidder wishes to be bound by this provision, the bidder shall execute the acceptance form in the Bid for the Asphalt Underseal Price Index. Failure by the bidder to execute the acceptance form will be interpreted to mean election to not participate in the Asphalt Underseal Price Index.

109.15.4 Polymer Modified Emulsion Membrane Price Index. Adjustments will be made to the payments due the contractor for Polymer Modified Emulsion Membrane placed in accordance with Sec 413.30 (UBAWS), but not when used for other purposes. Adjustments will be calculated in accordance with Sec 109.15.1 Asphalt Cement Price Index, except as defined herein.

109.15.4.1 Basis of Payment. To determine the adjustment for any material specified in this provision the following formula will be used.

A = B X (0.9/2000) x (D – E)

Where: A = adjustment for membrane placed during the index period
B = square yards of membrane placed during the index period
D = average index price at the beginning of the period
E = average index price at the time of bid

109.15.4.2 Optional. This provision is optional. If the bidder wishes to be bound by the provision, the bidder shall execute the acceptance form in the Bid for Polymer Modified Emulsion Membrane (UBAWS). Failure by the bidder to execute the acceptance form will be interpreted to mean election not to participate in the Polymer Modified Emulsion Membrane Price Index (UBAWS).

109.16 Fixed Cost Items. The following fixed prices shall be used when referenced in the specifications:

Sec	Item No.	Item of Work	Unit	Fixed Price
201.4.3	201-30.00	Clearing and Grubbing	Acre	$3,500.00
203.9.4	203-20.00	Class C Excavation ≤ 500 cy	cy	$75.00

206.6.2	206-36.00	Supplemental Foundation Test Holes	ft	$6.00
206.6.3.1	206-10.03	Class 1 Excavation in Rock	cy	$120.00
206.6.3.2	206-20.03	Class 2 Excavation in Rock	cy	$170.00
206.6.3.3	206-31.00	Class 3 Excavation in Rock	cy	$85.00
206.6.3.4	206-34.00	Class 4 Excavation in Rock	cy	$85.00
214.5.1.2	214-20.00	Furnishing Rock Fill	cy	$15.00
303.5.1.2	303-06.00	Furnishing Rock Base Material	sy	$10.00
401.14	401-05.00	Sample of Compacted Plant Mix Bituminous Pavement	Each	$75.00
403.23.2	403-05.00	Sample of Compacted Asphaltic Concrete Pavement	Each	$75.00
611.30.5.1	611-30.10	Furnishing Type 1 Rock Blanket	cy	$24.00
	611-30.20	Furnishing Type 2 Rock Blanket	cy	$25.00
701.7.7	701-15.00	Concrete Coring	lf	$100.00
703.5.1	**Concrete Fill > 2 cy**			
	703-20.02	Class B Concrete (Misc)	cy	$500.00
703.5.1	**Concrete Fill < 2 cy**			
	703-20.02	Class B Concrete (Misc)	cy	$750.00
704.6	706-10.00	Reinforcing Steel	lb	$2.00

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SECTION 110
STATE AND FEDERAL WAGE RATES AND OTHER REQUIREMENTS

110.1 Wage Rates. The contractor will be required to pay either the state or federal prevailing hourly wage rate for any craft or type of worker required to perform the work, except when expressly provided by the contract documents. State wage rates, information on the required federal aid provisions, and the current federal wage rates are available on MoDOT's web site. Applicable federal wage rates will be posted on MoDOT's web site ten days before the bid opening. These supplemental bidding documents have important legal consequences. It shall be conclusively presumed that the documents applicable to the contract are in the bidder's possession and have been reviewed and used by the bidder in the preparation of any bid submitted on a project.

110.2 Federal-Aid Projects. If the federal government is participating in the cost of construction of the project, all applicable federal laws, and the regulations made pursuant to such laws, will be applicable to and become part of the contract, shall be observed by the contractor, and the work will be subject to the inspection of the appropriate federal agency in accordance with Sec 105.10. Contracts with federal-aid will require payment of the prevailing hourly wage rate for each craft or type of work required to execute the contract as determined by the Missouri Department of Labor and Industrial Relations, and will require adherence to a schedule of minimum wages as determined by the U.S. Department of Labor. For work performed anywhere on the project, the contractor and the subcontractors shall pay the higher of these two applicable wage rates.

110.3 Prevailing Wages and Records. The prevailing state wage rate, overtime and fringe benefits for the locality of the work as determined by the Missouri Department of Labor and Industrial Relations, or by a court decision on appeal, will be contained in the contract. The effective date for the current wage rate, overtime and fringe benefits, for bidding purposes, will be in the bid documents by special provision. The contractor and all subcontractors shall pay no less than the prevailing wage rate, overtime and fringe benefits as specified or as same may be changed by a court decision on appeal, for all work performed under the contract. Per 290.250 RSMo., the contractor shall forfeit a penalty up to $100 per day per worker for each worker that is paid less than the prevailing rate for any work done under the contract by the contractor or any subcontractor as determined by the Missouri Department of Labor.

110.3.1 The contractor is advised that the prevailing wage rate, overtime and fringe benefits are subject to change during the life of the contract by court decision. No such change shall be the basis for adjustment in the contract price.

110.3.2 The contractor and each subcontractor shall keep an accurate record showing the names and occupation of all workers employed by the contractor, including the actual wages, overtime and fringe benefits paid to each worker. The record shall be open to inspection at all reasonable hours by the representatives of the Department of Labor and Industrial Relations of Missouri or the Commission. The contractor shall submit certified copies of payrolls to the engineer each week.

110.3.3 Subsistence Deductions. The contractor shall comply with all applicable federal and state laws for employee payroll deductions for subsistence and as specified herein:

(a) The contractor shall provide to the engineer a copy of the employee-signed agreement for each employee that agrees to a subsistence deduction prior to that employee beginning work on the project. If the employee does not speak English, such agreement shall be written in his/her native language.

(b) The contractor shall document each purpose (food, lodging, travel etc.) and amount of all subsistence deductions and provide documentation in support of each deduction to the engineer.

(c) The subsistence deductions shall serve the convenience and interest of the employee. No profit or other benefit shall otherwise be obtained, directly or indirectly, by the contractor or subcontractor or any affiliated person in the form of commission, dividend or otherwise.

110.4 Work Performed in Adjoining States. When a project requires work to be performed in both the State of Missouri and a bordering state, the contractor will be required to pay the applicable prevailing hourly rate of wage for the site of the work. The contractor shall determine which rates are applicable, and shall pay the greater of any conflicting wage rates. Additional information on obtaining wage rates and federal wage rates for the bordering state will be contained in the contract.

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SECTION 201
CLEARING AND GRUBBING

201.1 Description. This work shall consist of clearing, grubbing, removing and disposing of items, debris and other objectionable matter from within the limits of right of way and easement areas, except vegetation designated to remain or to be selectively treated.

201.2 Construction Requirements.

201.2.1 General. The engineer will designate all trees, shrubs, plants and other objects that are to remain. All designated items shall be preserved. Any damage to natural terrain, vegetation or objects designated to remain shall be repaired or replaced, as determined by the engineer, at the contractor's expense.

201.2.2 Clearing and Grubbing. Unless otherwise specified in the contract documents, the entire length of the project shall be cleared and grubbed to the limits and requirements specified. Clearing and grubbing shall include removal of all trees, stumps, roots and any objectionable matter resting on or protruding through the surface of the original ground, except for those items designated to remain.

201.2.2.1 Clearing. The area for clearing shall be within the following limits:

(a) Highway construction areas on the right of way or right of way easements, including structures, frontage roads, streets, ramps, approaches, ditches, channels and all other access roads, connections and incidental items that are to be constructed. These areas shall extend 10 feet outside of construction lines, or to the right of way limits if less than 10 feet.

(b) Material sites within the right of way or right of way easements.

(c) Areas enclosed by interchange loops and ramps.

(d) Site distance areas for intersecting routes.

201.2.2.2 Limits of Grubbing. Within the limits of the cut areas, grubbing shall be performed to a minimum depth of 18 inches below the finished earth grade of roadways, ditches, channels, borrows and structures. The areas below the natural ground surface shall be grubbed to a depth necessary to remove all stumps, roots, buried logs and other objectionable material. In embankment areas, undisturbed stumps and roots extending no more than 6 inches above the ground line may remain, provided the stumps and roots are a minimum of 4 feet below the finished earth grade. Except in areas to be excavated, holes created by removals shall be backfilled with suitable material and compacted to the approximate density of the adjacent area.

201.2.2.3 Selective Clearing and Grubbing. All areas outside the limits designated for clearing and grubbing, but on the right of way, shall be free of unsightly vegetation, debris and other objectionable matter. In lieu of grubbing, undisturbed stumps outside the slope stake limits and in mowable areas may be cut to a maximum height of 3 inches above the ground. Low hanging, unsound or unsightly branches on trees or shrubs designated to remain shall be removed as directed by the engineer.

201.2.3 Scalping. The contractor shall scalp all areas where excavation or embankment is to be performed, except mowed or burned over sod may remain where the embankment to be constructed is at least 4 feet above natural ground. Scalping shall include the removal of surface material such as sod, grass, residue of agricultural crops, sawdust and any other vegetative matter without removing more earth than is necessary.

201.2.4 National Forest Land. Before beginning work on a highway to be constructed over national forest land, the contractor shall obtain information from the forest ranger in charge to determine rules and regulations covering construction procedures and shall follow those requirements. Before any fires are set, the contractor shall notify the forest ranger in charge, and shall secure a burning permit.

201.2.5 Removal and Disposal of Material. The contractor shall dispose of all trees, stumps, brush, roots and all other objectionable matter removed in the clearing and grubbing process.

201.2.5.1 Open Burning. The contractor shall not be allowed to conduct open burning except for small quantities as approved by the engineer or as described in the contract. In lieu of open burning the contractor

shall make efforts to harvest marketable timber, utilize mulched timber for erosion control and utilized excess mulch for composting. Open burning in incorporated areas will be permitted only under a permit or waiver from MDNR. The contractor shall obtain all necessary permits and approvals before open burning is initiated, and shall comply with permit conditions, MDNR regulations, and all laws in accordance with Sec 107. A contractor representative shall be present during all burning. Measures shall be taken to ensure that structures or vegetation on adjacent property, or items designated to remain on the right of way, shall not be jeopardized. Fires set for the purpose of training fire fighters and industrial employees in fire fighting methods may be permitted after coordination with MDNR or local fire departments, and shall be in strict accordance with NFPA standards.

201.2.5.2 Disposal of Wood. Burial of stumps and debris will not be permitted on the right of way. Products of clearing and grubbing may be removed from the right of way and disposed of out of sight from the roadway, provided there is no conflict with governing regulations for the wasted material. A signed, written agreement with the property owner shall be submitted by the contractor to the engineer prior to the disposal of material on that property.

201.2.5.3 Disposal of Scalping. The products of scalping shall be deposited at the toe of embankments where such areas are available within the limits of the roadway balance affected. If such areas are not available, the products shall be neatly and uniformly deposited on the right of way in such a manner that no drainage will be blocked.

201.2.5.4 Disposal of Timber. Except in national forest areas, all timber that has not been removed from the right of way prior to construction and is not designated to remain in place shall become the property of the contractor.

201.3 Method of Measurement. The work provided herein will not be measured for payment, but will be considered a plan quantity. The following exceptions will be made on a measured quantity basis:

(a) An authorized change in the line or grade, or appreciable deviations in the original ground elevations in accordance with Sec 203.8.1, significantly alters the original construction limits of the contract.

(b) Authorized alterations or corrections to the plans provide additional work outside the original construction limits of the contract and will materially affect the final payment quantity.

(c) Appreciable errors within the original limits of construction, if the contractor provides written notification, and measurements of the proposed change to the engineer prior to commencing clearing operations. The engineer will accept or reject the changes by the close of the next business day.

201.3.1 If payment for additional work is required, a combined measurement of clearing and grubbing will be made on an area basis to the nearest 1/10 acre . An acre will consist of 87.12 units, each unit being a rectangular area 50 feet long and 10 feet wide.

201.3.2 The total area of the right of way, except that part secured for channel changes, inlet or outlet easements, and borrow areas will be laid out in units beginning at the centerline of the highway with corners at whole or half stations and extending outward until all of the right of way has been included. The total area of the right of way secured for channel changes, inlet or outlet easements, and borrow areas will be laid out in units in the same manner from longitudinal base lines run or designated for these areas.

201.3.3 Clearing and grubbing will be considered as one item. If additional clearing or grubbing is required, the entire unit will be counted for measurement. Areas of mowing or scalping, removal of small trees or brush 5 feet high or less, and all weeds, cornstalks and similar vegetation regardless of height, and the trimming of branches on trees and shrubs designated to remain, will not be measured and will be considered incidental to other required work. Only stumps 3 inches or more in diameter and 6 inches or more above the ground surface in areas where grubbing is required will be considered in the measurement of clearing and grubbing.

201.3.4 If any clearing or grubbing is performed within any unit, the entire area of that unit, except in the case of overlaps, will be included in the measurement. If individual trees or stumps, cause the overlapping of units as laid out, only one unit of clearing and grubbing, as applicable, will be allowed. If a fractional unit occurs as a result of measurement or of overlap, the fractional unit will be counted as one unit. If the boundary line of any unit intersects a single tree or stump, counting of another applicable unit will not be made if there is any clearing

and grubbing to be paid for in the adjacent unit.

201.4 Basis of Payment.

201.4.1 Clearing and grubbing will be paid for at the contract unit price based on plan quantity.

201.4.2 If a bid item for clearing and grubbing is not included in the contract, any necessary clearing and grubbing, including scalping, selective clearing and the removal and disposal of all the resulting material required within the contract items specified, will be considered incidental to the contract and additional compensation will not be made.

201.4.3 If additional clearing and grubbing in accordance with Sec 201.3 is required outside the initial contract work, payment for that clearing and grubbing will be made per acre at the contract unit price, or if separate payment for clearing and grubbing is not included in the contract, payment will be made in accordance with Sec 109.

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SECTION 202
REMOVAL OF ROADWAYS AND BUILDINGS

202.1 Description. This work shall consist of the removal and disposal of all existing improvements from the right of way and within the limits of any construction area outside the right of way, except improvements designated or permitted to remain in place or to be removed under other items of work. These specifications will apply to all removal work performed by the contractor.

202.2 General Requirements.

202.2.1 Containment and Disposal of Material. All abrasives used in blasting activities shall be collected using a containment system or enclosure to prevent the release of material to the environment. All improvements not designated to remain shall be removed or disposed of by the contractor as required. The work may involve the generation of excess material, which may be solid waste under the definitions of the MDNR Solid Waste Management Program. The contractor shall dispose of solid waste in accordance with the Missouri Solid Waste Management Law and implementing regulations, 10 CSR 80.

202.2.1.1 Regulated solid waste, including waste tires, shall be handled, transported and disposed of in accordance with applicable regulations. Documentary proof of proper transport and disposal of this waste, including transport forms, disposal forms, scale tickets, cancelled checks and receipts, shall be provided to MDNR and to the engineer prior to acceptance of the work.

202.2.1.2 Material designated for use elsewhere shall not be removed from the project. Open burning of material shall be conducted in accordance with Sec 201.2.5.1. Uncontaminated underground storage facilities not requiring removal shall be dewatered, filled with sand or grout to within one foot of the top of the facility, and crushed.

202.2.2 Damaged Items. Any item damaged by the contractor's operations that is designated to remain in place, to be used elsewhere, or to be used by the public or an adjoining property owner, shall be repaired or replaced at the contractor's expense, in a manner satisfactory to the engineer in accordance with Sec 107.12.

202.2.3 Dust and Emissions Control. All operations during demolition and removal shall be adequately controlled to prevent dust and visible emissions, unless otherwise approved by the engineer. All measures taken shall be provided by the contractor at the contractor's expense unless specified otherwise.

202.2.4 Salvage. All material designated in the contract to be salvaged for Commission use from existing structures or improvements shall be removed without damage, in sections that may be readily handled, transported and stored as approved by the engineer. Unless otherwise designated in the contract, all coldmilled material, existing guardrail, and guard cable material designated for removal shall become the property of the contractor. All buildings, material and equipment of any description not designated for salvage by the Commission shall become the property of the contractor, unless owned and claimed by a political subdivision or utility company. Salvaged material becoming the property of the contractor shall not be stored on the right of way, nor shall any portion of the right of way or land owned by the Commission be used by the contractor as a place of sale for salvaged material.

202.3 Construction Requirements.

202.3.1 Disposal of Material.

202.3.1.1 Clean fill, including uncontaminated soil, rock, sand, gravel, concrete, minimal amounts of wood, metal and inert solids, as approved by rule or policy by MDNR's Solid Waste Management Program, will not be regulated. These materials will not be considered solid waste, and may be disposed of without prior approval from MDNR's Solid Waste Management Program.

202.3.1.2 Material that is not clean fill by definition shall be disposed of in accordance with MDNR's or local regulations, and the contractor shall provide appropriate documentation, i.e. landfill receipts or a private owner waiver letter or statement from MDNR, that the disposal complies with applicable laws or regulations.

202.3.2 Removal Requirements. Removal of pavement, curb, gutter, sidewalk and other similar improvements, and where a portion of such improvements are to be left in place, shall be to an existing joint or to a joint sawed

full depth. Sufficient removal shall be made to provide for proper grades and connections in the new work regardless of removal limits shown on the plans.

202.3.2.1 Removal of concrete or bituminous material shall consist of breaking up and disposing of the material in areas furnished at the contractor's expense, within a basement excavation where approved backfill material over 24 inches deep is to be placed over such broken material, or within embankments where new embankment over 24 inches is to be placed over the broken material. If concrete or bituminous slabs are to be left within an embankment or basement, the slabs shall be broken into pieces not exceeding 4 square feet . At locations shown on the plans where piling is to be driven, existing pavement, sidewalks, footings, foundations, walls and all other types of removal items shall be completely removed for a sufficient distance to permit piles to be driven. Existing improvements not removed in their entirety shall be removed to a minimum depth of 12 inches below the finished grade section or natural ground. All reinforcing steel extending from concrete shall be removed to the exposed face prior to placement within water or on exposed ground surfaces.

202.3.2.2 The contractor shall remove slabs on grade more than 6 inches higher than existing street or alley grades or surrounding low grades. All other aboveground concrete and masonry improvements, fences, posts and other structures on the parcel shall be removed to adjacent surface grades. For any location on the plans designated as a bridge site, the contractor shall remove all basement and foundation walls, footings, floors, and any other incidental masonry construction prior to backfilling. All material from such removals meeting the requirements of clean fill shall be disposed of as directed by the engineer. All other material shall be disposed of off site at the contractor's expense.

202.3.2.3 All sidewalk slabs over basements, areaways, and all beams, fixtures and supports shall be removed except slabs that are part of the public sidewalks adjacent to structures being demolished. The contractor shall not remove coal hole covers, trap doors, sidewalk doors, gratings and similar appurtenances that occur in the public sidewalk adjacent to buildings being demolished.

202.3.2.4 The contractor shall leave in place any walls or structures that retain adjacent property to ensure lateral support to that property. Any wall perpendicular to and connected to the said wall or structure shall remain in place and connected to the wall for a distance at least one-half the height of the wall. The slope of the top of the perpendicular wall shall be 1:2 or flatter, sloping downward from the top of the wall or structure.

202.3.3 Sewers and Drains. All sewers, drainage pipes and floor drains that have been or are to be abandoned shall be permanently sealed at the ends with a minimum 8-inch thick bulkhead constructed of Class B concrete, a commercial mix concrete in accordance with Sec 501.15 or brick masonry. The use of salvaged brick will be permitted for constructing bulkheads, provided the brick is clean and sound.

202.3.4 Backfill. All trenches, holes and pits resulting from the removal of improvements, contaminated material, soil, tanks and piping shall be backfilled and graded to shape and finish disturbed areas. Backfilling shall be performed in accordance with applicable portions of Sec 203 and compacted in accordance with Sec 203.5 unless otherwise designated by the engineer. Material shall be placed in the same manner and compacted to the same density required in adjoining areas and shall be done in such a manner as to ensure proper drainage.

202.3.4.1 Backfill material may consist of previously stockpiled uncontaminated soil or may be obtained from the right of way if approved by the engineer. Only approved material free of trees, stumps, rubbish and any other deleterious material shall be used in the construction of backfills. Rock, broken concrete or other solid material shall not be placed in bridge fill areas. No slope shall be steeper than 2:1 . Broken masonry resulting from demolition of buildings or other improvements on the parcel may be used for backfill provided the masonry meets the requirements of clean fill. In no case shall broken masonry extend closer than 12 inches to the finished surface. In the event there is insufficient material in the immediate vicinity, the contractor shall provide material, at the contractor's expense, from a source obtained by the contractor and approved by the engineer in accordance with Sec 106.

202.3.4.2 All trees, shrubs or other vegetation within the limits of the contractor's backfilling operations shall be removed and disposed of in accordance with Sec 201.

202.3.5 Hazardous Material.

202.3.5.1 The contractor may encounter small quantities of hazardous material as defined by MDNR. This material shall be recycled or disposed of in a manner that maintains the material's qualifications as "small

quantities" in accordance with MDNR regulations.

202.3.5.2 In the event the contractor encounters what is reasonably suspected to be large quantities of hazardous material, the contractor shall immediately cease work and notify the engineer in accordance with the contract requirements. If the engineer determines the suspect material is not hazardous or does not constitute a large quantity of hazardous material, the contractor will be notified to continue the work. If the engineer determines the suspect material is hazardous or constitutes a large quantity of hazardous material, the engineer may require the contractor to perform work necessary to abate the hazardous material.

202.4 Basis of Payment. The accepted removal of improvements will be paid for at the contract lump sum price. If no lump sum unit for the removal of improvements is included in the contract, the removal of improvements required to complete the contract, or as directed by the engineer, will be considered incidental to the work and no direct payment for the removal will be made. If additional removals are encountered as described in Sec 202.30, payment will be accordance with Sec 104.3.

202.4.1 No direct payment will be made for the following work:

(a) Removal and disposal of abandoned fences and mailboxes.

(b) Sealing abandoned sewers, drainage pipes or floor drains.

(c) Removal and disposal of small quantities of hazardous material.

202.4.2 Payment for any additional work required for hazardous material abatement will be handled in accordance with Sec 104.3.

SECTION 202.10 PLUGGING AND CLOSURE OF WELLS.

202.10.1 Description. This work shall consist of plugging and closing wells as shown on the plans or as directed by the engineer.

202.10.2 Conformance Requirements. The contractor shall notify the engineer at least 24 hours in advance of the contractor's intent to plug the well. The contractor shall be in possession of a valid MDNR permit for well or pump installation. The abandonment procedure for wells shall be in accordance with requirements in specific MDNR regulations for monitoring wells, heat pump wells, test holes or all other wells, as applicable. A copy of the completed closed well registration shall be furnished to the engineer.

202.10.3 Basis of Payment. The accepted quantity of plugged and closed wells will be paid for at the contract unit price per each. Payment will be considered full compensation for all labor, equipment and material for plugging and closing, and the costs and fees associated with closed well registration.

SECTION 202.20 SEPTIC TANK PLUGGING AND DISPOSAL.

202.20.1 Description. This work shall consist of plugging and disposing of septic tanks shown on the plans or as directed by the engineer.

202.20.2 Conformance Requirements. The contractor shall notify the engineer at least 24 hours in advance of the contractor's intent to plug and dispose of the septic tank. Septic tanks shall be abandoned by pumping the septic tank, collapsing the top of the tank, plugging incoming and outgoing laterals, and breaking the bottom to permit drainage. The tank trench shall be backfilled with coarse gravel or rock, agricultural lime, or sand to a depth of 2 feet below the existing ground surface. The top 2 feet shall be backfilled with soil from the parcel and compacted in 6-inch lifts to the approximate density of the adjacent soil. In the event there is insufficient material in the immediate vicinity, the contractor shall provide material meeting the approval of the engineer, at the contractor's expense. All material pumped from septic tanks shall be properly disposed of at a permitted sewage treatment facility or other location approved by the engineer.

202.20.3 Basis of Payment. The accepted quantity of septic tanks, plugged and disposed of, will be paid for at the contract unit price per each. Payment will be considered full compensation for disposal of tank contents, permits, labor, equipment and material to complete the described work.

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SECTION 202.30 REMOVAL OF IMPROVEMENTS FOR ROADWAY CONTRACTS.

202.30.1 Description. This work shall consist of removing and disposing of all existing improvements for roadway contracts from the right of way and within the limits of any construction easement outside the right of way, except improvements designated to remain in place or to be removed under other items of work.

202.30.1.1 Removal of improvements shall include removing all drainage structures, pavement, surfacing and base courses, curb, gutter, sidewalks, house walks, steps, retaining walls, foundation walls, columns, footings, concrete floors, cisterns, catch basins, uncontaminated storage tanks, manholes, drainage and sewer pipes, water and gas main pipes, signs, fences, scattered or piled bricks, stones, broken masonry, rubbish, debris, outdoor advertising signs, etc., from existing improvements.

202.30.1.2 The plans may not show a complete list of all items to be removed. There may be an undetermined number of abandoned utilities, basement or foundation walls, columns, footings or other improvements encountered. The contractor shall determine the extent of the work to be performed under this item.

202.30.2 Method of Measurement. This work will not be measured for payment, but will be considered a lump sum unit. The work will include the removal of all items, regardless of whether the items are shown on the plans or encountered during construction, unless the presence of the improvement encountered could not have been determined by a visual inspection prior to bidding. No deductions will be made from the quantities measured for payment of excavation where existing improvements are removed from within the limits of the sections measured for determining pay quantities of excavation.

202.30.3 Basis of Payment. Accepted removal of improvements will be paid for at the contract lump sum price. If no lump sum unit for the removal of improvements is included in the contract, the removal of improvements required to complete the contract, or as directed by the engineer, will be considered incidental to the work and no direct payment for the removal will be made. If additional removals are encountered as described in Sec 202.30.2, payment will be made in accordance with Sec 104.3.

SECTION 202.40 DEMOLITION AND REMOVAL OF BUILDINGS.

202.40.1 Description. This work shall consist of demolishing, removing and disposing of all existing buildings from the right of way or within the limits of any construction easement outside the right of way as shown on the plans. Removal of buildings shall include all attached structures, existing rubbish, trash and contents in and adjacent to the building on each parcel.

202.40.1.1 Notification of Demolition. The contractor shall provide proper notification to all appropriate federal, state and local agencies prior to demolition. Notification is necessary for the demolition of a building, bridge or bridge deck regardless of whether asbestos is present. The notification procedures and forms are available from MDNR. The contractor shall provide copies of all completed and approved forms to the engineer prior to any demolition work.

202.40.2 Schedule. The contractor shall submit a plan and schedule for demolition and removal of any designated improvements, asbestos containing material (ACM), buildings, contaminated material, and storage tanks on the parcel. Prior to the start of removals, the contractor shall obtain approval from the engineer for all schedules and plans. The work shall be performed in accordance with the approved plan and schedule unless otherwise approved by the engineer. The contractor shall complete all demolition, removal and disposal of buildings, other than ACM removal, within seven days after starting work on the building, unless otherwise approved by the engineer.

202.40.3 Demolition and Removal General Requirements.

202.40.3.1 Backfilling. Backfilling operations for residential basements shall be completed within four days after residential buildings are removed. Backfilling operations for commercial basements shall be completed within 14 days after commercial buildings are
removed in accordance with the demolition and removal work schedule required in Sec 202.40.2.

202.40.3.2 Site Maintenance. All parcels included with each notice to remove shall be maintained by the contractor and kept in a safe and clean condition until acceptance of the work by the engineer. All access to the

interior of buildings located on a parcel for which a notice to remove has been issued shall be closed up and secured or otherwise covered such that the public cannot enter the buildings.

202.40.3.3 Utilities. Before beginning demolition, the contractor shall arrange for the disconnection of utilities to buildings to be demolished in accordance with the regulations of the utility concerned. The contractor shall take measures to prevent any material from entering storm and sanitary sewers. In the event that utility service lines are disrupted and utility service is needed, the contractor shall provide adequate substitute utility service, at the contractor's expense.

202.40.3.4 Site Security. Before starting demolition for each parcel, the contractor shall provide adequate security around buildings to be demolished to protect the public and workers from operating equipment and falling debris, and to block access to any situation that constitutes a hazard to the public

202.40.4 Removal of Asbestos Containing Material. Unless designated otherwise, the Commission will test all buildings or structures to be removed for ACM. Testing of buildings will be limited to ACM. Buildings will not be tested for other substances. The Commission disclaims any representation that the buildings are hazard-free. If ACM is present in a building or structure, the ACM shall be removed and disposed of by the contractor accordance with the contract documents. All regulated asbestos containing material (RACM), as defined in Sec 202.40.4.5, and Category I nonfriable ACM on concrete shall be removed from the buildings prior to demolition or salvage. Category II nonfriable ACM that does not have a high probability of becoming crumbled, pulverized or reduced to powder in the course of demolition, and Category I nonfriable ACM, except floor tile or sheeting on concrete, may remain in the building during demolition. All building demolition material, including the Category II nonfriable ACM and Category I nonfriable ACM, shall be disposed of in a licensed landfill. The contractor shall not crumble, pulverize or reduce to powder Category II nonfriable ACM and shall not cut, grind, sand, abrade or render the Category I nonfriable ACM friable during demolition and transportation to the licensed landfill. If the contractor elects to remove and dispose of Category II nonfriable ACM and Category I nonfriable ACM prior to demolition, disposal shall be performed properly and at the contractor’s expense.

202.40.4.1 Asbestos Identification and Testing. Suspect ACM will be sampled and tested. The results of the testing for friable and nonfriable ACM requiring removal will be made available to the contractor or included within the contract documents. For those buildings with unknown quantities at the time of award, results of testing for friable and nonfriable ACM requiring removal will be provided with the notice to remove.

202.40.4.2 Licensing and Permits. The contractor performing friable asbestos abatement in accordance with the regulations shall be registered with MDNR and certified as an asbestos contractor with the agency. Before beginning work on any parcel, the contractor shall provide the engineer with copies of all permits, licenses and certifications in accordance with local, state, or federal agencies.

202.40.4.3 Notification and Reporting. The contractor shall provide all information regarding asbestos abatement to the EPA, OSHA, MDNR and local agencies in accordance with applicable regulations concerning asbestos removal work. Notification shall be provided by the contractor to all applicable regulating agencies for all asbestos removal before removal and demolition begins. The contractor shall obtain any necessary authorization for the work from all applicable federal, state and local agencies. The contractor shall provide copies of all reports and authorization information to the engineer prior to beginning work on the project.

202.40.4.4 On-Site Supervisor. The contractor shall provide a trained supervisor to remain on site during all ACM removal work in accordance with EPA regulations. The contractor shall provide evidence of the supervisor's training to the engineer before any work begins.

202.40.4.5 Regulated Asbestos Containing Material and Category I Nonfriable Asbestos Containing Material on Concrete. The contractor shall remove, transfer and dispose of RACM and Category I nonfriable ACM (floor tile and sheeting on concrete) specified in the contract. The following material will be considered RACM:

(a) Friable asbestos material.

(b) Category I nonfriable ACM that has become friable.

(c) Category I nonfriable ACM that will be or has been subjected to sanding, grinding, cutting or abrading.

(d) Category II nonfriable ACM that has a high probability of becoming or has become crumbled, pulverized or reduced to powder by the forces expected to act on the material in the course of demolition.

202.40.4.6 Unidentified Asbestos. If the contractor encounters suspect ACM not previously identified in the contract, the contractor shall immediately notify the engineer in accordance with the contract requirements. The engineer will have the suspect material sampled and tested, and the contractor shall not remove the additional suspect ACM until directed by the engineer.

202.40.4.7 No Salvage Permitted. No salvage of items containing asbestos material will be permitted.

202.40.4.8 Airborne Asbestos Particle Testing. The contractor shall monitor and test for airborne asbestos particles during working hours within the area of the property or fence line. The contractor shall conduct operations to keep airborne particles beyond this area within the established regulation limits. The contractor shall furnish the engineer copies of correspondence, test results, recommendations and other information to document contractor's compliance with the following requirements:

(a) When asbestos removal is completed, all work shall be inspected by the contractor for the presence of asbestos debris. Removal and cleaning shall continue until air monitoring clearance testing indicates the level of airborne fibers meets required levels. The engineer shall be notified when sampling is started. The contractor shall provide documentation to the engineer within 24 hours after the sampling has been completed that the level of airborne fibers meets required levels.

(b) For asbestos abatement projects requiring third party air monitoring as determined by the engineer, the contractor shall cooperate and coordinate with the engineer and the third party air sampler designated by the engineer to perform the third party air sampling. The contractor shall provide to the engineer a minimum of 48 hours notice of the time when the services of the third party air sampler will be required as a result of the contractor's work. The contractor shall arrange work so as not to interfere with the third party air sampler's ability to conduct the necessary air sampling. The contractor and the third party air sampler shall work cooperatively with the engineer in a sequence such that air sampling shall be conducted in a proper and timely manner by the third party air sampler with minimal interruption to any other party.

202.40.4. 9 Disposal. All RACM and Category I nonfriable ACM shall be disposed of within seven days of removal from the building or structure. All RACM and ACM shall be disposed in accordance with applicable EPA, OSHA, MDNR and local agencies' regulations.

202.40.4.9.1 The contractor shall identify or mark hauling vehicles used to transport asbestos waste during loading, transporting and unloading in accordance with applicable regulations for transporting asbestos waste. The waste shall be transported in enclosed roll-offs or dumpsters, vehicles that have completely enclosed cargo areas, or a four-sided cargo area that shall be completely covered with two layers of 6-mil thick plastic sheeting or equivalent covering while the waste is being transported.

202.40.4.9.2 The contractor shall provide a Waste Shipment Record to the waste site owner or operator at the time the waste is delivered to the waste disposal site. A copy of the Waste Shipment Record shall be provided to the engineer.

202.40.5 Removal of Buildings. Removal of buildings shall include all attached structures. Under no circumstances shall the contractor burn, grind, pulverize or otherwise reduce any portion of the building into fine particles without prior approval from the engineer. Any buildings or portion thereof located on the parcel may be removed intact or substantially intact subject to the contractor's adherence to the following conditions:

(a) The contractor shall declare, in writing, the intention to move any building or substantial portion thereof to any other location. Such declarations shall be made within 30 days of the issuance of the notice to remove for the building. The contractor shall submit a separate declaration for each building.

(b) The name of the house mover or house moving company shall be included in the declaration. The engineer reserves the right to disapprove a house mover or house moving company with no prior performance record or based on unsatisfactory performance on previous moving jobs. Conditional

approval may be given at the discretion of the engineer for previously disapproved house movers or house moving companies for one building at a time.

(c) No building or portion thereof shall be removed from the parcel until the contractor has received written approval from the engineer and other authority having jurisdiction over the area involved in the total move by issuance of the proper permits.

(d) The contractor shall commence the removal of buildings promptly. Buildings removed shall not be placed on other portions of state right of way for storage or for any other purpose, except as specifically allowed by issuance of an overdimension permit from the Commission

(e) Interim storage of buildings for resale or any other purpose will be limited to areas where zoning allows for such storage. No public lands or right of way shall be used unless a permit is granted by the responsible agency.

(f) The contractor shall remove all components of the building to the foundation level, including those components suspended from the main level subfloor structure. The primary components of the building shall be removed intact as a whole structure. The contractor will not be paid for ACM removal from these structures unless required from the disturbance of the foundation or on the remaining foundation components after building removal, as determined by the engineer.

202.40.5.1 Demolition of Walls. All exterior walls shall be removed to the level of existing adjacent ground, streets, alleys or sidewalks. Interior walls shall be removed to the level of existing basement floors.

202.40.5.1.1 Where joint or party walls exist between two buildings that are not being demolished at the same time, the part of wall or walls serving both buildings shall be removed with the demolition of the last structure. No demolition work shall damage or weaken walls or portions of walls serving adjacent buildings.

202.40.5.1.2 Remaining portions of party walls shall be left in sound condition with demolition terminating in neat vertical and horizontal lines. Care shall be taken to ensure demolition without damage to roofs or other parts of adjoining buildings.

202.40.5.2 Removal of Flooring. Floor construction over basements, sub-basements or cellars, and all other floors regardless of elevation, shall be removed. All existing wood and other material attached to concrete and masonry construction shall be removed.

202.40.5.3 Disposal of Debris. The contractor shall remove any debris resulting from demolition as work progresses and dispose of the material in a licensed landfill.

202.40.5.4 Cooling Systems. Buildings to be demolished may have various cooling systems that contain freon or other refrigerants. The contractor shall identify the type of refrigerant present in each system and properly recover the refrigerant prior to salvage or demolition of the cooling systems.

202.40.6 Removal of Appurtenances. Removal and disposal shall include all existing building appurtenances on each parcel in the demolition and removal contracts from the right of way and within the limits of any construction easement outside the right of way, except those items designated to remain in place or to be removed under other items of work.

202.40.6.1 All elevated sidewalks, steps, retaining walls, basement and foundation walls, columns, footings, concrete floors, cisterns, catch basins, uncontaminated storage tanks, manholes, signs, fences, bricks, stones, broken masonry, rubbish, debris and any other items not covered elsewhere in Sec 202 will be considered building appurtenances.

202.40.6.2 The plans may not show a complete list of all items to be removed. There may be an undetermined number of basement or foundation walls, columns, footings or other improvements encountered. The contractor shall determine the extent of the work to be performed under this item.

202.40.7 Method of Measurement.

202.40.7.1 Final measurement of removal for ACM will be made to the nearest square foot or linear foot based

on the asbestos survey test report.

202.40.7.2 Measurement for demolition and removal of buildings and appurtenances will be considered a lump sum unit per parcel.

202.40.8 Basis of Payment.

202.40.8.1 Payment for removal of ACM will be made for field-measured quantities as approved by the engineer at the contract unit price. If additional suspect material tests positive for the presence of asbestos, payment will be made per the contract unit price. No direct payment will be made for recovering refrigerant.

202.40.8.2 Payment for demolition and removal of buildings and appurtenances will be made at the contract lump sum unit price per parcel.

SECTION 202.50 REMOVAL OF CONTAMINATED MATERIAL AND STORAGE TANKS.

202.50.1 Description. This work shall consist of removing and disposing of designated residual material, pavement, pump islands, all storage tanks and piping; excavation and disposal of uncontaminated and contaminated soil as required; obtaining the necessary regulatory permits; backfilling the excavated areas with uncontaminated soil after clean up levels have been achieved; and any incidental work or material required to complete the job.

202.50.2 Schedule. The contractor shall submit a plan and schedule for demolition and removal of any designated storage tanks on the parcel and shall obtain the engineer's approval prior to starting work. The work shall be performed in accordance with the approved plan and schedule unless otherwise approved by the engineer.

202.50.3 Removal Requirements.

202.50.3.1 Site Inspection. The contractor shall inspect and become familiar with the proposed work site, conditions and circumstances.

202.50.3.2 Conformance Requirements. Work shall be performed in accordance with industry recommended practices, including the American Petroleum Institute (API) Recommended Practices, and MDNR Underground Storage Tanks (UST) Closure Guidance (Closure Guidance).

202.50.3.3 Groundwater Monitoring Wells. The contractor shall protect all existing groundwater monitoring wells located within the area of underground storage tanks from damage and contamination, except for wells in an area of contaminated soil removal.

202.50.3.4 Tank Vapor Levels. Vapor levels in each tank shall be checked for explosive potential prior to removing the tank or piping. Non-sparking tools shall be used for gaining access to the tank atmosphere in order to measure the vapor level. If the explosive level is above 20 percent of the lower explosive limit, flammable vapors shall be removed in accordance with methods outlined by API Recommended Practices until the 20 percent level is reached. The contractor shall purge vapors from a vent pipe. Gasoline tanks shall not be purged during adverse weather conditions where vapors could accumulate at ground level and cause a public health or fire hazard.

202.50.3.5 Tank Dewatering and Removal. The contractor shall notify the engineer prior dewatering and removing storage tanks.

202.50.3.6 Residual Material. The contractor shall remove and dispose of all residual material in the tanks or drums on the site identified as being a regulated quantity of hazardous waste material. All product, sludge, and water in contact with the interior of a petroleum UST will be presumed to be hazardous waste, unless sample test results reporting the requirements of the Toxicity Characteristic Final Rule prove otherwise. Hazardous waste material shall be transported by a hazardous waste transporter licensed in the State of Missouri and manifested as hazardous waste to a Resource Conservation and Recovery Act (RCRA) treatment, storage or disposal facility. The generator's copy of the manifest shall be submitted to the engineer. The material in tanks or drums identified as being non-hazardous shall be managed properly.

202.50.3.7 Tank Pit Surface Water. Tank pits on the site may contain contaminated surface water or groundwater. The contractor shall remove, transport and dispose of all contaminated water from the tank pit at an appropriate treatment, storage or disposal facility.

202.50.3.8 Soil Excavation. Soil excavation shall be performed by the contractor to segregate contaminated soil from uncontaminated soil. Contaminated soil shall be excavated to the limits directed by the engineer. The contractor shall use calibrated field instrumentation approved by the engineer to evaluate approximate levels of contamination remaining in the unexcavated soil.

202.50.3.9 Hauling and Disposal of Contaminated Soil. Contaminated soil shall be hauled from the site and disposed of in a licensed landfill, or as directed by the engineer. Disposal of contaminated soil shall be in accordance with the Closure Guidance. The contractor shall provide the engineer with a copy of a completed MDNR form entitled Disposal of Soil Contaminated With Virgin Gasoline or Virgin Fuel Oil.

202.50.3.10 Use of Uncontaminated Soil. Uncontaminated soil may be reused as backfill at locations approved by the engineer.

202.50.3.11 Water Accumulated in Excavation. If stormwater accumulates in the excavated area and requires removal prior to backfilling, the contractor shall obtain an MDNR storm water discharge permit or approval to discharge accumulated water into a sewer system. Disposal of water removed from the excavated area will be at the contractor's expense.

202.50.3.12 Sample Analysis. The contractor's work will be regulated as follows:

(a) The contractor shall sample and analyze residual material, tank pit surface water or groundwater, and any stormwater that accumulates in the excavated area as necessary for proper disposal.

(b) The contractor shall provide the engineer with the name, location and testing requirements of the disposal facility for the contaminated material.

(c) The engineer will sample and analyze all soil prior to disposal; prior to beneficial reuse if beneficial reuse is designated in the contract; and prior to backfilling. Sampling and analysis will be done in accordance with the Closure Guidance and requirements of the Missouri Petroleum Storage Tank Insurance Fund.

(d) The engineer will obtain samples beneath the tank, down-gradient and around pumps and lines in accordance with the Closure Guidance.

(e) The engineer will determine if remaining soil requires excavation and when clean up levels have been achieved.

202.50.3.13 Backfill. The contractor shall not begin backfilling operations until directed by the engineer.

202.50.3.14 Closure Report. The contractor shall provide copies of all necessary documentation for tank cleaning and disposal, and soil, sludge and wastewater disposal to the engineer. Documentation shall be in accordance with the Closure Guidance and the Missouri Petroleum Storage Tank Insurance Fund. The engineer will prepare the underground storage tank closure report in accordance with the Closure Guidance.

202.50.4 Method of Measurement. Measurement of tank removal and disposal will be made per each; residual hazardous material removal and disposal will be measured per gallon; tank pit surface water removal and disposal will be measured per 10 gallons; and hauling and disposing of contaminated soil will be measured per ton based on landfill weight tickets. Measurement of excavation and backfill will be made to the nearest cubic yard, measured from the actual excavation limits to the existing surrounding ground line. A deduction equal to the volume of the tanks removed will be made from the volume measured for payment of contaminated soil excavation when existing tanks are removed from within the limits of the sections measured for determining pay volumes of excavation.

202.50.5 Basis of Payment.

202.50.5.1 The accepted quantities for removal and disposal of storage tanks will be paid for at the contract unit

price per each.

202.50.5.2 The accepted quantity of hazardous residual material will be paid for at the contract unit price. Payment will be considered full compensation for sampling and analysis, removal of the material, appropriate containerization and labeling, transportation and treatment or disposal. Payment will not be made until the engineer receives a Certification of Treatment or Disposal for all material from the RCRA treatment, storage or disposal facility.

202.50.5.3 The accepted quantity of tank pit surface water and groundwater removal and disposal will be paid for at the contract unit price. Payment will be considered full compensation for all sampling and analysis, transportation, disposal fees, and processing of approvals.

202.50.5.4 The accepted quantity for excavation of contaminated soil will be paid for at the contract unit price.

202.50.5.5 The accepted quantity for hauling contaminated soil will be paid for at the contract unit price, based on landfill weight tickets. Payment will be considered full compensation for removal from the site and transportation for treatment or disposal.

202.50.5.6 The accepted quantity for disposal of contaminated soil will be paid for at the contract unit price, based on landfill weight tickets. Payment will be considered full compensation for all landfill fees and processing of landfill approvals.

202.50.5.7 The accepted quantity for backfill will be paid for at the contract unit price and will be considered full compensation for material, transportation and compaction.

SECTION 202.60 INDIVIDUAL WASTEWATER LAGOON CLOSURES.

202.60.1 Description. This work shall consist of dewatering, sludge removal or treatment, and grading of individual residential wastewater lagoons as shown on the plans or as directed by the engineer.

202.60.2 Construction Requirements. The contractor shall notify the engineer at least 24 hours in advance of the contractor's intent to dewater by pumping and apply to a vegetated area approved by the engineer at a rate that will not cause runoff. Residual sludge remaining in the lagoon shall be mixed with soil on at least a one to one ratio. Lagoon berms shall be demolished and compacted over the lagoon bottom to the approximate density of the adjacent soil. The contractor shall provide material meeting the approval of the engineer to backfill the lagoon to the surrounding ground surface. Material required to backfill the lagoon will be considered incidental to the work. If material is available in the immediate vicinity of the lagoon, the engineer may authorize using on-site material. Disturbed areas shall be fertilized, seeded and mulched. All material pumped from the lagoon shall be properly disposed of at a sewage treatment facility unless otherwise directed by the engineer.

202.60.3 Method of Measurement. Measurement of individual residential wastewater lagoon closures will be made per each.

202.60.4 Basis of Payment. The accepted quantity of residential wastewater lagoon closures will be paid for at the contract unit price. Payment will be considered full compensation for removal, disposal of lagoon contents, required backfill material, seeding, fertilizing and mulching, permits, labor, equipment and material to complete the described work.

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SECTION 203
ROADWAY AND DRAINAGE EXCAVATION, EMBANKMENT AND COMPACTION

203.1 Description. This work shall consist of excavating, disposing of or compacting all material encountered within the limits of the work not being removed under some other item. This work shall be performed in accordance with the specifications and as shown on the plans, or directed by the engineer. All excavation will be classified as hereafter described.

203.2 Classification of Excavation.

203.2.1 Class A Excavation will consist of all roadway and drainage excavation not classified as Class C or Unclassified. Shale, fire clay, chert broken by intermittent clayey partings or clay seams (joint flint rock), stratified chert cemented with clay seams (hardpan), and plain or bituminous-bound bases or surface courses of macadam, gravel, broken stone or similar material will be considered as Class A Excavation, not Class C Excavation.

203.2.2 Class C Excavation will consist of the removal of stone, including sandstone or igneous formations, in ledges 6 inches thick or more. Laboratory analysis will be made, if necessary, to aid in the determination. A ledge will be considered to be a continuous deposit of rock that may or may not include thin, interbedded seams of soft material or shale. The vertical limits of each ledge will be determined by beds of soft material or shale greater than 24 inches thick. The beds of soft material or shale will be included in the measurement of Class A Excavation, unless the material falls within the vertical limits identified by Sec 203.8.2.3. Boulders or other detached stones, each having a volume of 2 1/2 cubic yards or more, will be considered Class C Excavation.

203.2.3 Unclassified Excavation will consist of the excavation of all material not classified within the contract.

203.3 Borrow.

203.3.1 Borrow will consist of approved material required for the construction of embankment or for other portions of the work, and shall be obtained either from borrow areas shown on the plans or from areas designated or approved by the engineer. The contractor shall notify the engineer sufficiently in advance of opening any borrow areas so the necessary cross sections or measurements may be taken. Borrow will be classified in the same manner as roadway excavation.

203.3.2 Borrow areas proposed by the contractor, other than those shown on the plans or designated by the engineer, may be approved, provided:

(a) The material and area are equally satisfactory.

(b) The final cost to the Commission, including the cost of easements, is not greater than the cost as originally designated.

(c) The substitution is in the best interest of the Commission.

(d) Proper environmental clearances have been obtained for use of any alternate borrow sites, with the exception of permitted quarries and other locations that have already obtained environmental clearances in accordance with Sec 203.3.2.5.

(e) The contractor has obtained appropriate land disturbance permits from MDNR in advance of excavation, unless the site is already under permit by MDNR.

203.3.2.1 Proposed sites for contractor furnished material will be sampled and tested only after award of the contract, and after a copy of the written agreement between the property owner and the contractor authorizing use of any borrow site and access has been provided to the engineer. The agreement shall include provisions for the final condition of the borrow site and access.

203.3.2.2 The preliminary subsurface investigations to determine depth to rock, general soil characteristics, etc., shall be the sole responsibility of the bidder or contractor.

203.3.2.3 The engineer shall be notified in writing sufficiently in advance of the proposed use of a borrow site to

allow six weeks for sampling under the direction of the engineer for testing.

203.3.2.4 The contractor shall furnish equipment suitable for the purpose of soil sampling, and shall make all necessary arrangements for performing the work at a time mutually agreeable to the contractor and the engineer.

203.3.2.5 Environmental clearances under applicable federal and state laws and regulations will include, but are not limited to the following: Clean Water Act (COE and MDNR), the Endangered Species Act (USFW and MDC), the National Historic Preservation Act (SHPO), the Farmland Protection Act (NRCS), Resource Conservation and Recovery Act (MDNR), Comprehensive Environmental Response (MDNR), Compensation, and Liability Act (MDNR) and RSMo Chapter 194, Section 194.400 Unmarked Human Burial Sites (SHPO). Certification shall be obtained in advance of the proposed use of a borrow site and furnished to the engineer. Certification shall include clearance letters and other evidence of coordination from the appropriate regulatory agencies as attachments. Guidelines for obtaining environmental clearances for contractor furnished borrow sites may be obtained from the project contact as designated in the contract proposal.

203.3.2.6 After borrow material has been removed, the borrow site and access shall be finished in accordance with the agreement of the property owner.

203.4 Construction Requirements.

203.4.1 General. Prior to beginning excavation and embankment operations in any area, all necessary clearing, grubbing and stripping in that area shall have been performed. The excavation and embankment for roadway, intersections and entrances shall be made to the designated alignment, grade and cross section. Sideslopes, cuts and fills shall be finished to a reasonably smooth and uniform surface that will merge with the adjacent terrain without variations readily discernible from the road. Finishing by hand methods will not be required, except that all brush, weeds, excess mud and silt, or other debris shall be removed from culverts and channels within the scope of the work in accordance with Sec 104.11.2, even if such structures are used in place. Areas disturbed by the contractor outside the limits of construction shall be restored at the contractor's expense to a condition similar to that prior to construction operations.

203.4.1.1 Field Stone. Before final project acceptance, all loose field stone greater than 4 inches in size within the limits of the right of way shall be disposed of as directed by the engineer.

203.4.1.2 Shoulders. Earth shoulders shall be constructed of suitable material to the grade and cross section shown on the plans and shall be compacted in accordance with Sec 203.5. The construction of shoulders shall start when sufficient surfacing has been completed and the surfacing has attained satisfactory strength to permit continuous shouldering operations. Equipment that will damage the surfacing will be prohibited from operating on the surfacing during shouldering operations. Surfacing and curbs shall be protected where equipment is crossing or turning.

203.4.1.3 Grading for Aggregate Type Surface Roadway. If a roadway to receive an aggregate-type surface is specified in the contract, reasonable tolerance in alignment, grade and cross section will be permitted. A reasonable tolerance in alignment will be defined as a maximum gradual deviation of 2 feet , free from sharp breaks, made in the interest of economy and to take advantage of favorable topography. A reasonable tolerance in grade will be defined as a final grade that is uniform in appearance, free from sharp breaks or humps, and within 6 inches of plan grade if such tolerance results in economy to the Commission. Economy to the Commission will not refer to each individual cut, but to the entire project after due consideration has been given to the need of the material removed from cuts that are below grade and to the compensating feature of cuts that are left above grade. Loose rock on the finished subgrade over 2 inches in size shall be removed, picked up and disposed of as directed by the engineer.

203.4.2 Maintenance. During construction, the roadway shall be maintained by the contractor in such a condition that the roadway will be passable and well-drained at all times. Roadway ditches, channel changes, inlet and outlet ditches, and any other ditches in connection with the roadway shall be cut and maintained to the required cross section. All drainage work shall be performed in proper sequence with other operations. All ditches and channels shall be kept free of debris or obstructions. All material resulting from slides shall be removed and disposed of as directed by the engineer.

203.4.3 Removal of Oversize Material in Subgrade. The engineer may order the contractor to remove oversize material if the upper 4 inches of the subgrade, as tentatively completed, contains loose rock over 2

inches in size to make the subgrade unacceptable as a roadbed for the proposed type of surfacing in the judgment of the engineer.

203.4.4 Excavating in Rock. Excavating and undergrading in rock, that is material in accordance with the description of Class C, whether the contract calls for classified or unclassified excavation, shall be performed in a manner to produce material of such size as to permit placement in embankments in accordance with the requirements. Rock shall be removed to the limits of undergrading insofar as practical and in such manner as to leave no undrained depressions in the cut. Care shall be taken to avoid overshooting when blasting. Any loose or shattered rock, overhanging ledges and boulders above the roadbed that might dislodge shall be removed. If the contract provides a specific use for rock from roadway excavation, the work shall be performed in such order and manner as may be necessary to ensure that the desired quantity of such material may be placed as required.

203.4.4.1 Blasting Requirements. Reporting for all blasting shall be made in accordance with Sec 107.7.

203.4.4.1.1 The contractor shall submit a rock excavation blasting plan to the engineer at least 14 days before drilling operations begin. The blasting plan shall address all trenching, presplitting and production shots, and shall include, but is not limited to the following information: powder factor per cubic yard , hole size, subdrill, stemming depth, drill pattern, type of explosives and detonators, and safety precautions. A preblast survey will be required on all uncontrolled structures within 500 feet of planned blasting operations. A separate blasting plan will be required on all locations requiring blasting within 50 feet of any roadway structure. Any changes to blasting plans shall be provided to the engineer for review prior to performing the work.

203.4.4.1.2 The contractor shall not exceed blasting holes larger than 4 inches in diameter. The powder factor shall be between 0.60 to 1.35 pounds per cubic yard except for presplitting or trenching. If stemming ejection becomes a problem, crushed stone stemmings shall be used. Subdrill shall be no more than 30 percent of burden. The contractor shall not drill within a radius equal to the depth of the cut of a loaded borehole. Seismic monitoring will be required when the scaled distance is less than 65 , where the scaled distance equals the distance, in feet , divided by the square root of explosive weight, in pounds, per 8-millisecond delay.

203.4.4.1.3 The contractor shall perform the excavation of rock cuts by the technique of presplitting, cushion blasting or air decking to produce a neat line of the proposed excavation, with the results subject to the approval of the engineer. Holes for presplitting shall be drilled to the full depth of the cut or to a pre-selected bench elevation as shown on the plans or as determined by the engineer. Presplitting shall be done according to accepted practice to produce a clean face on the excavated cut. Presplit shots shall be made prior to production shots. Production holes shall not be drilled any closer to the presplit line than 12 times the diameter of the production blast hole.

203.4.4.2 Undergrading. Regardless of whether the contract includes paving, the final surface for the backfilled undergraded areas shall be of a uniform texture and grade suitable to the engineer for paving.

203.4.4.2.1 Unless specified otherwise, the final surface shall be substantially free of exposed rock exceeding the 2 inch size that would interfere with the final preparation of the base for paving. Areas of required undergrading, except where an aggregate-type surface is specified, shall be backfilled with one of the following material, with preference in the order given, depending on availability:

(a) The top approximately 2 inches of the rock backfill shall consist of either rock fragments or spalls or a 2-inch granular-type material having a plasticity index not exceeding 10, and a gradation such that at least 50 percent of the material will be retained on the No. 4 sieve.

(b) A 2-inch maximum size granular-type material having a plasticity index not exceeding 10, and a gradation such that at least 50 percent of the material will be retained on the No. 4 sieve.

(c) A material having a low plasticity index and designated by the engineer as suitable. No material shall exceed 2 inches in size.

203.4.4.2.2 If a roadway to receive an aggregate type surface is specified in the contract, undergraded areas shall be backfilled with material obtained from roadway excavation, and the upper 6 inches shall be free of granular material larger than 4 inches.

203.4.4.3 Overbreak. Overbreak resulting from blasting rock below the limits of undergrading shall be

removed and backfilled with spalls or rock fragments at the contractor's expense. If spalls are not available and if the contractor does not elect to use rock fragments, the use of either of the following will be satisfactory.

(a) Material in accordance with Sec 1007.

(b) A granular-type material with a plasticity index not exceeding 10, and a gradation such that at least 50 percent of the material will be retained on the No. 4 sieve.

203.4.5 Unsuitable Material. Where excavation to the finished graded section results in a subgrade or slopes of unsuitable material, the engineer may require the contractor to remove the unsuitable material, and backfill to the finished graded section with approved material. The contractor shall conduct the operations in such a manner that the engineer may make the necessary measurements before the backfill is placed.

203.4.6 Borrow. Borrow material shall not be placed until after material from roadway excavation has been placed in the embankment, except as otherwise approved by the engineer. The contractor shall not excavate beyond the dimensions and elevations established, and no material shall be removed prior to staking and cross sectioning the site. If the contractor places more borrow than required, thereby causing a waste of excavation, such waste will be deducted from the borrow volume as measured in the borrow area. All borrow areas shall be bladed and left in such a shape as to permit taking the necessary cross sections after excavating has been completed. The finished borrow areas shall be approximately true to line and grade if so specified in the contract, and shall be finished, where practical, such that no water will collect or stand therein. If it is necessary to remove fencing in order to obtain borrow material, the fencing shall be replaced in as good condition as the fencing was at the time of removal. The contractor shall be responsible for confining livestock when a portion of the fence is removed. Removing and replacing such a fence or the confining of livestock shall be at the contractor's expense.

203.4.7 Roadway Obliteration. If obliteration of existing roadways or temporary construction is designated in the contract to be performed on a roadway excavation basis, such obliteration shall include all operations necessary to fill the ditches and blend the old road with the natural ground to provide a pleasing appearance. Removal of concrete pavement and concrete base course will be paid for in accordance with Sec 202.30. The earthwork for obliteration, including bituminous surfacing, will be included as roadway excavation.

203.4.8 Human, Criminal, Historical, Archaeological or Geological Remains. If any human remains, or archaeological artifacts that may be of historical, archaeological or geological significance such as arrowheads, pottery, stone tools, animal bones, or fossils, are encountered during construction, the contractor shall stop all work within a 50-foot buffer around the human remains and/or artifacts, and then shall notify the MoDOT resident engineer or construction inspector. The contractor shall maintain the 50-foot minimum buffer until otherwise directed by the Engineer.

203.4.8.1 In the case of human remains, MoDOT HP staff will notify the local law enforcement and the State Historic Preservation Office (SHPO) as per state law. If the contractor is unable to contact appropriate MoDOT staff, the contractor shall initiate this involvement by local law enforcement and the SHPO. In this instance, a description of the contractor's actions shall be promptly made to MoDOT.

203.4.8.2 In the case of archaeological artifacts, MoDOT HP will contact the appropriate staff at the Federal Highway Administration (FHWA) and the SHPO to report the discovery after a preliminary evaluation of the artifacts is made and reasonable efforts to see if the findings represent an archaeological site which can be avoided. If MoDOT determines that the site/artifact is significant and will be adversely affected by the contract work, MoDOT HP will immediately notify the FHWA and SHPO of this finding and provide recommendations to minimize and/or mitigate the adverse effect.

203.4.8.3 If a temporary suspension of work under this section lasts for an unreasonable period of time, as defined in Sec 108.15.1, and the suspension results in an actual increase in the time or cost of performance of the contract, then this condition will be deemed a suspension of the work directed by the engineer under Sec 108.15 and will be handled in accordance with that section.

203.4.9 Excavated Material Stockpile. During the process of excavating cuts, the engineer may order specific excavated material placed in stockpiles in order to have suitable material available to complete the upper portion of embankments and to backfill portions of undergraded cuts.

203.4.10 Embankment Construction. Embankment construction shall consist of constructing roadway embankments, including preparation of the area upon which the embankment is to be placed, constructing dikes and berms, placing and compacting approved material within roadway areas where unsuitable material has been removed, and placing and compacting embankment material in holes, pits and other depressions within the roadway area. Only approved material free of trees, stumps, rubbish and any other deleterious material shall be used in the construction of embankments and backfills. Rocks, broken concrete or other solid material shall not be placed in embankment areas where piling is to be placed or driven.

203.4.10.1 Embankments requiring surcharges, restricted loading rates, embankment control stakes or pore pressure measurement devices shall be constructed to the design template progressively for the full height. Failure of embankments or embankment foundations, or damage to structures that occurs when the contractor fails to observe restricted loading rates, or fails to construct slopes initially to the design template shall be repaired as directed by the engineer at the contractor's expense.

203.4.10.2 Construction of embankments shall not be started on foundation soil or partially completed embankments having more than 0.2 foot of frozen soil, nor shall embankment be built of frozen material. Frozen soil layers in partially completed embankments shall be at least 18 inches apart. No material shall be placed on frozen soil layers encountered within 12 inches of the top of the proposed grading section. Frozen material on foundation soil or partially completed embankment not meeting the above requirements shall be removed before placing material for the embankment. The removal of frozen material from the foundation of an embankment or from any layer of the embankment and the replacement with satisfactory material shall be at the contractor’s expense.

203.4.11 Embankment on Hillsides or Against Existing Embankment. Where embankment is to be placed on hillsides or where new embankment is to be constructed against existing embankments, existing slopes steeper than six horizontal to one vertical measured at a right angle to the roadway shall be continuously benched in no less than 12-inch rises over those areas as required, as the work is brought up in layers. Benching shall be of sufficient width to permit placing and compacting operations. Each horizontal cut shall begin at the intersection of the ground line and the vertical side of the previous bench. Existing slopes shall also be stepped to prevent any wedging action of the embankment against structures. The material thus cut out or compacted along with the new embankment material will be at the contractor’s expense.

203.4.12 Scalping. Scalping shall be performed in accordance with Sec 201.2.3. Where an embankment less than 4 feet high is to be constructed, all sod and vegetative material shall be removed from the surface upon which the embankment is to be placed, and the cleared surface completely broken up by plowing, scarifying or stepping to a minimum depth of 6 inches . This area shall be compacted in the same manner as that required for the embankment placed on the area. Sod not requiring removal shall be thoroughly disked before construction of embankment. Where an embankment less than 3 feet high is to be constructed over a compacted road surface containing bituminous or granular material, the old road surface shall be scarified to a depth of at least 6 inches . This scarified material shall be recompacted.

203.4.13 Embankment Against Existing Structures. If embankment is deposited on one side only of abutments, wingwalls, piers or culvert headwalls, care shall be taken that the area immediately adjacent to the structure is not compacted to the extent that the compaction will cause overturning of or excessive pressure against the structure. Equipment of such weight as may cause damage to culverts or other structures will not be permitted to work over or immediately adjacent to such structures. The embankment adjacent to the end bent of a bridge shall not be placed higher behind than in front of end bents until the superstructure is in place. If embankment is to be placed on both sides of a concrete wall or box-type structure, operations shall be conducted such that the embankment is kept at approximately the same elevation on each side.

203.4.14 Surcharged Embankments. Surcharged embankments shall be built in accordance with the plans and shall remain in place for such time as in accordance with the contract. The requirements for placing and compacting will be waived on the surcharge material above the specified compacted area.

203.4.15 Excess or Unsuitable Material. All excess or unsuitable excavated material, including rock and boulders that cannot be used in embankments, may be placed on the sideslopes of the nearest embankment in a satisfactory manner or shall be disposed of off the right of way in areas secured by the contractor. The contractor shall be responsible for compliance with all federal, state and local laws in the disposal of excess or unsuitable material. Rock or boulders greater than 24 inches shall not be used routinely in constructing sideslope embankments. A distinct shoulder line shall be maintained by keeping all such waste material at least

24 inches below the finished shoulder elevation, and specific density control will not be required.

203.4.16 Placement of Embankment. Roadway embankment shall be placed in layers not exceeding 8 inches , an uncompacted measurement, and shall be compacted as specified before the next layer is placed. The layers shall be placed approximately parallel to both the proposed profile grade and to the finished roadbed. Effective spreading equipment shall be used on each lift to obtain uniform thickness prior to compacting. Continuous leveling and manipulating will be required during compacting operations. Construction equipment shall be routed uniformly over the entire surface of each layer. Occasional rocks and boulders greater than 24 inches shall be dispersed to allow for uniform compaction between them.

203.4.16.1 Occasional stones or rock fragments exceeding the thickness of the 8-inch layer shall be disposed of by being incorporated into the embankment outside the limits of the proposed surfaced traffic lanes. The thickness of the layer in these areas may be increased if necessary to accommodate the stones, but shall not exceed 12 inches, an uncompacted measurement. The stones or rock fragments shall be placed such that there is no nesting.

203.4.16.2 Lifts may be increased to a maximum of 12 inches , an uncompacted measurement, for berms, filling of old channels, waste or similar areas, and any roadway or approach for which a granular-type surface is proposed. These areas shall be compacted by uniformly distributing all equipment movements over the entire area, and specific density control will not be required. Compaction performed in these areas will be at the contractor's expense.

203.4.17 Rock Embankment. If the excavated material consists predominantly of rock fragments of such a size that the material cannot be placed in layers of the prescribed thickness, such material shall be placed in the embankment in layers having a thickness of the approximate average size of the larger rocks but not exceeding 24 inches . Rocks or boulders too large to permit placing in a 24-inch layer shall be reduced in size as necessary to permit this placement. Rock shall not be dumped in place, but shall be distributed by blading or dozing in a manner to ensure proper placement in final position in the embankment. Construction equipment shall be routed uniformly over the entire surface of each layer. The spalls and smaller stone fragments shall be left on the surface of each layer as formed.

203.4.18 Rigid or Flexible Pavements. If the specified or proposed surfacing consists of a rigid or flexible-type pavement, the top consolidated rock layer for the full width between roadbed slopes shall be finished to the same limits as shown on the plans for undergrading in rock cuts. If rigid pavement is to be constructed without an aggregate base, the material requirements of Sec 203.4.4.2.1 (a) or (b) shall govern the construction of the area between the bottom of the pavement and the top of the top consolidated rock layer. Any embankment necessary outside the limits of the pavement shall be constructed of suitable earth or as otherwise specified in the contract.

203.5 Compaction of Embankment and Treatment of Cut Areas with Moisture and Density Control. AASHTO T 99, Method C, replacing any material retained on a 3/4-inch sieve, as provided therein, or MoDOT Test Method TM 40 will be used as the Standard Compaction Test for determining the moisture density relations of soils. The optimum moisture as determined by the Standard Compaction Test may be used as a guide in determining the proper moisture content at which each soil type should be compacted. Water shall be added or removed as necessary to permit obtaining the required density and moisture control. The field density of the embankment after compaction will be determined in accordance with AASHTO T 191 or T 205, using the total material or T 310, for wet density. The volume of the test hole may be reduced as necessary to accommodate available testing equipment. If nuclear density methods are used, moisture content will be determined in accordance with AASHTO T 239, except that a moisture correction factor will be determined for each soil in accordance with MoDOT Test Method TM 35. The calculated density obtained in a field density test will be compared with the maximum density as directed by the Standard Compaction Test to determine the percent of compaction attained.

203.5.1 Maximum Density Compaction Requirements. If payment of Compacting Embankment or Embankment in Place is specified as a contract pay item, compaction to at least 90 percent of maximum density, as determined by the Standard Compaction Test, will be required in the following areas:

(a) All roadway embankments except as otherwise provided in the following sections: Secs 203.4.14, 203.4.15, 203.4.16.2, 203.5.3, 203.5.4, 203.5.5 and 203.5.7

(b) All backfilled undergraded cuts, except as modified by Sec 203.5.3.

(c) Certain portions of the roadbed in cuts specified in Sec 203.5.8, except as modified in Sec 203.5.3.

203.5.2 Moisture Control. The moisture content of the soil at the time of compaction shall be as specified herein.

203.5.2.1 When necessary to eliminate a rubbery condition of the embankment, it may be required that some soils have a moisture content below the optimum during compacting work, except that Class A material having a liquid limit of 40 or more, where placed in embankments within 5 feet of the top of the finished subgrade or where encountered in areas of cut compaction, shall be compacted at no less than the optimum moisture content. The liquid limit determination will be in accordance with AASHTO T 89. Some Class A material, including heavy clays and material commonly known as shales and fireclays, shall require breaking down such that the moisture can be uniformly distributed.

203.5.2.2 Loessial soils shall have moisture controlled so as not to exceed optimum plus 3 percentage points when placed in embankments less than 30 feet high. When placed in embankments 30 feet high or more, such soils shall have moisture controlled such that the optimum moisture is not exceeded. If wet foundation conditions contribute to the embankment moisture while compacting, the engineer may waive this specified moisture content for a height not to exceed 3 feet above the embankment foundation. In the event of conflict of provisions of this section with provisions in Sec 203.5.2.1, Sec 203.5.2.1 shall govern.

203.5.3 Top Lift Thicknesses. The upper 18 inches of the earth subgrade extending the full width between roadbed slopes shall be compacted to at least 95 percent of maximum density.

203.5.4 Structure Approach. Roadway embankment within 100 feet of each end of a structure on which the top slab or deck is to be used as the riding surface and the spill fill under such a structure shall be compacted to no less than 95 percent of maximum density.

203.5.5 Rocky Fill. Density requirements will not apply to portions of embankments constructed of material so rocky that the embankment cannot be satisfactorily tested in accordance with AASHTO T 191 or T 205. Material of a gradation having more than approximately 20 percent retained on a 3/4-inch sieve will generally be considered too rocky for satisfactory density testing. In lieu thereof, the compactive effort on rocky material shall consist of making four complete passes on each layer with a tamping-type roller or two complete passes on each layer with a vibratory roller. The tamping-type roller shall have tampers or feet protruding no less than 6 inches from the surface of the drum and shall have a minimum load on each tamper of 250 psi of tamping area. The vibratory roller shall have a manufacturer's rating of 16 to 20 tons compacting power. During compaction, each layer shall have the moisture content controlled such that, in the judgment of the engineer, any silt and clay fraction is in a plastic state. Simple diagnostic tests to establish such a plastic state will include ability to indent with a thumb or heel or to roll a short thread of soil between the hands. Material that crumbles under pressure will be considered too dry.

203.5.6 Lift Consistency. Each layer shall be wetted or dried as necessary, and shall be compacted to the required density. Regardless of the type of equipment used, the roadway shall be compacted uniformly and the surface kept reasonably smooth at all times. If large pieces of heavy clay are encountered, the material shall be broken down by suitable manipulation to permit satisfactory embankment construction. If shale is encountered, the shale shall be broken down as much as practical and compacted at or above optimum moisture.

203.5.7 Deep Fills. Compaction to at least 95 percent of maximum density will be required for that portion of any embankment below an elevation 50 feet below the top of the finished subgrade. If, because of embankment foundation conditions, the 95 percent maximum density cannot be obtained after reasonable compactive effort has been expended, the engineer may waive the 95 percent requirement for a height not exceeding 3 feet above the embankment foundation.

203.5.8 Compacting in Cut. Cut compaction shall be performed in all Class A material areas and in all unclassified material areas that meet the requirements of Sec 203.2.2 after removal of the roadway excavation material to the required section. A surface parallel to the pavement slope, 12 inches below the bottom of the pavement or lowest base course, shall be temporarily exposed for the full width between roadway inslopes. The exposed material shall be manipulated and compacted to no less than the required density to a depth of 6 inches . The material above this compacted plane shall be spread in layers not exceeding 8-inch loose thickness, each

layer being wetted or dried as necessary and compacted to the specified density. The entire volume of material so handled and compacted, including the 6-inch layer compacted in place, will be considered as Compacting in Cut. All Class A material having a liquid limit of 40 or more, including the 6-inch layer compacted in place, shall be compacted at no less than the optimum moisture content.

203.5.8.1 Cut compaction shall be performed to an additional depth of 12 inches for 50 feet on each side of the intersection of the natural ground and the top of the subgrade, then uniformly graded for 30 feet to meet the depth requirements of Sec 203.5.8 and, if necessary, Sec 203.5.8.2.

203.5.8.2 The existing ground for the full width between roadway slopes under embankments less than 18 inches high shall be treated in accordance with Sec 203.5.8 to only such depth as to ensure having 18 inches of material of the required density and moisture below the top of the finished subgrade.

203.5.9 Field Laboratory. When authorized by the engineer, the contractor shall provide a Type 2 field laboratory in accordance with Sec 601.

203.6 Compaction of Embankment not Constructed with Density or Moisture and Density Control. If compaction of embankment is a requirement of the contract but has not been specified as a pay item, the compactive effort on each layer shall consist of distributing all equipment movements over the entire embankment area and of at least three complete passes with a tamping-type roller over the entire area to be compacted. The tamping-type roller shall have tampers or feet projecting no less than 6 inches from the surface of the drum and shall have a minimum load on each tamper of 250 psi of tamping area. Compactive efforts shall be continued, if necessary, until the tamping feet penetrate no more than 2 inches into the layer of material being compacted. Continuous leveling and manipulating will be required during compacting operations and the moisture content shall be adjusted as necessary, in the judgment of the engineer, to permit proper consolidation.

203.6.1 Dumping and rolling areas shall be kept separate, and no lift shall be covered by another until compaction complying with these requirements has been attained. Unstable areas in the embankment shall be removed and replaced with suitable material at the contractor's expense.

203.6.2 Each layer of embankment constructed of rock or rocky material shall also be compacted by three complete passes of the tamping-type roller. A vibratory roller may be used if approved by the engineer.

203.7 Compaction of Embankment Without Specified Compaction Results or Specified Compaction Equipment. If compaction of embankment is not designated by the contract, compaction will not be required other than that attained by distributing equipment movements over the entire embankment area.

203.8 Method Of Measurement.

203.8.1 Contract Quantity Payment. The quantities of excavation , compacting embankment, and embankment in place for which payment will be made will be those shown in the contract for the various items, provided the project is constructed essentially to the lines and grades shown on the plans. A partial check of existing ground elevations will be made at the time slope stakes are set, and of the finished work for deviations in the grade, width or slope from the authorized grade or typical section.

203.8.1.1 Final measurement will not be made of Class A Excavation, Unclassified Excavation , Compacting Embankment, and Embankment in Place except when:

(a) Appreciable errors are found in the original computations.

(b) An original cross section is found to have an average deviation from the true elevation in excess of one foot.

(c) An authorized change in grade, slope or typical section is made.

(d) Unauthorized deviations decrease the quantities on the plans.

(e) Class C excavation is encountered, unless the contract calls for unclassified excavation. If this condition is encountered, corrections or revisions will be computed and added to or deducted from the contract quantity.

(f) Quantities are determined by measurement as specified in Sec 203.8.2.

203.8.1.2 If the plans have been altered or when disagreement exists between the contractor and the engineer as to the accuracy of the plan quantities of any balance, or the entire project, either party has the right to request a recomputation of contract quantities of excavation within any area by written notice to the other party. The written notice will contain evidence that an error exists in the original groundline elevation or in the original computations that will materially affect the final payment quantity. If such final measurement will be required, measurement will be made from the latest available ground surface and the design section.

203.8.2 Measured Quantities. If payment of excavation is to be made on a measured quantity basis, volumes of authorized excavation will be computed from cross section measurements by the average end area method. When not attributable to carelessness of the contractor, slides in Class A Excavation and in Unclassified Excavation will be included in such measurements. Authorized excavation of rock, shale, muck or other unsuitable material will also be included.

203.8.2.1 Authorized excavation of rock, shale, muck or other unsuitable material below grade shall consist of that excavation necessary to provide the designated depth of undergrading. No measurement or payment will be made of any material removed and replaced below the design limits of undergrading. No measurement will be made for overbreak or for the disposal of the same if such material is obtained from outside the neat lines of the proposed backslopes in rock excavation, except that such overbreak will be measured as Class A Excavation or Unclassified Excavation, as applicable, when all suitable authorized excavation has been used and the overbreak material will be required for completion of the embankment. A maximum tolerance of one foot will be permitted for rock protruding or extending within the neat lines of the proposed backslopes.

203.8.2.2 While work involving classified excavation is in progress, the engineer will fix points of elevation and stationing as required to establish the lines of demarcation between material of different classification. These top points will be determined before any Class C, sandstone or igneous rock excavation is removed, and the contractor shall notify the engineer before removing any such material. Any excavation removed before the engineer has been notified and given 24 hours to establish lines of demarcation will be included in the measurement of Class A Excavation only.

203.8.2.3 Excavation may be encountered in which lines of demarcation between material of different classifications are impractical to establish. The quantity of material classified as other than Class A Excavation may be determined by the engineer on a percentage basis as the work progresses after the limits of determinate classification material have been established. Where vertical or near vertical excavation limits are indicated by the plans, all Class A Excavation material encountered within the actual Class C vertical excavation limits will be included with Class C Excavation quantities.

203.8.2.4 Measured quantities of excavation will be used where the ground elevations shown on the plans are found to be erroneous. No revision of contract quantities will be made if the actual ground elevations are considered to agree generally with the ground line shown on the plans. Where the engineer authorizes a change in grade, slope or typical section affecting the volume of excavation allowed for payment in that particular balance or area, the revised volume will be determined by the average end area method on the basis of the revised grade, slope or typical section. Where unauthorized deviations result in a decrease in the contract quantities, the deviations will be measured and deducted from the contract quantity.

203.8.2.5 The quantity of Class C Excavation will be computed on a measured quantity basis. The volume of Class A Excavation allowed for payment in roadway balances involving rock excavation will be determined by one of the following methods, whichever in the judgment of the engineer is more applicable:

(a) Measuring and computing both the Class A Excavation and the Class C Excavation within the limits affected or as defined by Sec 203.8.2.3.

(b) Deducting the volume of Class C, sandstone or igneous rock excavation from the total adjusted volume of roadway excavation, regardless of classification, within the limits affected or as defined by Sec 203.8.2.3.

203.8.2.6 Measurement will be made for unsuitable material actually excavated and removed to permit proper

compaction in cut sections and in foundations for embankment sections. No measurement will be made of the suitable material temporarily removed and replaced to facilitate compaction in cuts or under shallow embankments.

203.8.2.7 Borrow quantities will be determined by measuring the borrow area before and after excavating.

203.8.2.8 Excavated material stockpiled in accordance with Sec 203.4.9 will be measured in the stockpile by the average end area method.

203.8.2.9 Only that material placed in accordance with Sec 203.5 will be included in the measurement of Compacting Embankment and Embankment in Place. If an error has been found in the original computations or ground elevations, or if there has been an authorized change in grade, slope or typical section, the plan quantity for Compacting Embankment and Embankment in Place for those areas or balances affected will be adjusted for final payment. All required compaction above the original ground line and all compacting of material placed in undergraded cut sections will be considered as Compacting Embankment and Embankment in Place.

203.8.2.10 Compacting in cuts will be measured to the nearest 1/10 station along the centerline of each roadbed regardless of width, and will include any required compaction of the original ground under shallow embankments. For the purpose of measurement, a divided highway will be considered as having two roadbeds. Measurement of ramps will be made from or to the ramp's gore point. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

203.8.2.11 Measurement of roadway and drainage excavation, compacting embankments and embankments in place will be made to the nearest cubic yard .

203.9 Basis of Payment. Roadway and drainage excavation will be paid for at the contract unit price per cubic yard and will be considered full compensation for the following:

(a) Excavating.

(b) Hauling any distance.

(c) Placing and forming embankments.

(d) Preparation of subgrade.

(e) Shouldering, rounding slopes, obliterating existing roadbeds or temporary construction, finishing of graded earth roadway, picking up and disposing of field stone and other rock.

(f) Disposal of excess excavation.

(g) Any work noted on the plans to be included in the contract unit price for excavation.

203.9.1 No payment will be made for any material used for purposes other than those designated, except as approved by the engineer.

203.9.2 Payment will be made at the contract unit price per cubic yard for the applicable item of Class A Excavation or Unclassified Excavation for each handling of stockpiled excavation approved by the engineer.

203.9.3 No payment will be made for rock overbreak or for backfilling overbreak areas below the undergrading limits. Payment for the material for backfilling required undergraded areas will be made under an applicable excavation item. No direct payment will be made for backfilling around structures, the excavation for which has been paid for as roadway excavation.

203.9.4 If the contract does not contain a contract unit price for Class C Excavation and such material is encountered during construction, unless the project is let on an unclassified excavation basis, payment will be made per cubic yard at the fixed contract unit price specified in Sec 109, except that payment will be determined in accordance with Sec 109.4 when the quantity exceeds 500 cubic yards.

203.9.5 No direct payment will be made for water required in compaction work. Any costs involved in reducing the moisture content in soils will be at the contractor's expense.

203.9.6 Payment for finishing a graded earth roadway will be considered completely covered by the contract unit price for the various classes of excavation except as otherwise specifically noted under Sec 104.11.2 in regard to material excavated in cleaning channels and culverts used in place.

203.9.7 When removal of unsuitable material is directed by the engineer, the contractor will be reimbursed for excavation of the unsuitable material and the excavation of the suitable replacement material. Payment will be made for each operation at the contract unit price of Class A Excavation or Unclassified Excavation. Payment for placement of the suitable material will be paid for at the contract unit price of Compacting Embankment.

203.9.8 Embankment in Place will be paid for at the contract unit price per cubic yard , and will be considered full compensation for:

(a) Furnishing and transporting material from stockpile sites or from a contractor-provided source.

(b) Placing and forming embankments.

(c) Compacting embankment or for adding or reducing the water content of the embankment.

(d) Any excavation required to provide the embankment material included under the item of embankment in place, including mulching and seeding a borrow site.

(e) Any work noted on the plans to be included in the contract unit price for embankment in place.

203.9.9 Payment will be made at the contract unit price for each of the pay items included in the contract.

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SECTION 204
EMBANKMENT MONITORING

SECTION 204.10 SETTLEMENT GAUGES.

204.10.1 Description. This work shall consist of installing settlement gauges for the purpose of obtaining foundation settlement data during and following placement of embankment and surcharge construction. An estimated number of settlement gauges will be indicated in the contract. The exact number and locations will be determined by the engineer.

204.10.2 Material. A settlement gauge shall consist of the following:

(a) A plate with a galvanized riser pipe attached perpendicular to the center of the plate.

(b) Lengths, to be approved by the engineer, of 3/4-inch threaded galvanized riser pipe and couplings.

(c) Lengths, to be approved by the engineer, of galvanized 1 1/2-inch threaded pipe and couplings to act as a cover or guard for the riser pipe.

204.10.3 Construction Requirements.

204.10.3.1 The first section of the 3/4-inch pipe shall be firmly attached to the plate. The distance from the top of plate to the top of pipe will be accurately measured and recorded by the engineer.

204.10.3.2 An excavation, slightly larger than the plate, shall be made to a depth approximately 18 inches below the natural ground surface. Care shall be exercised during excavation to ensure that the bottom of the pit is level and that the material at this location is undisturbed. The pit bottom shall be covered with a layer of Portland cement mortar, approximately 3 inches thick, and the plate bedded therein in such position that the riser pipe is vertical. After the mortar has set, the cover pipe, cut approximately 6 inches shorter, shall be slipped over and centered around the riser pipe. The backfill shall then be placed in 6-inch layers and thoroughly compacted. The contractor shall notify the engineer when the installation is complete. No embankment shall be placed around the gauge until the elevation of the top of the riser has been determined by the engineer.

204.10.3.3 Embankment material in the immediate vicinity of the settlement gauge pipe shall be placed and compacted in accordance with Sec 726.3.4. When the elevation of the embankment reaches a level approximately one foot below the top of the cover pipe, the engineer shall be notified and the next section of riser pipe and cover pipe shall be installed in the engineer's presence. As the height of the embankment increases, this procedure shall be repeated until the embankment and surcharge is completed, and the pipe sections, both riser and cover, extend approximately 2 feet above the surface of the completed embankment and surcharge.

204.10.3.4 All necessary precautions shall be taken to keep the alignment of the riser pipe and cover pipe maintained in a vertical position at all times. The contractor shall operate equipment such that the settlement gauges are not damaged or displaced. Protective barriers shall be erected when directed by the engineer. Settlement gauges shall be maintained in a satisfactory operating condition until after placement of the embankment and surcharge and until, in the judgment of the engineer, the settlement readings are no longer necessary. Any damaged gauges shall be repaired or replaced by and at the contractor's expense.

204.10.3.5 The engineer will obtain and record all measurements and elevations necessary for accurate determination of settlement data during and after completion of embankment and surcharge.

204.10.4 Basis of Payment. Accepted settlement gauges, complete in place, will be paid for at the contract unit price. No direct payment will be made for any devices required to protect the gauges.

SECTION 204. 20 PORE PRESSURE MEASUREMENT DEVICES.

204.20.1 Description. This work shall consist of placing and maintaining pore pressure measurement devices as shown on the plans for obtaining foundation pore pressure measurements during the placement of embankment. Pore pressure measurement devices, locations, elevations and limits of embankment subject to control by each device will be shown on the plans.

204.20.2 Equipment. Pore pressure measuring devices shall consist of the following types:

(a) Type A. This device shall consist of a pneumatic transducer sealed within a sand chamber which is set into the foundation to the specified elevations.

(b) Type B. This device shall consist of a 1/2-inch PVC standpipe extending to the surface of the embankment from a sand chamber set into the foundation to the specified elevations.

204.20.2.1 The pneumatic transducer, jacketed tubing, and necessary pressurizing and gauging equipment for Type A installations will be furnished by the Commission without cost to the contractor upon two weeks written notice preceding the date of installation. The balance of the material for the Type A installation shall be furnished by the contractor. All material for the Type B installation shall be furnished by the contractor, except for the electrical sounding device.

204.20.3 Construction Requirements.

204.20.3.1 The contractor shall be responsible for the installation, furnishing all incidental material, providing all necessary protection of the installation, and replacement in the event of damage, including cost of any replacement equipment furnished by the Commission. In the event of damage to the installation, the engineer may require suspension of embankment construction in the controlled area until the contractor has restored the installation to satisfactory working order. No embankment may be placed until the installation is complete and tested to the satisfaction of the engineer.

204.20.3.2 A hole of no less than 5 inches or no more than 8 inches in diameter shall be drilled to Elevation "B" as shown on the plans. If necessary, casing shall be used to prevent sloughing of material from the walls of the hole and contamination of the walls or bottom of the hole by sloughed material. The outer diameter of the casing shall be no smaller than the diameter of the hole. The casing shall have no externally coupled joints in the bottom 10 feet.

204.20.3.3 If casing is required, the hole shall be washed to the bottom with clean water circulated through the bit until the discharge is clear. Clean sand shall then be poured into the hole to the approximate depth shown on the plans. The assembled pore pressure measurement device shall then be lowered to the device's indicated position with care to avoid contamination with soil from the side of the hole, and additional sand shall be placed around the device to Elevation "A" as shown on the plans. During these steps, any casing shall be pulled ahead of the backfill in increments of 6 to 24 inches as necessary to prevent collapse or sloughing of the hole. The hole shall be maintained full of clean water during these steps to at least the elevation of the top of the sand chamber. The creation of pockets of soil, air or voids in the sand backfill shall be avoided.

204.20.3.4 After sand is placed to the specified elevation, the hole shall be backfilled with wetted, plastic bentonite clay as the casing is withdrawn, for no less than 4 feet above the top of the sand filled chamber. If necessary, the clay shall be worked by hand into plastic balls to be dropped into the hole and tamped into a coherent mass. An acceptable alternate is the use of preformed dry bentonite pellets. In dry installation, dry granular bentonite may be tamped in place. The remainder of the hole shall be filled with a thick slurry of bentonite.

204.20.3.5 At natural ground level, or as otherwise directed by the engineer, four layers of 3/4-inch exterior grade plywood, 4 x 4 feet , nailed and clinched together with rustproof nails, and with a 3-inch diameter hole cut at the center shall be centered over the installation after the ground is smoothed and leveled with sand. A closet flange or other suitable receptacle shall be securely fastened to the plywood over the 3-inch diameter hole to securely receive a 5-foot length of 3-inch iron or steel casing. Earth or sand shall be compacted about the casing in 6-inch lifts with care to avoid misalignment after the engineer has established the elevation of the plywood slab and the top of the casing.

204.20.3.6 Upon completion, each installation shall be tested. Type A installations shall be tested in accordance with recommendations of the transducer manufacturer. Type B installations shall be tested by dropping a weighted line through the standpipe to check for possible obstructions. The standpipe shall then be filled with water and periodic readings made of the water level in the standpipe until the level of natural groundwater is reached. If less than a 70 percent drop in head is experienced in the first 24 hours, the standpipe shall be flushed and retested. Records of rate of head loss shall be kept for subsequent evaluation of possible time lags in the

response of water levels to embankment placement.

204.20.3.7 The engineer may require the installation of additional pore pressure measurement devices, at the contract unit price, within any area subject to control by such devices, at any time during construction of the embankment. The engineer will determine the type of device, location and elevation of additional installations. Any such additional pore pressure measurement devices shall govern the rate of construction in the same manner as the original devices. The reference pressure levels for additional devices shall be either that of the original devices or as determined from boreholes located outside the loaded area, as directed by the engineer.

204.20.4 Pore Pressure Measurements and Records.

204.20.4.1 The engineer will make and record all observations and measurements required to determine natural ground water pressures and pore water pressures induced by embankment construction. The pressure of the natural ground water existing at the time of installation and prior to placement of any embankment will be used as a reference to determine pore pressures induced by subsequent embankment placement. The engineer may subsequently require borings outside the loaded area to facilitate observations to determine if the natural groundwater table has lowered due to seasonal or climatic variations. Such observations may be used to lower, but not raise, the initial reference groundwater pressure.

204.20.4.2 The engineer will make all records of groundwater and pore water pressures readily available to the contractor for guidance in the planning of the contractor's work.

204.20.4.3 If foundation pore pressure, in excess of pressure from the natural water table, equals or exceeds 35 percent of the unit pressure of the embankment in place over the installation at any time, placement of embankment shall be immediately suspended. Construction shall not resume until such excess pressure declines to 25 percent of embankment pressure, unless otherwise authorized by the engineer.

204.20.4.4 After the embankment reaches an elevation equal to 60 percent of the maximum height, the contractor shall control the rate of construction in such a manner that foundation pore pressure, in excess of pressure from the natural water table, will not exceed 35 percent of the unit pressure of the embankment in place over the installation at any time. An example of pressure relationships follows: Soil embankment with an average wet density of 125 pounds per cubic foot is equal to twice the unit weight of water. A foot of such embankment thus has a potential to create, at most, 2 feet of water rise in a standpipe, or a 0.87 psi increase in a Type A installation. The contractor shall anticipate the maximum possible effect of any load to be added. Type B installations may exhibit some time lag in rate of response to a pressure increment. Records of pore pressure response during placement of the first 60 percent of embankment height shall be examined for evidence of such lag. The time required for dissipation of head during testing will also be indicative of the rate of response.

204.20.4.5 When embankment has advanced to within approximately one foot of the top of the casing, the casing and the 1/2-inch PVC pipe for the Type B installations, shall be advanced in 5-foot increments. No extension shall be made without the engineer's approval. PVC pipe extensions shall be made using solvent welded couplings exercising care to make smooth, squared cuts with all burrs removed, in accordance with recommendations of the pipe and solvent cement manufacturers. Pneumatic tubing leads used with Type A installations shall be long enough to permit extension, without connections, to the top of the embankment or surcharge. Excess tubing shall be stored in a steel container attached to the last casing extension as shown on the plans.

204.20.5 Settlement Records. The engineer will make and record all measurements and elevations necessary, including elevations of the plywood plate and all casing extensions, for use in establishing a settlement record at the site of the pore pressure measurement device. The 3-inch outer steel casing will be used for this purpose. Care shall be taken to ensure the tightest possible coupling connections, using pipe wrenches, without rotating the bottom pipe. Settlement records obtained in this manner may be used to satisfy such settlement rate requirements as may be outlined in the contract.

204.20.6 Basis of Payment.

204.20.6.1 The contract unit price shall include all effects, impacts and cumulative impacts of possible restraints inherent in the use of these devices upon the rate of construction. No additional compensation will be made for any impact, cumulative impacts, inefficiency or any costs incurred as a result of compliance with this requirement.

204.20.6.2 Accepted pore pressure measurement devices, complete in place, will be paid for at the contract unit price per each.

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SECTION 205
MODIFIED SUBGRADE

205.1 Description. This work shall consist of modifying a subgrade to improve stability. This work shall be performed as specified in the contract, at the contractor's option with concurrence from the engineer or at the direction of the engineer.

205.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows.

205.2.1 The modifying material shall be hydrated lime or other chemical material, a geogrid, a geotextile, or other material approved by the engineer.

205.2.1.1 If hydrated lime is used, the contractor shall furnish or require the supplier to furnish with each load certification that the product is in accordance with AASHTO M 216.

205.2.1.2 If chemical modifying material other than hydrated lime is used, the material and application plan shall be approved by the engineer prior to use.

205.2.2 If a geogrid or geotextile is used the product type and layout plan shall be approved by the engineer prior to use.

205.3 Construction Requirements.

205.3.1 Application.

205.3.1.1 If not directed by the engineer or specified in the contract, the contractor may determine the locations, amount of modifying material and depth of application, within the limits of this specification and subject to concurrence from the engineer.

205.3.1.2 Where performed, subgrade modification shall be done to all areas uniformly and laterally between outside shoulder points plus 18 inches on each side. When the chemically modified areas are stopped and started, there shall be a longitudinal transition zone at the rate of 30 feet per 6 inches of modified depth. The transition may be made by reducing modifying material or by mixing depth.

205.3.1.3 Chemical modifying material shall be spread in uniform and regular patterns. No material shall be applied if the material is being blown from the work area.

205.3.1.4 The application rate of the chemical modifying material shall be approved by the engineer.

205.3.2 Compaction. When chemically modified, the subgrade shall be uniformly mixed with the modifying material. Mixing and compaction shall continue until the subgrade is shown to have suitable compaction as demonstrated by the roller equipment. Density and moisture testing will ordinarily be waived for subgrade chemically modified under this specification, except that should compaction not be demonstrated to the engineer's satisfaction, the engineer reserves the right to run such tests as necessary to ensure density. When stabilized with a geogrid or geotextile, the subgrade will require recompaction to the specified density and moisture content only of it is disturbed by the goegrid or geotextile placement.

205.4 Method of Measurement. Measurement of modified subgrade will be made to the nearest square yard, including transition areas. Subgrade meeting all other requirements, suitable for the placing of base material and having modifying material incorporated as specified herein, will be paid for at the contract unit price per square yard except as noted herein.

205.5 Basis of Payment.

205.5.1 If included in the contract, payment for modified subgrade will be made per square yard of modified subgrade at the contract unit price. No direct payment will be made for the required modifying material.

205.5.2 If performed at the option of the contractor, payment for modified subgrade will be made at the invoiced material cost from the supplier, and no reimbursement will be made for incorporation or for processing.

205.5.3 If modified subgrade is not included in the contract and is directed by the engineer, payment will be made in accordance with Sec 104.3.

205.5.4 Reimbursement for transition areas will be made at the contract unit price per square yard for 1/2 the area of the transition.

205.5.5 Reimbursement will be limited to modified areas, the width of the pavement and shoulders, plus 18 inches on each side.

205.5.6 Only one payment for modified subgrade will be made for any area, regardless of the depth of stabilized material, number of applications or other circumstances.

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SECTION 206
EXCAVATION FOR STRUCTURES

206.1 Description. This work shall consist of the necessary excavation for the foundations of all structures, removal and disposal of all excavated material, backfilling around the completed structures, and all related work.

206.1.1 All removal work that might endanger the new structure shall be completed before any work on the new structure is started. Partial removals of any structure or adjustments to any utility shall be made with care to preserve the value of the retained portions. Work around any live utility shall be done in such a manner that uninterrupted service is maintained.

206.1.2 Excavated material that is unsuitable for backfill and embankments, and excess material not required for either, shall be disposed of. Excavated material shall not be dumped into the channel of a stream.

206.2 Depth of Excavation. The elevation of the bottoms of footings as shown on the plans shall be considered an approximate elevation, and the engineer by written order may make changes in plan elevations and dimensions of footings as necessary to secure a satisfactory foundation.

206.3 Foundation Stabilization and Tests.

206.3.1 The contractor shall furnish and place sand, rock, gravel or other suitable granular backfill material to replace unsuitable material encountered below box culvert slabs or below the foundation elevation of the structures.

206.3.2 The contractor shall stabilize suitable foundation material or form the bottom of pile footings, if necessary to obtain a stable foundation. The contractor shall assist in driving sounding rods or shall drill test holes to permit an adequate inspection of the foundation subgrade. The depth of the excavation, the character of the material and the condition of the foundation shall be approved by the engineer before any concrete is placed in the footing.

206.4 Construction Requirements.

206.4.1 Foundation Excavation Protection. Methods shall be used in excavating for foundations of structures that will ensure maintaining the stability of the material adjacent to the excavation. Sheeting, cribbing, timbering or bracing shall be placed by the contractor where indicated on the plans and wherever considered necessary. The contractor shall ensure the adequacy of all sheeting, cribbing, timbering or bracing used.

206.4.2 Foundation Key. Foundations for structures and retaining walls shall be free of loose material, and the footing shall be placed on undisturbed material. Footings shall be keyed no less than 6 inches into rock (limestone, dolomite or other suitable material with $q_u \geq 100$ ksf), and no less than 18 inches into weak rock (shale or other suitable material with 5 ksf $\leq q_u \leq$ 100 ksf)other suitable material specified for spread footings. Excavation in rock or weak rock for the key shall be made as near as practical to the size of the footing, or of the key, as shown on the plans. When placing the footing, the key portion shall be cast against the vertical, undisturbed face of the rock or weak rock. If side forms are necessary for footings, the forms shall be removed approximately 24 hours after placing the concrete, and the excavation immediately backfilled to the top of the footing. All cavities or crevices shall be cleaned out and filled with concrete in accordance with Sec 703.3.3.9, or spanned with a reinforced concrete beam, as directed by the engineer.

206.4.3 Foundation Subgrade. Care shall be taken to avoid disturbing the material below the bottom of the footings where the structure is founded on material other than rock, and final removal to grade shall not be made until just prior to placing concrete. Where foundation piles are required, the excavation of each pit shall be completed before the piles are driven, and after the driving is completed, all loose and displaced material shall be removed.

206.4.4 Culverts on Rock. If rock is encountered under a portion of the bottom slab of a concrete box-type structure, the rock shall be removed to at least 6 inches below the bottom of the slab and curtain walls, and backfilled with material similar to that under the remainder of the structure.

206.4.5 Footing Construction. Concrete footings for structures shall be placed on foundation material that is

reasonably dry in the judgment of the engineer. The contractor shall perform all draining, bailing or pumping operations, drive any sheeting, and construct any cofferdams or cribs necessary to obtain this condition. Pumping from the interior of any foundation enclosure shall be done in a manner to preclude the possibility of the movement of water, or other fluids or semi-fluids, through any fresh concrete. If necessary, the footing form shall be made watertight and shall be sealed around the bottom, and all pumping done between the footing form and the wall of the enclosure.

206.4.6 Footing Drainage. All holes, pits or sumps resulting from excavating operations shall be kept drained or pumped out until the completion of the work. No ponding of water around footings on other than rock will be permitted.

206.4.7 Cofferdams. In accordance with the contract, the contractor shall provide cofferdams, consisting of sheet piling, or the contractor may propose alternate methods for the construction of the bridge foundations. Alternate designs or methods may consist of, but are not limited to: the construction of cofferdams, seal courses, over excavation, well point systems, dewatering and drainage diversion. The method proposed by the contractor shall stay within the right of way limits provided in the contract. The interior dimensions of cofferdams shall provide sufficient clearance for the construction of forms, and ample room for a sump and for pumping outside the footing forms. Cofferdams that have been tilted or moved laterally during the process of sinking shall be corrected to provide the necessary clearance. Cofferdams shall be constructed to protect the work against damage from sudden rising waters and to prevent damage to the foundation by erosion. Cofferdams shall be removed after the completion of the substructure unit, unless specific authority is given for the cofferdam to remain in place. The contractor shall submit the proposed method of cofferdam construction to the engineer prior to beginning work.

206.4.8 Temporary Shoring. When temporary shoring is required by the contract documents, the contractor shall provide temporary shoring as needed, consisting of sheet piling or alternate methods for the construction of roadway fills, mechanically stabilized earth walls or structures. The contractor shall submit the proposed method of temporary shoring construction to the engineer prior to beginning work.

206.4.9 Seal Courses. Seal courses will be required if indicated on the plans or if conditions are encountered that, in the judgment of the engineer, render it impractical to dewater the foundation area. The dimensions of the seal course shall be adequate to seal the foundation area. Pumping will not be permitted while excavating, pile driving or placing the seal course, and not until, by determination of the engineer, the seal course has attained sufficient strength to withstand the hydrostatic pressure. If seal courses are shown on the plans, and the engineer determines that the footings may be satisfactorily placed without sealing, the contractor shall dewater any completed excavation for investigation purposes. The seal course designs shown on the plans are based on the use of sheet piling in construction of the cofferdams at the indicated water elevations. If the contractor's proposed alternate method includes cofferdams that are to be constructed with seal courses, the contractor shall prepare construction plans that are properly designed for the site conditions and water elevations that may be encountered during footing construction. These plans shall be signed and sealed by a professional engineer licensed in the State of Missouri and shall be provided to the engineer for review a minimum of two weeks prior to the beginning of actual footing construction. The contractor is responsible for the safety and performance of the contractor's proposed system.

206.4.10 Backfill. Backfill material shall be free from large or frozen lumps, wood or other extraneous material. All spaces excavated and not occupied by the new structure or by porous backfill shall be refilled with earth to the original ground surface or to the finished ground lines shown on the plans. The backfill at end bents, walls or other units that fall within the limits of the roadbed shall be placed in successive 6-inch layers and compacted to the same density required for the adjacent roadbed. Dry footings at interior bents shall be backfilled and compacted to no less than the density of the adjacent undisturbed material. Precautions shall be taken to prevent any wedging action against the masonry. The slope bounding the excavation, if steeper than 6:1 shall be stepped or serrated. Backfill placed around culverts and piers shall be kept at approximately the same elevation on opposing sides. Drains consisting of 5 cubic feet of coarse aggregate shall be placed at weep holes, except where porous backfill is required. Backfill material shall not be placed against end bents of bridges, on sides of box culverts or behind retaining walls until the concrete has attained the strength specified in Sec 703.3.2.13. Backfill material shall not be placed higher behind than in front of end bents until the superstructure, including the bridge deck, is in place. Until the grade is in place, drainage shall be maintained away from the end bent backwall by constructing a 6:1 or steeper slope away from the backwall for a minimum distance of 3 feet and by providing a lateral path for all water to flow off the roadbed section.

206.4.11 Porous Backfill. Porous backfill, in accordance with Sec 1009, shall be placed behind abutments, wings and retaining walls where specified and shown on the plans. Porous backfill shall be placed and consolidated in successive 12-inch layers such that the porous backfill will not become mixed with other backfill material.

206.4.12 Flowable Backfill. Flowable backfill will be required when indicated on the plans. The contractor may, with approval from the engineer, use flowable backfill as an alternate to compacted backfill for structures, pipes or utility cuts. Flowable backfill intended for any other use by the contractor shall also be approved by the engineer. Flowable backfill shall not be used to surround drainage systems such as vertical drains or edge drains. Flowable backfill shall be in accordance with Sec 621.

206.4.13 Excavation Classification. Unless otherwise shown on the plans, excavation for structures will be classified as Class 1 Excavation, Class 1 Excavation in Rock, Class 2 Excavation, Class 2 Excavation in Rock, Class 3 Excavation, Class 3 Excavation in Rock, Class 4 Excavation and Class 4 Excavation in Rock. In general, Class 1 Excavation and Class 2 Excavation will apply to excavation for bridges and large retaining walls. Class 3 Excavation will apply to excavation for pipe culvert installations, utilities, retrofit pipe culverts, drop inlets, and manholes. Class 4 Excavation will apply to excavation for box culverts, small retaining walls and other miscellaneous structures. Class 1 Excavation will include all excavation above a specified elevation indicated on the plans while Class 2 Excavation will include all excavation below this specified elevation. The classification of excavation for all structures will be shown on the plans.

206.5 Method of Measurement.

206.5.1 Measurement of Class 1 and Class 2 Excavation will be made to the nearest 1/2 cubic yard for each structure of that volume of material actually removed from within the limits established in this section. The volume measured will be limited by vertical planes 18 inches outside of and parallel with the neat lines of footings, tie beams or overhangs of structures classed as bridges or retaining walls. The upper limits of the volume measured will be the existing ground line or the lower limits of the roadway, drainage or channel excavation, including any allowable overbreak, whichever is lower. Where roadway spill fills are required to be placed and compacted before driving piles or before constructing bridge substructure units, any required additional excavation for the substructure units will be measured from the spill slope. For stream crossings, the measured volume will not include water, but will include mud, muck and other semi-solids. The lower limits of the volume measured will be the bottom of the footings, bottom of seal courses, or 18 inches below the bottom of tie beams and overhangs. Excavation for columns above drilled shafts will be Class 1 Excavation, with measurement made of the volume of material actually removed above the top of the drilled shaft. The volume measured will not exceed that of a cylinder having a diameter 36 inches greater than that of the column above the drilled shaft. No measurement will be made of the material excavated for the drilled shaft below the bottom of the column.

206.5.2 Final measurement of Class 3 Excavation for pipe culverts, utilities, retrofit pipe culverts, drop inlets or manholes will not be made unless there is an authorized change from plan location resulting in a different quantity or there is an authorized change averaging more than 6 inches in the foundation elevation. If a revision is made or an appreciable error is found in the contract quantity, the revision or correction will be computed and added to or deducted from the contract quantity. Measurement of Class 3 Excavation will be made to the nearest cubic yard for each structure of that volume of material actually removed from within the area bounded by vertical planes 18 inches outside of the outer walls of the structure. The upper limits of the volume measured, will be the existing ground line, or the lower limits of the roadway excavation, whichever is lower. The lower limits of the volume measured will include excavation necessary for pipe bedding.

206.5.3 Measurement of Class 4 Excavation for box culverts classified as bridges will be made to the nearest cubic yard for each structure of that volume of material actually removed from within the area bounded by vertical planes 18 inches outside of the outer walls of box culverts with bottom slabs. The upper limits of the volume measured will be the existing ground line, or the lower limits of the roadway excavation, whichever is lower. Class 4 Excavation under embankments and in channel changes will be measured from the original ground surface unless otherwise designated on the plans. For box culverts without bottom slabs, measurement will be made as above except no material below plan flow line will be included that is outside of the area bounded by vertical planes 18 inches each side of and parallel with the neat lines of the walls or footings. Final measurement of Class 4 Excavation for box culverts not classified as bridges, small retaining walls and miscellaneous structures will not be made unless there is an authorized change from plan location resulting in a different quantity or there is an authorized change averaging more than 6 inches in the foundation elevation. If a

revision is made or an appreciable error is found in the contract quantity, the revision or correction will be computed and added to or deducted from the contract quantity. Excavation classification will not change if a substitution of a drainage structure type is approved.

206.5.4 Where concrete in footings or walls is cast against the vertical faces of the excavation, the neat lines of the concrete footings will be considered the limits of excavation for that depth in which the concrete is in contact with the excavation, and no measurement will be made of any excavation or overbreak beyond the neat footing lines.

206.5.5 Final measurement of the porous backfill will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. Where required, the volume of porous backfill will be computed to the nearest cubic yard at each structure from dimensions on the plans. Any porous backfill material placed outside the neat lines shown on the plans shall be placed at the contractor's expense. The revision or correction will be computed and added to or deducted from the contract quantity.

206.6 Basis of Payment.

206.6.1 Payment for additional Class 1 and Class 2 Excavation required to carry footings a maximum of 8 feet below elevations shown on the plans will be made at 125 percent of the contract unit price for that additional excavation within the limits of Class 1, and at 150 percent of the contract unit price for that additional excavation within the limits of Class 2 Excavation. Additional excavation required to carry footings a depth of more than 8 feet
below plan elevations will be considered changes in the work, and will be paid for in accordance with Sec 104.3.

206.6.2 Payment for drilling test holes for foundation tests will be made per foot of hole drilled at the fixed contract unit price specified in Sec 109.

206.6.3 Payment will not be made for removal or replacement of foundation material that became unsuitable because of improper methods of construction by the contractor. Payment for removal of inherently unsound material for foundation stabilization will be made at the contract unit price for excavation for structures. No payment will be made for any costs involved in replacing the volume below the foundations, except that the contractor will be reimbursed for the delivered cost of the granular backfill when directed by the engineer.

206.6.3.1 If Class C Excavation material, as defined in Sec 203, is encountered in Class 1 Excavation, and no pay item for Class 1 Excavation in Rock is included in the contract, payment for that material will be made per cubic yard at the fixed contract unit price specified in Sec 109.

206.6.3.2 If Class C Excavation material, as defined in Sec 203, is encountered in Class 2 Excavation and no pay item for Class 2 Excavation in Rock is included in the contract, payment for that material will be made per cubic yard at the fixed contract unit price specified in Sec 109.

206.6.3.3 If Class C Excavation material, as defined in Sec 203, is encountered in Class 3 Excavation and no pay item for Class 3 Excavation in Rock is included in the contract, payment for that material will be made per cubic yard at the fixed contract unit price specified in Sec 109.

206.6.3.4 If Class C Excavation material, as defined in Sec 203, is encountered in Class 4 Excavation and no pay item for Class 4 Excavation in Rock is included in the contract, payment for that material will be made per cubic yard at the fixed unit price specified in Sec 109.

206.6.4 No direct payment will be made for placing porous backfill at weepholes in accordance with Sec 206.4.11, or for backfilling the structure.

206.6.5 The accepted quantities of excavation for structures and porous backfill will be paid for at the contract unit price for each of the pay items included in the contract.

206.6.6 All costs for furnishing material, labor or equipment, construction, dewatering, drainage, and any other incidental work necessary to complete cofferdam construction; and subsequent removal of any cofferdams, berms, diversions, and any other features constructed for cofferdams as identified by the engineer will be considered completely covered in the contract unit price per lump sum per bent, regardless of construction

method. Payment for Class 1 Excavation and/or Class 2 Excavation will be limited to the volume defined in Sec 206.5. No additional payment for excavation will be made for a contractor proposed method of cofferdam construction.

206.6.7 All costs for furnishing material, labor, equipment, construction, drainage and other incidental work necessary to complete temporary shoring construction; and subsequent removal of any temporary shoring, berms, diversions, and any other features as identified by the engineer will be considered completely covered in the contract unit price per lump sum regardless of construction method.

206.6.8 No direct payment will be made for removing existing structures within the limits of excavation for structures. Existing headwalls or culvert concrete to be removed will be paid for as removal of improvements for roadway culverts or partial removal of culvert concrete for bridge culverts.

206.6.9 Payment for seal courses other than those on the plans will be made only with written authorization from the engineer.

206.6.10 Any material excavated in cleaning out culverts to be used in place will be paid for at the contract unit price per each structure. However, only the initial excavation will be paid for, and any subsequent cleaning required prior to final acceptance shall be done at the contractor's expense.

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SECTION 207
LINEAR GRADING

207.1 Description. This work shall consist of grading work necessary to bring the roadway to the required grade and cross section within reasonable tolerances. The work shall also include the following:

(a) Construction of all inlet and outlet ditches and ditch blocks within the linear grading limits unless otherwise provided for in the contract.

(b) Construction of entrances and approaches.

(c) Breaking up and satisfactory removal or incorporation into the roadway of all gravel, macadam or bituminous surfaces.

(d) Compaction of the roadway subgrade within linear grading limits.

207.1.1 Linear Grading, Class 1, shall consist of grading where the topography is such that the excavation necessary to bring the roadway to the designated cross section will approximately complete the nearby embankments with a minimum of drifting, and where it is not necessary to control the finished grade line for purposes other than to obtain minimum cover over culverts.

207.1.2 Linear Grading, Class 2, shall consist of grading where it is necessary to excavate and haul material approximately 200 feet to bring the roadway to the desired grade and may involve work on high banks and side hills.

207.1.3 The class of linear grading designated on the plans will apply only to those sections that have been specifically indicated as such on the plans and will not be subject to change unless approved by the engineer.

207.2 Construction Requirements.

207.2.1 The roadway shall be brought to the required grade and cross section within reasonable tolerances by backsloping, ditching, removing stone and boulders from the roadbed surface, or any other work necessary, including drifting and hauling of any excavated material. A reasonable tolerance in alignment will be defined as a maximum gradual deviation of 2 feet, free of sharp breaks, to take advantage of favorable topography. Gradual deviation in alignment will be permitted, if necessary to center an existing drainage structure that is to be used in place. A reasonable tolerance in grade will be defined as a final grade that is uniform in appearance, free of sharp breaks or humps, and within 6 inches of plan grade.

207.2.2 Stumps, roots, rubbish or any other deleterious material shall not be placed in embankments. Where an embankment less than 2 feet high is to be constructed, all vegetative matter shall be cut and removed from the surface upon which the embankment is to be placed. The cut-over surface shall be thoroughly broken. All ditches, including inlet and outlet ditches, shall be cut to grades that will properly drain. The required cross section for inlet and outlet ditches leading to or from structures shall be of a width no less than the width of the floor or the diameter of the structure being served. Finishing operations shall continue until the roadbed is free from sharp breaks in alignment and grade, and until the roadbed has been shaped to the required cross section. Material considered unsuitable for the subgrade shall be disposed of on nearby slopes or as otherwise directed by the engineer.

207.2.3 If obliteration of existing roadways or temporary construction is designated in the contract to be performed on a linear grading basis, such obliteration shall include all operations necessary to fill the ditches and blend the old roadbed with the natural ground to provide a pleasing appearance.

207.2.4 Any subgrade upon which a paved surface is to be placed shall be compacted in accordance with Sec 203.5.

207.3 Method of Measurement. Measurement of Linear Grading, Class 1 and Class 2, will be made to the nearest 1/10 station.

207.3.1 Unless otherwise in accordance with the contract, measurement and payment for entrances and approaches will be made as Linear Grading, Class 1. Entrances and approaches will be measured along the

centerline of each facility, regardless of the width to be constructed, beginning at the shoulder line of the road that is being entered and extending to the point of zero cut or embankment of the entrance or approach. Measurement will be made to the nearest 10 feet for each facility and totaled to the nearest 100 feet.

207.3.2 If material is encountered that may be classified as other than Class A Excavation as described in Sec 203.2.1, the limits of linear grading will not be underrun. Material classified as other than Class A Excavation will be measured and paid for per cubic yard in accordance with Sec 203.8. Where undergrading is necessary, backfilling of the undergraded area will be considered as a part of the linear grading operation.

207.4 Basis of Payment. The accepted quantities of linear grading will be paid for at the contract unit price for each of the pay items included in the contract, and will be considered as full compensation for all labor, equipment, material or other construction involved to complete the described work. Removal of concrete pavement and concrete base course will be paid for in accordance with Sec 202.30.3. The earthwork for obliteration, including bituminous surfacing, will be included as linear grading.

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SECTION 208
INTERCEPTION DITCH

208.1 Description. This work shall consist of all work necessary to construct an interception ditch or levee, or both, as shown on the plans or as directed by the engineer.

208.2 Construction Requirements. Interception ditches shall be constructed in a manner to provide a profile free from sharp breaks or irregularities. The work shall be finished to a reasonably smooth and uniform surface. Loose rock shall be removed from the finished surfaces.

208.3 Method of Measurement. Measurement will be made to the nearest 10 feet along the flow line of the ditch for each segment and totaled to the nearest 100 feet for the sum of all segments.

208.4 Basis of Payment. The accepted quantity of interception ditch will be paid for at the contract unit price.

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SECTION 209
SUBGRADE PREPARATION

209.1 Description. This work shall consist of preparing the subgrade upon which a base course is to be constructed or a surfacing placed as shown on the plans or as directed by the engineer. After a base course has been constructed, the top of the completed base course will be considered the subgrade for the next operation. In surfacing contracts involving only incidental grading, the contractor shall complete subgrade compaction in accordance with Sec 210 before proceeding with this work.

209.2 Construction Requirements. The subgrade shall be substantially uniform in density throughout the entire width of the subgrade. The subgrade shall be constructed to drain surface water to the side ditches and all ditches shall be kept open by the contractor. Where hauling results in ruts or other objectionable irregularities, the contractor shall reshape and reroll the subgrade before the base or surfacing is placed. If an old roadway comprises any part of the roadbed, the contractor shall loosen the compacted portions to a depth of at least 6 inches and shall reshape the roadbed.

209.2.1 All subgrade shall be rolled. The subgrades shall be checked after rolling and, if not at the proper elevation at all points, sufficient material shall be removed or added and compacted to bring all portions of the subgrade to the required elevation and density. The moisture content of the top 6 inches of the finished subgrade at the time the base is placed, or at the time pavement is placed if no base is provided under the pavement, shall be no less than the minimum specified for compacting in Sec 203.5.3. If the moisture content has not been maintained, the subgrade shall be scarified, wet to the required moisture content and compacted. A maximum deviation of 1/2 inch, plus or minus, from the required elevation will be permitted on the surface of the finished subgrade.

209.2.2 Soft spots shall be removed to a maximum depth of 24 inches and backfilled with approved stable material. Unsuitable material shall be removed and backfilled in accordance with Sec 203.4.5.

209.2.3 The subgrade shall be compacted and brought to true shape. Any material added shall be satisfactorily incorporated and compacted. Care shall be taken in forming the crown and shaping the subgrade to ensure that the specified thickness of pavement will be attained. The finished concrete pavement subgrade at the time of paving shall be moist, but sufficiently firm to resist rutting or deforming under construction traffic.

209.3 Basis of Payment. No direct payment will be made for subgrade preparation.

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SECTION 210
SUBGRADE COMPACTION

210.1 Description. This work shall consist of compacting the earth subgrade on the roadbed of a previously graded roadway. This work shall be performed prior to any work under Sec 209. The contractor shall perform this work on the subgrade at all locations specified by the engineer. Tentative locations of subgrade compaction will be shown in the plans, but the engineer will specify all locations and depths of this work by written order. No contract adjustment will be made for the direct or indirect costs, incidental or consequential costs, or effects of any overrun, or partial or complete underrun.

210.2 Construction Requirements.

210.2.1 The subgrade for the full width of the roadbed shall be scarified to a depth of at least 6 inches, and the scarified material shall be brought to a uniform moisture content either by drying or by adding water and manipulating. At the contractor's option, the upper 6 inches of soil may be removed and replaced with satisfactory material, or removed and manipulated before replacing. The material shall be compacted to the required density and within the moisture contents specified under Sec 203.5.

210.2.2 If it is determined that the required subgrade density cannot be obtained by moisture control and compaction of the upper 6 inches, the unsuitable material shall be excavated to a maximum depth of 18 inches, and replaced with satisfactory material compacted in layers not to exceed 6 inches, except as otherwise permitted by the engineer. Each 6-inch layer shall be processed, wetted or dried as necessary, and compacted to the required density.

210.2.3 If the contractor’s operations cause an unsatisfactory subgrade, the contractor shall restore the subgrade to a satisfactory condition at the contractor's expense.

210.3 Method of Measurement. Measurement will be made to the nearest 1/10 station along the centerline of each roadbed, regardless of width, for each depth of compaction authorized and totaled to the nearest 100 feet for the sum of all segments. For the purpose of measurement, a divided highway will be considered as having two roadbeds. Measurement of ramps will be made from the ramp’s gore point.

210.4 Basis of Payment. The accepted quantity of subgrade compaction, 6-inch depth, will be paid for at the contract unit price. Subgrade compaction to a depth of 12 inches will be paid for at the rate of two times the contract unit price for subgrade compaction, 6-inch depth. Subgrade compaction to a depth of 18 inches will be paid for at the rate of three times the contract unit price for subgrade compaction, 6-inch depth.

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SECTION 211
SUBGRADE SCARIFYING

211.1 Description. This work shall consist of loosening the surface of the roadbed and removing all rocks larger than 4 inches. Tentative locations of subgrade scarifying will be shown on the plans, but the engineer will specify all locations of this work by written order.

211.2 Construction Requirements. The engineer will specify areas where subgrade scarifying is to be performed. The contractor shall perform all specified work necessary to loosen the surface of the roadbed over the full width to a depth of 6 inches below the finished grading section, and to remove all rocks larger than 4 inches. Oversized material shall be disposed of as directed by the engineer. After all oversized material has been removed; the roadbed shall be brought back to a satisfactory grade and cross section by the addition of extra material, if needed, without rocks exceeding 4 inches .

211.3 Method of Measurement. Measurement will be along the centerline of the roadbed, regardless of the width, to the nearest 1/10 station for each segment and totaled to the nearest 100 feet for the sum of all segments.

211.4 Basis of Payment. The accepted quantity of subgrade scarifying will be paid for at the contract unit price.

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SECTION 212
SUBGRADING AND SHOULDERING

212.1 Description.

212.1.1 Subgrading and Shouldering, Class 1, shall consist of preparing the earth subgrade for surfacing and shoulders by fine-grading, and shaping the existing roadbed of a previously graded roadway and shaping fillslopes, inslopes and ditches as required to complete a finished roadway in accordance with the typical section shown on the plans.

212.1.2 Subgrading and Shouldering, Class 2, in addition to the above, shall include the construction and final shaping of earth shoulders.

212.2 Construction Requirements.

212.2.1 Subgrading and shouldering will normally be restricted to the roadway from ditch to ditch or to the roadbed and upper portions of fill slopes. All ditches shall be graded to drain. The median, if any, shall be shaped to conform to the typical section. If oversize rock in the subgrade cannot be removed by scarifying, compensation for additional work will be made in accordance with Sec 104.3. No work will be required on backslopes, except that necessary to blend the lower portion of the existing backslope with the regraded ditch. The work on fillslopes shall be confined to the upper 10 feet of the slope, measured along the slope line.

212.2.2 If the subgrade has less density than that required under Sec 203.5, the engineer may order the item of Subgrade Compaction to be performed. When lack of satisfactory density results from improper maintenance by the contractor, the subgrade density shall be restored at the contractor's expense. Earth shoulders shall be constructed in accordance with Sec 203.4.1.2.

212.2.3 Finishing of ditches, side slopes, cuts and fills shall be to a reasonably smooth and uniform surface that will merge with the adjacent slopes. Finishing by hand methods will not be required, except that all brush, weeds, excess mud and silt or other debris shall be removed from all channels and culverts within the scope of the work in accordance with Sec 104.11, even though such structures are used in place.

212.2.4 Any additional material required to complete the subgrade or shoulders to proper grade and section shall be obtained from within the right of way limits as directed by the engineer. Excess excavation shall be used for widening shoulders on fill sections or shall be wasted within the limits of the right of way as directed by the engineer.

212.3 Method of Measurement. Measurement of Subgrading and Shouldering, Class 1 and Class 2, will be made to the nearest 100 feet along the centerline of each roadbed, regardless of width. For the purpose of measurement, a divided highway will be considered as having two roadbeds. Measurement of ramps will be made from the ramp's gore point.

212.3.1 Subgrading and Shouldering, Class 1 and Class 2, will apply only to those sections that have been specifically designated as such on the plans and the class will not be subject to change during construction.

212.4 Basis of Payment. The accepted quantity of subgrading and shouldering will be paid for at the contract unit price.

212.4.1 No direct payment will be made for minor drifting of excavated material or for any additional material required. If additional material is required to be hauled approximately 1000 feet or more to complete the work, compensation will be made in accordance with Sec 104.3.

212.4.2 The repair of major erosion beyond the limits as described in Sec 212.2.1 will be paid for in accordance with Sec 104.3.

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SECTION 214
ROCK FILL

214.1 Description. This work shall consist of constructing fill of rock or broken concrete for protection of embankment.

214.2 Material. The material for rock fill shall be durable stone or broken concrete containing a combined total of no more than 10 percent of earth, sand, shale and non-durable rock. The material shall be similar to quarry-run stone graded from coarse to fine with a minimum of voids. The coarse stone shall be as large as can be conveniently handled, but at least 25 percent of the material shall be of pieces having a volume of one cubic foot or more. Acceptance of quality and size of material may be made by visual inspection at the job site.

214.3 Construction Requirements. Successive horizontal layers of stone or broken concrete not exceeding 24 inches thick shall be spread over the area of the rock fill. The larger pieces shall be well distributed and the voids filled with smaller pieces. Each layer shall be spread in accordance with Sec 203.4.16. Where rock fill is placed as a portion of embankment with controlled density, the material shall be compacted in accordance with Sec 203.5.5. The fill shall conform to the elevations and dimensions shown on the plans, and the slopes shall present a dense, finished appearance free from segregation with a proportionate quantity of the large pieces exposed.

214.4 Method of Measurement. Measurement will be made to the nearest cubic yard of material in place in the completed fill.

214.5 Basis of Payment.

214.5.1 Commission Furnished Rock Fill. If shown on the plans that the material for rock fill is to be obtained from the right of way or other source furnished by the Commission, the excavating, including all breaking, loading and hauling, regardless of haul distance, will be paid for and considered completely covered under the contract items of Class A Excavation, Class C Excavation, Unclassified Excavation, Excavation for Structures or other applicable items. If payment is made under these conditions, separate payment for furnishing rock fill will not be made.

214.5.1.1 If the rock fill from the right of way or other sources furnished by the Commission is made unsuitable or unattainable by the contractor's operations, the contractor shall provide suitable material and dispose of any surplus material at the contractor’s expense.

214.5.1.2 If all or part of the required quantity of acceptable material is not actually available and was not made unacceptable by the contractor’s operations, payment will be made per cubic yard at the fixed unit price specified in Sec 109 for such additional rock fill material that the contractor is required to furnish and haul.

214.5.2 Contractor Furnished Rock Fill. If the plans do not provide for a source of material, the contractor shall provide the material and all costs of securing the source, quarrying, excavating, breaking and hauling the material to the site will be paid for at the contract unit price per cubic yard for furnishing rock fill.

214.5.3 Placing Rock Fill. Payment for placing rock fill will be made at the contract unit price per cubic yard.

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SECTION 215
SHAPING SLOPES

215.1 Description. This work shall consist of grading and shaping existing slopes to eliminate shoulder drop off conditions as shown on the plans or as directed by the engineer.

215.1.1 Shaping Slopes, Class I, shall consist of shaping slopes where, in general, the material required to bring the roadway to the designated cross section can be obtained or disposed of within 1000 feet on the right of way as directed by the engineer.

215.1.2 Shaping Slopes, Class II, shall consist of shaping slopes where it may be necessary to haul in excess of 1000 feet or go outside the limits of the right of way for additional material to construct the slopes to the designated cross section or where it may be necessary to dispose of waste material outside the limits of the right of way. The contractor shall provide the engineer with an acceptable written agreement with any property owner from whose property additional material is to be obtained or on which excess excavation is to be disposed.

215.1.3 Shaping Slopes, Class III, shall consist of providing fill material and shaping slopes to construct additional shoulder width for the installation of guardrail and Type A crashworthy end terminals in accordance with Missouri Standard Plans for Highway Construction. Material used shall be Type 1, 5, or 7 Aggregate Base, or other granular material approved by the engineer. Any excess material shall be disposed of outside the limits of the right of way.

215.1.3.1 In lieu of aggregate base, earth material may be used for Shaping Slopes, Class III. When earth material is used, an approved seed mixture shall be applied in accordance with Sec 805, mulch shall be applied in accordance with Sec 802 and erosion and sediment control shall be utilized in accordance with Sec 806. All cost for seeding, mulching, and erosion control shall be incidental to the cost of Shaping Slopes, Class III.

215.2 Construction Requirements. Slope areas to be shaped by the addition of material shall be scarified to allow bonding with the added material. Density shall be obtained from reasonable compactive efforts consisting of no less than three passes with a roller or other methods approved by the engineer. The contractor will not be required to excavate any classified rock excavation under this item.

215.2.1 Benching of the existing slope may be necessary to provide stability to the additional shoulder width constructed by Shaping Slopes, Class III. All costs for benching shall be included in the cost of Shaping Slopes, Class III.

215.3 Method of Measurement. Final measurement will not be made except where appreciable errors are found in the contract quantity.

215.3.1 Where required, measurement will be made to the nearest 1/10 station separately for each length of slope measured along the centerline of the traveled way and totaled to the nearest 100 feet for the sum of all segments.

215.3.2 Shaping Slopes, Class I, Class II, or Class III will apply only to those sections that have been specifically designated as such on the plans.

215.4 Basis of Payment. The accepted quantity of shaping slopes will be paid for at the contract unit price for each of the pay items included in the contract. If Shaping Slopes, Class I, Class II, or Class III is not provided but is required, payment will be in accordance with Sec 104.3. No direct payment will be made for any additional material required for shaping slopes.

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SECTION 216
REMOVALS FOR BRIDGE STRUCTURES

SECTION 216.10 REMOVAL OF BRIDGES

216.10.1 Description. This work shall consist of removing and disposing of existing bridge structures as shown on the plans or as directed by the engineer.

216.10.2 Removal Requirements. The entire structure, including all substructure units, shall be removed to an elevation 2 feet below the finished ground line or streambed. Any portion of an existing structure below the ground line that interferes with the construction of the new structure shall be removed. Existing structures used for handling temporary traffic shall not be removed until the replacement structure is open to traffic. Notification of demolition shall be made in accordance with Sec 202.40.1.1.

216.10.3 Method of Measurement. No measurement will be made for removal of bridges.

216.10.4 Basis of Payment. Removal of bridges will be paid for at the contract lump sum price.

SECTION 216.20 SCARIFICATION OF BRIDGE DECKS .

216.20.1 Description. This work shall consist of scarifying the bridge deck to the depth shown on the plans or as directed by the engineer.

216.20.2 Removal Requirements. The bridge deck shall be uniformly scarified to the depth as shown on the plans. Excessive tearing of the deck surface shall require immediate correction. Over areas of half-sole repair and full depth repair, the scarified removal depth may be coincidental with the repair removal operation. The scarification shall produce a very rough texture that is acceptable to the engineer as a bondable surface for the new concrete wearing surface or as a starting profile for total surface hydro demolition. The scarifying process shall not produce a polished or slick surface. Any epoxy patches encountered shall be completely removed to sound, natural concrete.

216.20.3 Method of Measurement. Final measurement of scarification of bridge decks will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, scarification of the bridge decks will be measured to the nearest square yard based on measurement longitudinally from end of slab to end of slab and transversely from roadway face of curb to roadway face of curb. The revision or correction will be computed and added to or deducted from the contract quantity.

216.20.4 Basis of Payment. Scarification of bridge decks will be paid for at the contract unit price.

SECTION 216.30 SEAL COAT AND WEARING SURFACE REMOVAL.

216.30.1 Description. This work shall consist of the complete removal and disposal of the unbonded seal coat, bonded seal coat, asphalt wearing surface or concrete wearing surface from the bridge deck as shown on the plans or as directed by the engineer.

216.30.2 Removal Requirements.

216.30.2.1 All material and residue shall be removed. Staining will be permitted. The equipment and procedures used for removal shall be such that no damage will be done to the existing concrete deck. Any epoxy patches encountered shall be completely removed to sound, natural concrete. Excessive tearing of the deck surface shall require immediate correction.

216.30.2.2 When a concrete wearing surface is to be installed, the removal of the wearing surface plus the amount of deck as shown on the plans shall produce a very rough texture that is acceptable to the engineer as a bondable surface for the new concrete wearing surface or as a starting profile for total surface hydro demolition. The removal process shall not produce a polished or slick surface.

216.30.3 Method of Measurement. Final measurement of the seal coat and wearing surface removal will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, removal of bonded seal coat, asphalt wearing surface and concrete wearing surface

will be measured to the nearest square foot based on measurement longitudinally from end of slab to end of slab and transversely from roadway face of curb to roadway face of curb. The revision or correction will be computed and added to or deducted from the contract quantity. No measurement will be made for removal of unbonded seal coat.

216.30.4 Basis of Payment. Seal coat and wearing surface removal will be paid for at the contract unit price, except that all costs incurred by the contractor while removing the unbonded seal coat will be considered completely covered in the contract unit price for other items.

SECTION 216.40 REMOVAL AND STORAGE OF EXISTING BRIDGE RAILS.

216.40.1 Description. This work shall consist of disassembling, removing, transporting and storing existing bridge rails at the location specified in the contract documents or as directed by the engineer.

216.40.2 Storage Requirements. Storage shall be by stacking in a neat and orderly manner on contractor furnished timbers. The contractor shall notify and make arrangements with the engineer a minimum of 24 hours prior to commencing the storage of these materials. The contractor shall be responsible for damage to or loss of any part, including necessary repair or replacement, until storage has been acceptably completed.

216.40.3 Method of Measurement. Final measurement of the removal and storage of existing bridge rails will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, removal and storage of existing bridge rails will be measured to the nearest linear foot from end of rail to end of rail. The revision or correction will be computed and added to or deducted from the contract quantity.

216.40.4 Basis of Payment. Removal and storage of existing bridge rails will be paid for at the contract unit price.

SECTION 216.50 REMOVAL OF EXISTING BRIDGE DECKS.

216.50.1 Description. This work shall consist of removing and disposing of existing bridge rails, curbs, slab, expansion devices and any other items necessary to reconstruct the bridge deck as shown on the plans or as directed by the engineer.

216.50.2 Removal Requirements.

216.50.2.1 The existing bridge deck shall be removed by methods such that the girders, stringers or floor beams that are to remain in place are not damaged. Any damage to the girders, stringers and floor beams resulting from the contractor's operations shall be repaired or replaced as directed by the engineer, at the contractor's expense. Notification of demolition shall be made in accordance with Sec 202.40.1.1.

216.50.2.2 The contact surfaces of all existing structural steel, including any shear connectors, exposed by removal of the bridge deck shall be cleaned, including the removal of stratified rust, with a minimum of SSPC-SP-3 surface preparation. Any tightly adhered concrete remaining after the surface preparation may be left in place. The area, including the welded connection between the shear connector and the top flange, shall be coated with one coat of gray epoxy-mastic primer (non-aluminum) in accordance with Sec 1081 to produce a dry film thickness of no less than 3 mils. SSPC Certified Contractor QP qualification will not be required for the coating of the top flanges prior to placement of the new concrete deck. Overspray on other areas of the shear connector will be considered acceptable. The gray epoxy-mastic primer (non-aluminum) shall be compatible with concrete.

216.50.3 Method of Measurement. Final measurement of removal of the existing bridge decks will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, removal of the existing bridge decks will be measured to the nearest square foot based on measurement longitudinally from end of slab to end of slab and transversely from out to out of the bridge deck. The revision or correction will be computed and added to or deducted from the contract quantity.

216.50.4 Basis of Payment. Removal of the existing bridge deck will be paid for at the contract unit price.

SECTION 216.60 PARTIAL REMOVAL OF EXISTING BRIDGE DECKS.

216.60.1 Description. This work shall consist of removing and disposing of the existing curbs, rails, slab and any other items necessary to reconstruct the bridge deck as shown on the plans or as directed by the engineer.

216.60.2 Removal Requirements.

216.60.2.1 Concrete shall be removed by conventional hand/mechanical equipment in accordance with Sec 704. A removal line shall be established with the joint sawed to a depth of one inch with a vertical face. In no case shall existing reinforcement be cut or damaged by the sawing operation.

216.60.2.2 The existing reinforcing steel shall be stripped, cleaned, straightened and extended into or utilized in the new concrete as shown on the plans. Care shall be taken to prevent damage to the reinforcement or the reinforcement bond to the concrete. If any reinforcement is damaged or deteriorated, the engineer shall be notified. Cut or broken bars or bars having 10 percent or more cross sectional area lost shall be spliced 24 diameters on each side of the damage.

216.60.2.3 The existing bridge deck shall be removed by methods such that the girders, stringers and floor beams that are to remain in place are not damaged. Any damage to the girders, stringers and floor beams resulting from the contractor's operations shall be repaired or replaced as directed by the engineer at the contractor's expense.

216.60.2.4 The contact surfaces of all existing structural steel, including any shear connectors, exposed by partial removal of the bridge deck shall be cleaned and coated in accordance with Sec 216.50.2.2.

216.60.3 Method of Measurement. Final measurement of the partial removal of existing bridge decks will not be made except for authorized changes during construction or where appreciable errors are found in the contact quantity. Where required, partial removal of existing bridge decks will be measured to the nearest square foot based on measurement longitudinally from end of slab to end of slab and transversely from outside edge of the existing slab to the line shown on bridge plans. The revision or correction will be computed and added to or deducted from the contract quantity.

216.60.4 Basis of Payment. Partial removal of existing bridge decks will be paid for at the contract unit price.

SECTION 216.70 PARTIAL REMOVAL OF CULVERT AND SUBSTRUCTURE CONCRETE.

216.70.1 Description. This work shall consist of removing and disposing of existing culvert wings and slab or substructure concrete as shown on the plans or as directed by the engineer.

216.70.2 Material. The qualified special mortar shall be in accordance with Sec 704.2.

216.70.3 Removal Requirements.

216.70.3.1 Any excavation required during the removal of concrete shall be backfilled after the new concrete is poured and cured. Any part of the roadway that is removed or damaged and any part of the remaining structure damaged during the removal of the existing concrete shall be repaired or the material replaced, at the contractor's expense, as directed by the engineer.

216.70.3.2 Concrete removal shall be in accordance with Sec 216.60.2.1. The concrete to be removed will not be included in the excavation volume. Areas exposed by removal of concrete and not covered by new concrete shall be coated with a qualified special mortar.

216.70.3.3 Existing reinforcing steel utilized in the new concrete shall be prepared in accordance with Sec 216.60.2.2. Existing reinforcing steel not utilized in the new concrete shall be cut off one inch into the concrete. Any holes outside the limits of new concrete shall be filled with a qualified special mortar.

216.70.4 Method of Measurement. No measurement will be made for partial removal of culvert and substructure concrete.

216.70.5 Basis of Payment. Partial removal of culvert and substructure concrete will be paid for at the contract lump sum price.

SECTION 216.80 CURB REMOVAL.

216.80.1 Description. This work shall consist of removing and disposing of existing curbs, rails and end posts as shown on the plans or as directed by the engineer.

216.80.2 Material. Qualified special mortar shall be in accordance with Sec 704.2.

216.80.3 Removal Requirements.

216.80.3.1 Concrete removal shall be in accordance with Sec 216.60.2.1. Areas exposed by removal of concrete and not covered by new concrete shall be coated with a qualified special mortar.

216.80.3.2 Existing reinforcing steel utilized in the new concrete shall be prepared in accordance with Sec 216.60.2.2. Existing reinforcing steel not utilized in the new concrete and existing rail post bolts shall be cut off one inch into the concrete. Any holes outside the limits of new concrete shall be filled with a qualified special mortar.

216.80.4 Method of Measurement. Final measurement of curb removal will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, curb removal will be measured to the nearest linear foot based on measurement from end of curb to end of curb. The revision or correction will be computed and added to or deducted from the contract quantity.

216.80.5 Basis of Payment. Curb removal will be paid for at the contract unit price.

SECTION 216.90 REMOVAL OF EXISTING EXPANSION JOINTS AND ADJACENT CONCRETE

216.90.1 Description. This work shall consist of any excavation, backfill, removal and disposal of the existing expansion joint system, curb plates and adjacent concrete as shown on the plans or as directed by the engineer.

216.90.2 Material. Qualified special mortar shall be in accordance with Sec 704.2.

216.90.3 Removal Requirements.

216.90.3.1 Any excavation required during the removal of concrete shall be backfilled after the new concrete is poured and cured. Any part of the roadway that is removed or damaged and any part of the remaining structure that is damaged during the removal of the existing concrete shall be repaired or the material replaced as directed by the engineer at the contractor's expense.

216.90.3.2 Concrete removal shall be in accordance with Sec 216.60.2.1. The concrete to be removed will not be included in the excavation volume. Areas exposed by removal of concrete and not covered by new concrete shall be coated with a qualified special mortar.

216.90.3.3 Existing reinforcing steel utilized in the new concrete shall be prepared in accordance with Sec 216.60.2.2. Existing reinforcing steel not utilized in the new concrete shall be cut off one inch into the concrete. Any holes outside the limits of new concrete shall be filled with a qualified special mortar. Any reinforcement that interferes with the installation of the new expansion joint system shall be called to the attention of the engineer and may be shifted, cut or removed as directed by the engineer. Any reinforcing steel removed that was to remain in place shall be replaced with bars of like size and shape, Grade 60, in accordance with Sec 706 or Sec 710 and spliced 24 bar diameters as directed by the engineer.

216.90.3.4 The contact surfaces of all existing structural steel exposed by removal of the existing expansion joints and adjacent concrete shall be cleaned and coated in accordance with Sec 216.50.2.2.

216.90.4 Method of Measurement. Final measurement of the removal of existing expansion joints and adjacent concrete will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, removal of the existing expansion joint system and adjacent concrete will be measured to the nearest linear foot based on measurement from roadway face of curb to roadway face of curb along centerline of the existing joint. The revision or correction will be computed and added to or deducted from the contract quantity. Portions of the joint extending past the roadway face of curbs

will not be measured for payment.

216.90.5 Basis of Payment. Removal of existing expansion joints and adjacent concrete will be paid for at the contract unit price for each of the items included in the contract.

SECTION 216.100 REMOVAL OF EXISTING EXPANSION JOINT SEAL OR SEALANT.

216.100.1 Description. This work shall consist of removing and disposing of existing expansion joint seals or sealant, curb plates and any partial removal of concrete as shown on the plans or as directed by the engineer.

216.100.2 Material. Qualified special mortar shall be in accordance with Sec 704.2.

216.100.3 Removal Requirements.

216.100.3.1 Concrete removal shall be in accordance with Sec 216.60.2.1. Areas exposed by removal of concrete and not covered by new concrete shall be coated with a qualified special mortar. Any damage to the remaining structure resulting from the contractor's operations shall be repaired or replaced, at the contractor's expense, as directed by the engineer.

216.100.3.2 Existing reinforcing steel utilized in the new concrete shall be in accordance with Sec 216.60.2.2. Existing reinforcing steel not utilized in the new concrete shall be cut off one inch into the concrete. Any holes outside the limits of new concrete shall be filled with a qualified special mortar. Any reinforcement that interferes with the installation of the new expansion joint seal or sealant shall be called to the attention of the engineer and may be shifted, cut or removed as directed by the engineer. Any reinforcing steel removed that is to remain in place shall be replaced with bars of like size and shape being Grade 60.

216.100.4 Method of Measurement. Final measurement of removal of existing expansion joint seal or sealant will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, removal of the existing expansion joint seal and sealant will be measured to the nearest linear foot based on measurement from roadway face of curb to roadway face of curb along centerline of the existing joint. The revision or correction will be computed and added to or deducted from the contract quantity. Portions of the joint extending past the roadway face of curbs will not be measured for payment.

216.100.5 Basis of Payment. Removal of existing expansion joint seal or sealant will be paid for at the contract unit price.

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SECTION 302
STABILIZED PERMEABLE BASE

302.1 Description. This work shall consist of furnishing and placing a stabilized permeable base material. The mixture shall be placed, spread and compacted as shown on the plans or as directed by the engineer.

302.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Aggregate for Drainage	1009
Asphalt Binder (PG 64-22, PG 70-22, PG 76-22)	1015
Portland Cement	1019
Water	1070

302.2.1 General. Stabilized permeable base shall be either asphalt binder stabilized or Portland cement stabilized at the option of the contractor. All stabilized permeable base shall use Grade 4 drainage aggregate in accordance with Sec 1009.

302.2.2 Asphalt Stabilized Permeable Base. Mixtures shall be composed of the base aggregate and 2.5 percent asphalt binder by weight of the total mixture. PG 64-22, PG 70-22 or PG 76-22 asphalt binder shall be used. All proportioning, mixing and transporting shall be in accordance with Sec 401.

302.2.3 Cement Stabilized Permeable Base. Cement stabilized base mixtures shall be composed of the base aggregate with a cement factor of 2.5 sacks per cubic yard. All proportioning, mixing and transporting shall be in accordance with Sec 501. Fly ash and ground granulated blast furnace slag shall not be used.

302.3 Construction Requirements.

302.3.1 Contamination. Contamination of the finished base material that affects the drainage capability of the product will not be permitted. Any areas determined to be contaminated shall be completely removed without disturbing the adjacent or underlying material and replaced at contractor's expense.

302.3.2 Displacement. Rutting or other displacement of the permeable base or the underlying base will not be permitted. If displacement occurs, which could result in ponding or a non-uniform, non-draining thickness of permeable base, the material shall be completely removed without disturbing the adjacent or underlying material and shall be replaced at the contractor's expense.

302.3.3 Asphalt Stabilized Permeable Base. Applicable portions of Sec 401 will apply, except as noted herein. The final mixture, when discharged from the pugmill or drum, shall be 250-300 F. A minimum of three passes of a 5 to 10 ton steel wheel roller shall be made, compacting the material until no further displacement is noted. Compaction shall begin as soon after spreading the mixture as the mixture is able to bear the weight of the roller without undue displacement and shall be completed before the temperature of the mixture drops below 100 F. The approximate compacted thickness of a single lift shall be a maximum of 4 inches .

302.3.4 Cement Stabilized Permeable Base. Applicable portions of Sec 502 will apply, except as noted herein. Segregation of the mixture shall be minimized. Normal concrete pavement consolidation equipment such as vibrators or vibrating pans will be considered adequate, provided the mixture can be satisfactorily compacted. The mixture shall be cured for a minimum of 48 hours in accordance with Sec 502.6, except that white-pigmented membrane or straw shall not be used. A fine water mist may be applied several times each day for the 48-hour period as needed to maintain moisture. The water application shall not be heavy enough to wash away the cementitious material or mortar.

302.4 Method of Measurement. Final measurement of the completed permeable base will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, measurement of permeable base, complete in place, will be made to the nearest square yard . The revision or correction will be computed and added to or deducted from the contract quantity.

302.5 Basis of Payment. The accepted quantities of permeable base of the thickness specified will be paid for at

the contract unit price for each of the pay items included in the contract. Payment will be considered full compensation for all labor, equipment and material, including the stabilizing agent, to complete the described work.

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SECTION 303
ROCK BASE

303.1 Description. This work shall consist of furnishing and placing select rock material in the top 12 or 18 inches of the subgrade for use as a base to provide pavement support and drainage as shown on the plans or as directed by the engineer.

303.2 Material. The material source for rock base shall be in accordance with approval from the engineer. Geologic conditions may vary from available subsurface information. Approval from the engineer of a source for the inherent stone will not constitute approval of the final rock base product.

303.2.1 Material for rock base shall be durable stone or broken concrete containing a combined total of no more than 10 percent, by weight, of earth, sand, shale and non-durable rock. Material from geologic-filled sink deposits or stone indicating evidence of solution activity shall not be used.

303.2.2 The material shall be as large as can be conveniently handled within the limits of this specification. No particle dimension shall exceed approximately 12 inches, for 18 inch rock base or 9 inches for 12 inch rock base. There shall be some material with particle dimensions exceeding approximately 9 inches for 18 inch rock base or 6 inches for 12 inch rock base. The material shall be uniformly graded from coarse to fine.

303.2.3 Broken, sound concrete pavement and composite pavements may be used provided the ratio of the longest dimension measurement to thickness does not exceed 2:1 and provided there is no excessive exterior steel mesh that would affect compaction. Milled, crushed or chunked forms of bituminous pavement shall not be used. Small, thin amounts adhering to broken concrete pavement will be permitted.

303.2.4 Acceptance of quality and size of material will be made by visual inspection at the job site.

303.3 Construction Requirements.

303.3.1 Except as noted herein, all applicable provisions in Sec 203 for the handling and placement of roadway excavation material shall apply.

303.3.2 The material shall not be dumped in place, but shall be distributed by blading or dozing in a manner to ensure proper placement in final position in the subgrade.

303.3.3 Material for either 12 inch or 18 inch rock base may be placed in one lift. Rock base material may be placed thicker, with approval from the engineer, in maximum 24-inch lifts, provided a uniform drainage plane under the rock base is provided. No particle dimension shall exceed approximately 6 inches less than the placed lift thickness. There shall be some material with particle dimensions exceeding approximately 50 percent of the lift thickness. No additional payment will be made for the thicker rock base material. Class C Excavation in rock cuts shall be performed to allow placement of the specified lift thickness.

303.3.4 Material shall be compacted in accordance with Sec 203.5.5.

303.3.5 The final surface shall be of a uniform texture and grade suitable for paving. The top 2 inches of rock base shall consist of either 2 inch maximum rock fragments, spalls, reclaimed asphalt, or concrete. The 2 inch maximum size granular material shall have a plasticity index not to exceed 10 and a gradation such that at least 50 percent of the material will be retained on the No. 4 sieve or have a gradation meeting Type 5 or 7 aggregate as specified in Sec. 1007. There shall be no exposed rock exceeding the inch size in the final surface that would interfere with final preparation of the base for paving.

303.3.6 A roughly compensating maximum deviation of ± 1/2 inch from the required elevation will be permitted on the surface of the finished rock base.

303.3.7 When the contract includes paving over existing rock base, the paving contractor shall adjust the rock base grade as needed to that required using approved backfill material as specified herein. No additional payment will be made for this adjustment.

303.4 Method of Measurement. Final measurement of the completed rock base will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. Where

required, measurement of rock base, complete in place, will be made to the nearest square yard. The revision or correction will be computed and added to or deducted from the contract quantity.

303.5 Basis of Payment.

303.5.1 If the contract documents provide that the material for rock base shall be obtained from the right of way or other source furnished by the Commission, the excavating, breaking, processing, loading and hauling, regardless of distance to the site, of the rock base will be paid for and considered completely covered under Class A Excavation, Class C Excavation, Unclassified Excavation, Excavation for Structures, or other applicable items. Separate payment for furnishing rock base will not be made.

303.5.1.1 If the contract documents provide that the material for rock base shall be obtained from the right of way or other source furnished by the Commission, and the material is made unsuitable or unattainable by the contractor's operations, the contractor shall provide suitable material and dispose of any surplus material at the contractor's expense.

303.5.1.2 If the contract documents provide for obtaining material from the right of way or other source furnished by the Commission, but all or part of the required quantity of acceptable material is not available, unless the shortage is due to the contractor’s operations, payment for such additional rock base material that the contractor will be required to furnish and haul will be made per square yard at the fixed contract unit price in Sec 109 and will be measured in accordance with Sec 109.1.

303.5.2 If the contract documents do not provide for a source of material, the contractor shall provide the material. All costs of securing the source, quarrying, excavating, breaking, processing and hauling the material to the site will be paid for at the contract unit price per square yard for furnishing rock base.

303.5.3 Payment for placing rock base will be made at the contract unit price per square yard complete in place, based entirely on the surface area of the design thickness. No additional payment will be made for material needed to maintain the required edge slopes.

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SECTION 304
AGGREGATE BASE COURSE

304.1 Description. This work shall consist of furnishing and placing one or more courses of aggregate on a prepared subgrade in accordance with these specifications, and as shown on the plans or as directed by the engineer. The type of aggregate to be used will be specified in the contract.

304.2 Material. Material for Type 1, 5 and 7 aggregate bases shall be crushed stone or reclaimed asphalt or concrete which meet the requirements of Sec 1007.

304.3 Construction Requirements.

304.3.1 Field Laboratory. When authorized by the engineer, the contractor shall provide a Type 2 field laboratory in accordance with Sec 601. Payment for the laboratory will be made in accordance with Sec 601.

304.3.2 Subgrade. All work on that portion of subgrade on which the base is to be constructed shall be completed in accordance with Sec 209.2.1 prior to placing any base material on that portion. Aggregate base shall not be placed on frozen subgrade.

304.3.3 Placing.

304.3.3.1 The contractor shall place base material on the roadbed as shown in the contract documents. The maximum compacted thickness of any one layer shall not exceed 6 inches. If the specified compacted depth of the base course exceeds 6 inches, the base shall be constructed in two or more layers of approximately equal thickness. The compacted depth of a single layer of the base course may be increased to 8 inches for shoulders.

304.3.3.2 Types 1 and 5 aggregate base used for shoulders adjacent to rigid or flexible type pavement, including pavement resurfacing, shall be simultaneously deposited and spread on the subgrade. Aggregate shall not be deposited on the pavement and bladed or dozed into place.

304.3.4 Shaping and Compacting. Each layer shall be compacted to the specified density or dynamic cone penetration index value before another layer is placed.

304.3.4.1 Segregated surface areas constructed of Type 1 aggregate base may be corrected by adding and compacting limestone screenings of such gradation and quantity as required to fill the surface voids, and firmly bind the loose material in place. Screenings used in correcting segregated surface areas will be measured and paid for as base material. Type 5 and Type 7 aggregate bases are intended to provide some drainage and shall not be segregated. Trimmed Type 5 and 7 aggregate base may not be reused until the material is verified as meeting the required specifications. Base material contaminated to the extent that the material no longer complies with the specifications shall be removed and replaced with satisfactory material at the contractor's expense.

304.3.4.2 Type 1 aggregate base used for shoulders shall be compacted to a minimum 95 percent of standard maximum density. Type 1 aggregate base used on other than shoulders shall be compacted to no less than standard maximum density. Type 5 aggregate base under both roadway and shoulders shall be compacted to a minimum 95 percent of standard maximum density. The Standard Compaction Test will be conducted in accordance with AASHTO T 99, Method C, replacing any material retained on the 3/4-inch sieve, as provided therein. Field density will be determined in accordance with AASHTO T 191 or AASHTO T 310, Direct Transmission, for wet density. The volume of the test hole may be reduced as necessary to accommodate available testing equipment. If nuclear density test methods are used, moisture content will be determined in accordance with AASHTO T 310, except a moisture correction factor will be determined for each aggregate in accordance with MoDOT Test Method TM 35. In lieu of the density requirements for Type 1 aggregate base used for shoulders with thicknesses less than 4 inches, the aggregate shall be compacted by a minimum of three complete coverages with a 5 ton roller. Rolling shall be continued until there is no visible evidence of further consolidation.

304.3.4.3 Type 7 aggregate base under both roadway and shoulders shall be compacted to achieve an average dynamic cone penetration index value through the base lift thickness less than or equal to 0.4 inches per blow, as determined by a standard dynamic cone penetrometer (DCP) device with a 17.6 lb hammer meeting the

requirements of ASTM D6951.

304.3.4.3.1 Water shall be applied to the Type 7 base material during the mixing and spreading operations so that at the time of compaction the moisture content is not less than 5 percent of the dry weight.

304.3.4.3.2 Type 7 base shall be tested with the DCP within 24 hours of placement and final compaction.

304.3.4.4 If at any time the compacted aggregate base or subgrade becomes unstable, the contractor, at the contractor's expense, shall restore the earth subgrade and the aggregate base to the required grade, cross section and density.

304.3.5 Substitutions for Aggregate Base. If available, the contractor may substitute bituminous pavement cold millings or crushed recycled concrete in lieu of aggregate base for any temporary surface, regardless of the type or thickness of aggregate shown on the plans. If this option is exercised, the contractor shall notify the engineer at least two weeks prior to using the millings or recycled concrete, and shall identify the location from where the millings or concrete will be removed. The millings or recycled concrete shall be installed to the same dimensions shown on the plans for the aggregate base. Millings or recycled concrete shall be placed in maximum 4-inch lifts, and each lift shall be compacted by a minimum of three passes with a 10-ton roller.

304.3.6 Maintenance. The contractor shall maintain, at the contractor's expense, the required density and surface condition of any portion of the completed aggregate base until either the prime coat or a succeeding course or pavement is placed. If a prime coat is specified in the contract, the contractor will be required to apply the prime coat on any completed portion of the aggregate base as soon as practical, or as otherwise specified. The contractor will not be permitted to apply prime if the moisture in the top 2 inches of the Type 1 or 5 aggregate base exceeds the higher of either (1) the average of the optimum moisture as determined by the Standard Compaction Test and the absorption of the plus No. 4 fraction, or (2) two-thirds of the optimum moisture as determined by the Standard Compaction Test.

304.4 Quality Control/Quality Assurance (QC/QA).

304.4.1 Quality Control. The contractor shall control operations to ensure the aggregate base, in place, meets the specified requirements for density, thickness, gradation, deleterious, and plasticity index. Tests shall be taken at random locations designated by the engineer at the following frequency:

Tested Property	Test Method	Contractor Frequency	Engineer Frequency
Density	AASHTO T 191 or AASHTO T 310	1 per 1000 tons, minimum of 1 per day	1 per 4,000 tons, minimum of 1 per project
Dynamic Cone Penetrometer Index Value (for Type 7 base)	ASTM D6951	1 per 1000 tons, minimum of 1 per day	1 per 4,000 tons, minimum of 1 per project
Thickness	Applicable method meeting engineer's approval	1 per 1000 tons, minimum of 1 per day	1 per 4,000 tons, minimum of 1 per project
Gradation and Deleterious Material[a]	AASHTO T 11, AASHTO T 27 and MoDOT Test Method TM 71	1 per 2000 tons, minimum of 1 per day[b]	1 per 8,000 tons, minimum of 1 per project
Plasticity Index[a]	AASHTO T 89 and AASHTO T 90	1 per 10,000 tons, minimum of 1 per project	1 per 40,000 tons, minimum of 1 per project

[a]Sampled at point of delivery, prior to rolling.
[b]When production for a week is anticipated to be 1,000 tons or less, the contractor may test the material at a frequency of 1 per 250 tons or 1 per week, whichever occurs first.

304.4.1.1 The contractor shall provide copies of the test results, including all raw data, to the engineer the next business day following testing or sampling.

304.4.1.2 The contractor or the contractor's representative shall also determine the standard maximum dry density and the optimum moisture content for Type 1 and 5 base material and the dry weight for Type 7 base material and supply all test data to the engineer.

304.4.1.3 When density or DCP index value tests are less than specified or when thickness measurements indicate the thickness is deficient by more than 1/2 inch from the plan thickness, additional measurements will be taken at 100-foot intervals parallel to centerline ahead and behind the tested location until the extent of the deficiency has been determined. Each measurement will be assumed as representative of the base thickness for a distance extending one-half the distance to the next measurement, measured along centerline, or in the case of a beginning or ending measurement, the distance will extend to the end of the base section. Any deficient areas shall be corrected by reworking or adding material within the limits of the deficiency.

304.4.1.4 When two consecutive tests for gradation, deleterious material, or plasticity index do not meet the specification limits, the material shall be removed beginning at the point where the first test was conducted.

304.4.1.5 The contractor shall retain the untested portion of the plasticity index, gradation and deleterious sample for the engineer's use.

304.4.2 Quality Assurance. The contractor's QC test results and the engineer's QA test results shall meet the specifications and the following. For Type 1 and 5 base the contractor's compaction standard tests shall compare within 3.0 pounds of the maximum density of the MoDOT determined compaction standard. For Type 7 base the contractor's average DCP penetration index shall compare within 0.1 inches per blow of the MoDOT determined average penetration index. For retained samples, the contractor's test results and the engineer's test results shall compare within the following limits:

(a) The total deleterious material shall be within 2.0 percentage points.

(b) The plasticity index shall be within 2.

(c) The gradation test results shall compare within the following limits:

Sieve	Tolerance (%)
1 1/2-inch	± 5.0
1-inch	± 5.0
3/4-inch	± 5.0
1/2-inch	± 5.0
No. 4	± 4.0
No. 8	± 4.0
No. 10	± 3.0
No. 30	± 3.0
No. 40	± 2.0
No. 100	± 2.0
No. 200	± 1.0

304.5 Method of Measurement. Final measurement of the completed aggregate base course will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. Measurement will include aggregate course placed under curb and gutter. Where required, measurement of aggregate base course, complete in place, will be made to the nearest square yard . Where the aggregate base course extends to the inslope of the shoulder, the pay limit of the aggregate base course will be measured from the mid-point of the sloped portion. The revision or correction will be computed and added to or deducted from the contract quantity.

304.6 Basis of Payment. The accepted quantities of aggregate base course of the thickness and type specified will be paid for at the contract unit price for each of the pay items included in the contract. Payment will be considered full compensation for water used in performing this work. When bituminous pavement cold millings or recycled crushed concrete are substituted for aggregate base, payment will be made for the aggregate base quantity provided in the plans, regardless of whether millings, recycled crushed concrete or the aggregate base is used. Payment will be considered full compensation for hauling of millings, cold milling operations, and all other material or labor necessary to substitute bituminous pavement millings for aggregate base.

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SECTION 310
AGGREGATE SURFACE

310.1 Description. This work shall consist of furnishing and placing chat, gravel or crushed stone surfacing in the quantity shown in the contract document or as directed by the engineer.

310.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically Sec 1006. The type and gradation of the surfacing material to be used will be specified in the contract.

310.3 Construction Requirements.

310.3.1 General. The contractor shall furnish, haul and spread surfacing material on the subgrade at the designated rate. The rate of application may be varied at the discretion of the engineer, depending on the nature of the soil encountered in the subgrade. The contractor shall uniformly unload and distribute the required quantity of material throughout each station. The subgrade shall be prepared as specified in Sec 209, and any work done in reshaping the subgrade before placing surfacing material shall be at the contractor's expense. When it is determined by the engineer to be to the Commission's advantage, hauling may be done over surfacing material previously spread, otherwise, all hauling shall be over the subgrade.

310.3.2 Surface Requirements. Material shall be spread to a uniform thickness over the subgrade and shaped as shown on the plans until the surface is free from ruts and waves. The surface shall be compacted under traffic. Maintenance of the surface shall continue until final project acceptance is made.

310.3.3 Stockpiles. Material shall be stockpiled at locations approved by the engineer, and in the approximate quantity shown on the contract.

310.3.4 Salvage. Designated areas shall be scarified to the full depth of the existing surfacing and such material pulverized to a maximum size of approximately 2 inches. Uncontaminated material shall be removed from the roadbed and placed in stockpiles or spread at locations approved by the engineer. Salvaged surfacing material shall be maintained as free as practical of dirt, vegetation or other objectionable material. Salvaging shall not be performed unless approved by the engineer.

310.4. Vehicle Scales. Vehicle scales shall be approved by the engineer and shall be in accordance with the requirements specified herein.

310.4.1 Basis of Acceptance. Scale acceptance will be based on one of the following:

(a) A valid certification or seal of approval by the Missouri Department of Agriculture, Division of Weights and Measures.

(b) A valid certification or seal of approval by a State of Missouri duly appointed Sealer of Weights and Measures in cities or counties of 75,000 population or more.

(c) Certification of calibration from a commercial scale service company showing that the scale meets the requirements of these specifications. The contractor shall furnish the certification of calibration to the engineer.

(d) Calibration from zero weight through the maximum load to be applied by the application of standard weights in the presence of the engineer by the contractor's personnel. In lieu of starting the calibration at zero weight, standard weights may be applied to an unloaded truck, the weight of which has been determined on a certified scale and the calibration continued through the maximum load to be applied. Regardless of the form of acceptance, the calibration shall be within the accuracy requirements specified in Sec 310.4.2, and the scales shall meet all requirements of these specifications.

310.4.2 Scale Calibration. Scales shall have been calibrated within the 12-month period immediately prior to any material being delivered or any time the engineer has cause to question the accuracy of the scale. Scales shall be accurate to within 0.4 percent of the net load applied, regardless of the location of the load on the platform. The value of the smallest unit of graduation on a scale shall be no greater than 20 pounds. Sensitivity requirements of scales not equipped with balance indicators shall be twice the value of the minimum graduated interval on the weigh beam or 0.2 percent of the nominal capacity of the scale, whichever is less. For scales

equipped with balance indicators, the sensitivity requirement shall be the value of the minimum graduated interval on the weigh beam.

310.4.3 Verification. Verification of a vehicle scale may be required by weighing a hauling unit on another recently calibrated and certified scale.

310.4.4 Long Vehicles. If equipment to be weighed is of such length that all axles cannot be weighed simultaneously, a level area of concrete or bituminous pavement shall be provided permitting those axles not on the scale platform to be on the pavement during the weighing operation. The approach shall be at least as wide as the platform and of sufficient length to ensure the level positioning of vehicles during weight determinations. The weighing shall be performed with all brakes released. If equipment to be weighed is equipped with an air bag suspension unit on any axle, the equipment, including semi-trailers or pup trailers, shall be determined on vehicle scales of sufficient size to weigh all axles of the combination simultaneously.

310.4.5 Certification. All costs incurred in obtaining certification of calibration or verification shall be at the contractor's expense.

310.5 Method of Measurement.

310.5.1 Measurement by Volume. Stockpiles of salvaged surfacing material may be measured by the average end area method.

310.5.2 Measurement of Aggregate Surfacing by Area. Final measurement of the completed aggregate surface will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. Where required, measurement of aggregate surface, complete in place, will be made to the nearest square yard . The revision or correction will be computed and added to or deducted from the contract quantity.

310.5.3 Measurement by Weight. Measurement will be made by weighing each truck load on scales in accordance with Sec 310.4. Deductions will be made for any moisture in excess of 2.0 percent of the dry weight of the material. After deduction for excess moisture has been made, measurement will be made to the nearest ton for the total tonnage of material accepted.

310.6 Basis of Payment. The accepted quantities of aggregate surface will be paid for at the contract unit price.

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SECTION 401
PLANT MIX BITUMINOUS BASE AND PAVEMENT

401.1 Description. This work shall consist of a bituminous mixture placed, spread and compacted as shown on the plans or as directed by the engineer.

401.2 Material.

401.2.1 The grade of asphalt binder will be specified in the contract. When the plasticity index on individual aggregate fractions with 10 percent or more passing the No. 30 sieve exceeds 3, a moisture susceptibility test shall be required in accordance with Sec 401.4.5 during the mix design process. If the plasticity index exceeds that of the material approved for the mix design, additional testing may be required. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Coarse Aggregate	1004.2
Fine Aggregate	1002.3
Mineral Filler	1002.4
Hydrated Lime	1002.5
Asphalt Binder, Performance Graded (PG)	1015

401.2.2 Reclaimed Asphalt. Reclaimed Asphalt may be obtained from Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS). The asphalt binder content of recycled asphalt materials shall be determined in accordance with AASHTO T 164, ASTM D 2172 or other approved method of solvent extraction. A correction factor for use during production may be determined for binder ignition by burning a sample in accordance with AASHTO T 308 and subtracting from the binder content determined by extraction.

The use of reclaimed asphalt shall be limited to one of the following options with the exception of bituminous base. For bituminous base the limits specified may be increased according to the recycled materials used as follows; 10% for RAP only, 5% for RAS only and 10% for the appropriate RAP and RAS combination.

Binder	Percent Effective Virgin Binder Replacement		
	RAP	RAS	RAP and RAS combination
Contract Grade Virgin Binder shall be used	0 - 20	0 -10	RAP + (2*RAS) ≤ 20
Virgin Binder shall be Softened One Grade[a]	21 - 40	11 - 20	20 < RAP + (2*RAS) ≤ 40
Blend Chart[b]	0 - 100	N/A	N/A
Extraction and Grading of Binder from final Mixture[c]	0 - 100		

[a]The virgin binder shall have a low temperature grade 6 degrees lower than the binder grade specified in the contract. Lowering the high temperature of the virgin binder is not required; however, if lowered, the virgin binder shall have a high temperature grade no lower than 6 degrees below the binder grade specified in the contract. (Ex. Contract grade PG 64-22; virgin binder could be either PG 58-28 or PG 64-28). The Pressure Aging Vessel (PAV) test temperature (AASHTO M320) shall be tested at 19° C, regardless of the high temperature grade of the selected virgin binder

[b]Testing in accordance with AASHTO M323 including raw data shall be included with the mix design which demonstrates that the grade of the combine mixture meets the contract requirements.

[c]Testing in accordance with either AASHTO T319, or AASHTO T164 and R59 along with grading in accordance with AASHTO M320 including raw data shall be included with the mixt design which demonstrates that the grade of the combine mixture and rejuvenator, if applicable, meets the contract requirements.

401.2.2.1 Reclaimed Asphalt Pavement. Reclaimed Asphalt Pavement (RAP) may be used in any Sec 401, Plant Mix Bituminous Base and Pavement. All RAP material, except as noted below, shall be tested in accordance with AASHTO T 327, Method of Resistance of Coarse Aggregate Degradation by Abrasion in the

Micro-Deval Apparatus. Aggregate shall have the asphalt coating removed either by extraction or binder ignition during production. The material shall be tested in the Micro-Deval apparatus at a frequency of once per 1500 tons. The percent loss shall not exceed the Micro-Deval loss of the combined virgin material by more than five percent. Micro-Deval testing will be waived for RAP material obtained from MoDOT roadways. All RAP material shall be in accordance with Sec 1002 for deleterious and other foreign material. The aggregate specific gravity shall be determined by performing AASHTO T 209 in accordance with Sec 403.19.3.1.2 and calculating the G_{se} to which a 0.98 correction factor will be applied in order to determine G_{sb} as follows:

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}}$$

RAP G_{sb} = RAP G_{se} X 0.98

See Sec 401.4.4.1 for mixes containing more than 40% effective binder replacement from reclaimed asphalt.

401.2.2.2 Reclaimed Asphalt Shingles. Reclaimed Asphalt Shingles (RAS) may be used in any mixture specified to use PG 64-22 in accordance with AASHTO PP 53. In addition, shingles shall be ground to 3/8-inch minus. Waste, manufacturer or new, shingles shall be essential free of deleterious materials. Post-consumer RAS shall not contain more than 1.5 percent wood by weight or more than 3.0 percent total deleterious by weight. Post-consumer RAS shall be certified to contain less than the maximum allowable amount of asbestos as defined by national or local standards. The bulk specific gravity of RAS used in the job mix formula shall be 2.600.

RAS G_{sb} = 2.600

See Sec 401.4.4.1 for mixes containing more than 40% effective binder replacement from reclaimed asphalt.

The gradation of the aggregate may be determined by solvent extraction of the binder or using the following as a standard gradation:

Shingle Aggregate Gradation	
Sieve Size	**Percent Passing by Weight**
3/8 in.	100
No. 4	95
No. 8	85
No. 16	70
No. 30	50
No. 50	45
No. 100	35
No. 200	25

401.2.2.3 Rejuvenators. Rejuvenators may be used in any asphalt mixture containing recycled material. When a rejuvenator is used for the purpose of softening the binder grade, the requirements for the Extraction and Grading of Binder from Final Mixture option in Sec 401.2.2 must be satisfied.

401.3 Composition of Mixtures. Aggregate sources shall be from the specific ledge or combination of ledges within a quarry, or processed aggregate from a particular product, as submitted in the mix design. The total aggregate prior to mixing with asphalt binder shall be in accordance with the following gradation requirements:

Sieve Size	Percent Passing by Weight			
	Base	**BP-1**	**BP-2**	**BP-3**
1 inch	100	100	100	100
3/4 inch	85-100	100	100	100
1/2 inch	60-90	85-100	95-100	100
3/8 inch	---	---	---	100
No. 4	35-65	50-70	60-90	90-100
No. 8	25-50	30-55	40-70	---
No. 16	---	---	---	30-60

No. 30	10-35	10-30	15-35	---
No. 200	4-12	5-12	5-12	7-12

401.4 Job Mix Formula. At least 30 days prior to placing any mixture on the project, the contractor shall submit a mix design for verification and approval by Construction and Materials. The mixture shall be designed in accordance with Asphalt Institute Publication MS-2, Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types. The mixture shall be compacted and tested at a minimum of three asphalt contents separated by a maximum of 0.5 percent in accordance with AASHTO T 245, except as herein noted. The test method shall be modified by short-term aging the specimens in accordance with AASHTO R 30. A detailed description of the mix design process shall be included with the job mix formula. Representative samples of each ingredient for the mixture shall be submitted with the mix design. Aggregate fractions shall be in accordance with the same proportions as the proposed job mix formula. A minimum of 150 pounds will be required for any individual fraction. The amount of each ingredient submitted shall be as follows for each mix design to be verified:

Ingredient	Minimum Amount
Aggregate	300 lbs
Hydrated Lime, Mineral Filler and/or Baghouse Fines	20 lbs
Asphalt Binder	10 gal.

401.4.1 Mixture Design. Laboratories that participate and achieve a score of 3 or greater in the AASHTO proficiency sample program for T 11, T 27, T 84, T 85, T 166, T 209, T 308 and T 245 or T 312 will have the mixture verification process waived. The mix design shall be submitted to Construction and Materials for approval at least seven days prior to mixture production.

401.4.2 Required Information. The mix design shall include raw data from the design process and shall contain the following information:

(a) All possible sources intended for use, and grade and specific gravity of asphalt binder.

(b) Source, type (formation, etc.), ledge number(s) if applicable, gradation, and percent chert of each aggregate fraction.

(c) Plasticity index of each aggregate fraction which has 10 percent or more passing the No. 30 sieve.

(d) Bulk and apparent specific gravities and absorption of each aggregate fraction in accordance with AASHTO T 85 for coarse aggregate and AASHTO T 84 for fine aggregate, including all raw data, or in accordance with TM 81.

(e) Specific gravity of hydrated lime, mineral filler or baghouse fines, if used, in accordance with AASHTO T 100.

(f) Percentage of each aggregate component.

(g) Combined gradation of the job mix.

(h) Percent of asphalt binder, by weight, based on the total mixture.

(i) Bulk specific gravity (G_{mb}) by AASHTO T 166, Method A of a laboratory compacted mixture.

(j) Percent air voids (V_a) of the laboratory compacted specimen.

(k) Voids in the mineral aggregate (VMA) and voids in the mineral aggregate filled with asphalt binder (VFA).

(l) Theoretical maximum specific gravity (G_{mm}) as determined by AASHTO T 209 in accordance with Sec 403.19.3 after the sample has been short-term aged in accordance with AASHTO R 30.

(m) Mixing temperature and molding temperature.

(n) Bulk specific gravity (G_{mb}) of the combined aggregate.

(o) Percent deleterious content of the combine aggregate.

(p) Baghouse fines added for design. Provide the combine gradation with and without the baghouse percentage.

401.4.3 Mixture Approval. No mixture will be accepted for use until the job mix formula for the project is approved by Construction and Materials. The job mix formula approved for each mixture shall be in effect until modified in writing by the engineer. When unsatisfactory results or other conditions occur, or should a source of material be changed, a new job mix formula may be required. In lieu of a new laboratory design, mixtures requiring adjustment beyond the limits allowed in Sec 401.8.2 may be designed in the field based on characteristics of plant-produced mixture in accordance with Sec 401 and verified by Construction and Materials, which may require new aggregate characteristics.

401.4.4 Mixture Characteristics.

401.4.4.1 Base, BP-1, BP-2 and BP-3 mixtures shall have the following properties, when tested in accordance with AASHTO T 245 or AASHTO T 312. The number of blows with the compaction hammer shall be 35 or the number of gyrations shall be 35 with the gyratory compactor. BP-1 and BP-2 mixtures shall have between 60 and 80 percent of the VMA filled with asphalt binder and dust to effective binder ratio of 0.8 to 1.6. BP-3 mixtures shall be compacted with the gyratory compactor to 35 gyrations and shall have a minimum 75 percent of the VMA filled with asphalt binder and dust to effective binder ratio of 0.9 to 2.0.

Mix Type	Percent Air Voids	AASHTO T 245 Stability lb	Voids in Mineral Aggregate (VMA)[b]
BB	3.5	750	13.0[a]
BP-1	3.5	750	13.5
BP-2	3.5	750	14.0
BP-3	3.5	750	15.0

[a]Bituminous base mixtures that would require 12.0 percent VMA following Asphalt Institute MS-2 will have a minimum 12.0 percent requirement.
[b]If the effective virgin binder replacement from any combination of RAP and RAS is greater than 40 percent; then the minimum VMA required shall be increased by 0.5.

401.4.4.2 When specified in the contract as BP-3NC, BP-3 mixtures containing limestone aggregate shall contain a minimum amount of non-carbonate aggregate as shown in the table below, or the aggregate blend shall have an acid-insoluble residue (A.I.R.), MoDOT Test Method TM 76, meeting the criteria of crushed non-carbonate material. The A.I.R. shall be determined on the minus No. 4 sieve. Non-carbonate aggregate shall have an A.I.R. of at least 85 percent insoluble residue.

Aggregate	Minimum Non-Carbonate by Volume
Limestone	20% Minus No. 4
Dolomite	No Requirement

401.4.5 Moisture Susceptibility. When required moisture susceptibility shall be tested in accordance with AASHTO T 283. The mixture shall have a tensile strength ratio (TSR) of 70 percent or greater when compacted to 3.7 inches with 7 ± 0.5 percent air voids. An approved anti-strip additive may be added to increase retained strength to a passing level. When testing is required by Sec 401.2.1 or Sec 401.9, the mixture shall be tested during production in accordance with Sec 403.19.

401.4.6 Time Limit. A mix design may be transferred to other projects for a period of three years from the original approval date provided satisfactory results are obtained during production and placement.

401.5 Gradation and Deleterious Content Control. The engineer shall be notified as soon as possible, but no

later than 24 hours if a change is made to the cold feed settings, hot bin settings or the binder content. The contractor shall determine the mixture gradation at the frequency stated in Sec 401.8.1. The mixture gradation may be determined directly by using residual aggregate from the binder ignition process or by mathematical combination of the cold feed and recycled materials gradations. When the mathematical combination method is used, the RAS gradation shall be from the JMF and RAP gradation from the ignition or extraction residual aggregate. Mixtures as produced shall be subject to the following tolerances and controls:

(a) The maximum variations from the approved job-mix formula shall be within the tolerances as shown in the table below:

Sieve Size	Percent Passing by Weight	
	Tolerance	Action Limit
No. 8[a]	± 5.0	± 10.0
No. 200	± 2.0	± 4.0

[a] Use No. 16 sieve for BP-3

(b) The deleterious content of the material retained on the No. 4 sieve shall not exceed the limits specified in Sec 1004.2.

(c) The quantity of asphalt binder introduced into the mixer shall be the quantity specified in the job-mix formula. No changes shall be made to the quantity of asphalt binder without written approval from the engineer. The quantity of asphalt binder determined by tests on the final mixture shall not vary by more than - 0.3 to + 0.5 percent from the job-mix formula.

401.5.1 Sample Location. The gradations of the total aggregate will be determined from samples taken from the hot bins on batch-type plants or continuous mixing plants or from the composite cold feed belt on drum mix plants. The deleterious content of the total aggregate shall be determined from samples taken from the composite cold feed belt. When required, samples for plasticity index shall be taken from the stockpile. The RAP shall be sampled from the RAP feeding system on the asphalt plant. Samples for asphalt content determination may be taken at the plant.

401.5.2 Substitutions. At the option of the contractor and at no cost to the Commission, the contractor may use a Sec 401 mixture with a smaller nominal maximum size aggregate or an approved Sec 403 mixture, design level C, E, or F with the same or smaller nominal maximum size aggregate in lieu of any Sec 401 mixture. When a Sec 403 mixture is substituted, the layer thickness requirements of Sec 403 will apply. The gradation, asphalt content, deleterious, and density acceptance of the substituted mixture during production will be in accordance with Sec 401.

401.5.3 Commercial Mixture. If specified in the contract that an approved commercial mixture may be used, the contractor shall, at least seven days prior to the desired time of use, furnish a statement setting out the source and characteristics of the mixture proposed to be furnished. The statement shall include:

(a) The types and sources of aggregate, percentage range of each, and range of combined gradation.

(b) The percent and grade of asphalt binder.

(c) The mixing time and range of mixture temperature.

The plant shall be designed and operated to produce a uniform, thoroughly mixed material free from segregation. It will not be necessary for the plant to meet the requirements of Sec 404. A field laboratory will not be required. If the proposed mixture and plant are approved by the engineer, the component material and the mixture delivered will be accepted or rejected by visual inspection. The supplier shall furnish with the first truckload of each day's production, a certification that the material and mixture delivered are in conformance with the approved mixture. Upon completion of the work, a plant certification shall be furnished by the supplier for the total quantity delivered. The mixture shall be transported, placed and compacted in accordance with Sec 401.7. Without specific contract designation, an approved commercial mixture may be used in lieu of plant mix bituminous pavement or base course mixtures for work that is considered temporary construction and is to be maintained at the contractor's expense. Temporary construction will be defined as work that is to be removed prior to completion of the contract.

401.5.4 Moisture Content. The bituminous mixture, when sampled and tested in accordance with AASHTO T 329, shall contain no more than 0.5 percent moisture by weight of the mixture.

401.5.5 Contamination. The bituminous mixture shall not be contaminated with deleterious agents such as unburned fuel, objectionable fuel residue or any other material not inherent in the job mix formula.

401.6 Field Laboratory. The contractor shall provide a Type 3 field laboratory in accordance with Sec 601. The contractor may use the equipment provided in the Type 3 laboratory as long as adequate space is provided for the engineer's work.

401.7 Construction Requirements.

401.7.1 Weather Limitations. Bituminous mixtures shall not be placed on any wet surface or frozen pavement. Temperatures shall be obtained in accordance with MoDOT Test Method TM 20.

401.7.2 Bituminous Mixing Plants. Bituminous mixing plants and preparation of material and mixtures shall be in accordance with Sec 404.

401.7.3 Subgrade or Surface Preparation. The subgrade upon which the bituminous mixture is to be placed shall be prepared in accordance with Sec 209 and primed as specified in the contract in accordance with Sec 408, as applicable. All material requirements of a tacked surface shall be in accordance with Sec 407.

401.7.3.1 Base Widening. For base widening work, the bottom of the trench shall be compacted until further consolidation is not visually evident, by use of a trench roller having a weight of no less than 300 psi of width of rear roller, or by mechanical tampers or other methods approved by the engineer. Suitable excavated material may be used in shouldering operations. On the outside of curves, the design depth of trench at the beginning of the superelevation transition shall be varied gradually to the minimum depth at the end of the superelevation transition. Slight transitioning of the width of the base widening will be necessary to permit the indicated angle of repose or shear angle outside of the ultimate edge of surface. The bottom of the trench shall in no case be less than 3 inches below the surface of the existing pavement. All surplus excavated material shall be disposed of by the contractor in areas to be secured by the contractor beyond the right of way limits. An acceptable written agreement with the property owner on whose property the material is placed shall be submitted to the engineer.

401.7.3.2 Application of Prime or Tack. Application of prime or tack shall be in accordance with Sec 403.12.

401.7.4 Hauling Equipment. Trucks used for hauling bituminous mixtures shall be in accordance with Sec 404.

401.7.5 Spreading. The base course, tacked or primed surface, or preceding course or layer shall be cleaned of all dirt, packed soil or any other foreign matter prior to spreading the bituminous mixture. The mixture shall be spread in the number of layers and in the quantity required to obtain the compacted thickness and cross section shown on the plans. When placing multiple layers with varying thicknesses, the thicker layer shall be placed first.

401.7.5.1 Irregularities. The mixture shall be spread without tearing the surface and struck off such that the surface is smooth and true to cross section, free from all irregularities, and of uniform density throughout. Care shall be used in handling the mixture to avoid segregation. Areas of segregated mixture shall be removed and replaced with a suitable mixture at the contractor's expense. The outside edge alignment shall be uniform. Irregularities shall be corrected by adding or removing mixture before compacting. In situations where there is a dispute in the existence of segregation, the area in question will be tested in accordance with MoDOT Test Method TM 75. Mixture production shall immediately cease if either criteria of MoDOT Test Method TM 75 fail. Segregated mixtures shall be removed and replaced to the limits determined by the engineer.

401.7.5.2 Leveling Course. If required by the contract, a leveling course consisting of a layer of variable thickness shall be spread to the desired grade and cross section to eliminate irregularities in the existing surface. Spot-leveling operations over small areas, with feather-edging at high points and ends of spot areas, may be required prior to placing the leveling course. Rigid control of the placement thickness of the leveling course will be required. The mixture shall be practically free from segregation.

401.7.5.3 Base Widening. The specified total thickness of base widening shall be completed to the adjacent

traveled way elevation as shown on the plans. Additional thickness of base widening may be placed as required prior to coldmilling, at the contractor's expense, and shall subsequently be coldmilled to the same elevation as the traveled way, if conducive to expedite operations. On base-widening work, a succeeding layer of bituminous mixture may be placed the same day as the previous layer, if it can be shown that the desired results are being obtained. On small areas, and on areas that are inaccessible to mechanical spreading and finishing equipment, the mixture may be spread and finished by hand methods if permitted by the engineer. At least one lane of the existing pavement and the adjacent shoulder shall be kept open to traffic at all times during construction, except for short intervals when the movement of the contractor's equipment will seriously hinder the flow of traffic. Intervals during which the contractor will be allowed to halt traffic shall be as designated by the engineer. The contractor shall not open more trenches ahead of the first layer of the base widening than is necessary for placing that layer in one half a day's operations. The first layer of the base widening shall not be placed for a greater distance ahead of the second layer than is necessary for placing the second layer in one half a day's operations. The second layer shall not be placed for a greater distance ahead of the final layer than is necessary for placing the final layer in one day's operation. Any changes in these lengths shall be made only with written permission from the engineer.

401.7.5.4 Edge Differential. For roadways constructed under traffic, no pavement edge differential shall be left in place for more than seven days, unless approved by the engineer.

401.7.6 Joints. The minimum density of all traveled way pavement within 8 inches of a longitudinal joint, shall be no less than 2.0 percent below the specified density. The cores taken to evaluate this area shall be centered 6 inches from the longitudinal joint. If no deficient cores are found in the first 25 percent of production, the established rolling procedure may be used, at the direction of the engineer, in lieu of density tests provided no changes in the material, typical location or temperatures are made. Pay adjustments due to longitudinal joint density shall apply to the full width of the lane paved. Adjustments due to joint density shall apply to the day's production from which the cores are obtained. Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the layer. When a transverse vertical edge is to be left in place and opened to traffic, a temporary depth transition shall be constructed as approved by the engineer. The longitudinal joints in one layer shall offset those in the layer immediately below by approximately 6 inches. The joints in the final surface layer shall be at the lane lines of the traveled way, except that the placement width shall be adjusted such that pavement marking shall not fall on a longitudinal joint. Each side of the joint shall be flush and along true lines.

401.7.7 Surfaced Approaches. At locations designated in the contract or as specified by the engineer, approaches shall be primed in accordance with Sec 408 and surfaced with a plant mix bituminous mixture. The bituminous surface shall be placed as shown on the plans or as directed by the engineer. Approaches shall not be surfaced before the surface course adjacent to the entrance is completed. No direct payment will be made for any work required to condition and prepare the subgrade on the approaches.

401.7.8 Compaction. The compacted mixture shall have a minimum density of 92 percent of the theoretical maximum specific gravity. Density will be determined by the direct transmission nuclear method in accordance with MoDOT Test Method TM 41 or by a specific gravity method. When the contractor elects to place a lift of mixture greater than six times the nominal maximum aggregate size, cores shall be cut in half and the density of each half determined separately. In lieu of density requirements, mixtures used for wedging, transitions, existing shoulder overlays, new shoulders constructed on a sub-grade or base that does not specify density control, temporary bypasses to be maintained at the expense of the contractor, and areas where a commercial mixture is used shall be thoroughly compacted by at least three complete coverage's over the entire area with either a pneumatic tire roller weighing no less than 10 tons, a tandem-type steel wheel roller weighing no less than 10 tons or an approved vibratory roller. Rolling shall be performed at proper time intervals on each layer and shall be continued until there is no visible evidence of further consolidation.

401.8 Quality Control. The contractor shall maintain equipment and qualified personnel to perform QC field inspection, sampling and testing in accordance with applicable portions of Sec 403. A QC Plan will not be required. A proposed third party for dispute resolution shall be included with the mix design submittal.

401.8.1 Mixture Testing. The contractor shall randomly test the mixture within the following frequencies. The gradation and the asphalt content shall be determined at least once every 1,000 tons of production or a minimum of once per day. Deleterious content shall be determined once per 5,000 tons unless quality concerns dictate more frequent testing as directed by the engineer. Gradation and asphalt content of RAP shall be determined once every 10,000 tons of production. If RAP is used and AASHTO T 308 is used to determine the asphalt

content, the binder ignition oven shall be calibrated in accordance with MoDOT Test Method TM 77. At the engineer's discretion, testing may be waived when production does not exceed 200 tons per day. The contractor shall certify the proper proportions of a previously proven mixture were used.

401.8.2 Failing Test. If a, deleterious content, or asphalt content test result falls outside of the specification tolerances, a review or adjustment of the plant settings and production shall be made and another sample shall be immediately taken. If the second test falls outside of the specification tolerances, production shall be immediately ceased until the mixture can be brought back into specification. If a gradation test falls between the Tolerance and Action Limits, adjustments to plant shall be made and another gradation shall be taken immediately. Plant production for the following day shall not resume until the mixture is brought back into specification when the final gradation for the day is not within tolerance. If a gradation test falls outside the Action Limit, production shall cease until the mixture is brought back into specification.

401.8.3 Retained Samples. One half of the contractor's sample for gradation, deleterious content, and asphalt content and all cores shall be retained for the engineer. The contractor shall retain the samples for 7 days after testing has been completed and the results accepted by the engineer.

401.8.4 Pavement Testing. During construction, the engineer will designate as many tests as necessary to ensure that the course is being constructed of proper thickness, composition and density. Density of the roadway shall be determined by one core obtained by the contractor at a random location selected by the engineer for every 500 tons of production. The cores from each day's production will be averaged to determine acceptance. A joint density core shall be taken from the same transverse cross section as the mat core and alternate sides. The maximum theoretical density shown on the job mix formula shall be used for this determination. Minimum 4-inch diameter cores, shall be taken the full depth of the layer to be tested. Cores tested by AASHTO T 166 shall be in accordance with Sec 403.19.3.1.3. The contractor shall restore the surface from which samples have been taken immediately with the mixture under production or with a cold patch mixture acceptable to the engineer.

401.8.5 Density Adjustment. Payment for mixture placed at or below the required minimum density will be adjusted as follows:

Field Density Percent of Maximum Theoretical Density	Percent of Contract Unit Price[a]
91.5 or above	100%
91.0 to 91.4, inclusive	97%
90.5 to 90.9, inclusive	94%
90.0 to 90.4, inclusive	90%
89.5 to 89.9, inclusive	80%
Below 89.5	Remove and Replace

[a]When adjustments are necessary, the lower percent of the contract unit price of either the pavement or joint density adjustment will apply.

401.9 Quality Assurance. Acceptance tests for gradation, deleterious content and asphalt content will be performed by the engineer at a minimum rate of one independent sample per 4 QC samples. A favorable comparison will be considered when a QA test is within the specification tolerances. An acceptance test for plasticity index will be performed at a minimum rate of one per project by the engineer on an independent sample taken during production. Initial testing will be performed the first week of production. When the plasticity index on an individual aggregate fraction is more than two percentage points above the value shown on the approved mix design, moisture susceptibility testing shall be required in accordance with Sec 401.4.5. At least once for every five days of production, a split of the contractor's sample will be tested. If the results of the split sample are not within five percent on all sieves above the No. 200, two percent on the No. 200, within the specification ranges on the deleterious content, and within 0.5 percent on the asphalt content from the contractor's results, another split sample will be taken jointly with the contractor and tested. If the second test results do not compare within the specification tolerances, production shall cease until the discrepancy is resolved. If the second test results compare within the above tolerances, production may continue. The engineer will retain one half of the plasticity index test and moisture susceptibility test for 7 days after testing is complete. Results of QA testing will be furnished to the contractor within 24 hours of obtaining the sample, with the exception of moisture susceptibility testing.

401.10 Surface Smoothness. The finish of the pavement surface shall be substantially free from waves or

irregularities and shall be true to the established crown and grade. The pavement shall be thoroughly tested for smoothness by profiling or straightedging in accordance with Sec 610.

401.11 Defective Mixture. Any mixture showing an excess of bituminous material or that becomes loose and broken, mixed with dirt, or is in any way defective, shall be removed and replaced with a satisfactory mixture, which shall be immediately compacted to conform to the surrounding area.

401.12 Pavement Marking. If the contractor's work has obliterated existing pavement marking on resurfacing projects open to through traffic, the pavement marking shall be replaced at the contractor's expense in accordance with Sec 620.

401.13 Method of Measurement. Measurement will be in accordance with Sec 403.

401.14 Basis of Payment. The accepted quantities of plant mix bituminous pavement and base course will be paid for at the contract unit price for each of the pay items included in the contract. Payment for obtaining and delivering samples of compacted mixture from the base and replacement of the surface will be made per sample at the fixed contract unit price specified in Sec 109. No direct payment will be made for QC cores, excavating the trench for base widening, or for hauling and disposing of excess excavation material.

SECTION 402
PLANT MIX BITUMINOUS SURFACE LEVELING

402.1 Description. This work shall consist of placing, spreading and compacting a bituminous mixture as shown on the plans or as directed by the engineer. Spot wedging will not be required.

402.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Coarse Aggregate	1004.2
Fine Aggregate	1002.3
Mineral Filler	1002.4
Asphalt Binder, Performance Graded (PG)	1015.3

402.2.1 Asphalt Binder. The grade of asphalt binder will be specified in the contract.

402.2.2 Wet Bottom Boiler Slag. The contractor may furnish wet bottom boiler slag of approved quality in lieu of coarse aggregate specified in Sec 402.2. If wet bottom boiler slag is used, the slag shall meet the requirements for coarse aggregate, except that the percentage of wear specified in Sec 1004.2.1 will not apply.

402.2.3 Reclaimed Asphalt. The asphalt binder content of recycled asphalt materials shall be determined in accordance with AASHTO T 164, ASTM D 2172 or other approved method of solvent extraction. A correction factor for use during production may be determined for binder ignition by burning a sample in accordance with AASHTO T 308 and subtracting from the binder content determined by extraction.

402.2.3.1 Reclaimed Asphalt Pavement. Reclaimed Asphalt Pavement (RAP) may be used in any mixture, except SMA mixtures. Mixtures may be used with more than 30 percent virgin effective binder replacement provided testing according to AASHTO M 323 is included with the job mix formula that ensures the combined binder meets the grade specified in the contract. All RAP material, except as noted below, shall be tested in accordance with AASHTO T 327, *Method of Resistance of Coarse Aggregate Degradation by Abrasion in the Micro-Deval Apparatus*. Aggregate shall have the asphalt coating removed either by extraction or binder ignition during production. The material shall be tested in the Micro-Deval apparatus at a frequency of once per 1500 tons. The percent loss shall not exceed the Micro-Deval loss of the combined virgin material by more than five percent. Micro-Deval testing will be waived for RAP material obtained from MoDOT roadways. All RAP material shall be in accordance with Sec 1002 for deleterious and other foreign material. The aggregate specific gravity shall be determined by performing AASHTO T 209 in accordance with Sec 403.19.3.1.2 and calculating the G_{se} to which a 0.98 correction factor will be applied in order to determine G_{sb} as follows:

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}}$$

RAP G_{sb} = RAP G_{se} X 0.98

402.2.3.2 Reclaimed Asphalt Shingles. Reclaimed Asphalt Shingles (RAS) may be used in any mixture specified to use PG 64-22 in accordance with AASHTO PP 53 except as follows:

For mixtures containing RAS or a combination of RAS and RAP, the RAS contribution shall not exceed 20 percent effective virgin binder replacement. Mixtures containing a combination of RAS and RAP may have a maximum 30 percent effective virgin binder replacement with no virgin binder grade change. Mixtures containing a combination of RAS and RAP may have a 30 to 40 percent effective virgin binder replacement under the following conditions: (1) with a virgin binder grade change from a PG64-22 to a PG 58-28 or (2) with a combination of a PG64-22 binder and a rejuvenator provided testing demonstrates that a PG58-28, meeting the requirements of AASHTO M320, is achieved. Shingles shall be ground to 100 percent passing the 3/8-inch sieve. Waste, manufacturer or new, shingles shall be essential free of deleterious materials. Post-consumer RAS shall not contain more than 1.5 percent wood by weight or more than 3.0 percent total deleterious by weight. Post-consumer RAS shall be certified to contain less than the maximum allowable amount of asbestos as defined by national or local standards. The bulk specific gravity of RAS used in the job mix formula shall be

2.600.
RAS G_{sb} = 2.600

The gradation of the aggregate may be determined by solvent extraction of the binder or using the following as a standard gradation:

Shingle Aggregate Gradation	
Sieve Size	**Percent Passing by Weight**
3/8 inch	100
No. 4	95
No. 8	85
No. 16	70
No. 30	50
No. 50	45
No. 100	35
No. 200	25

402.3 Composition of Mixture. Aggregate sources shall be from the specific ledge combination of ledges within a quarry, or processed aggregate from a particular product, as submitted in the mix design. The total aggregate prior to mixing with asphalt binder shall be in accordance with the following gradation requirements:

Plant Mix Bituminous Surface Leveling	
Sieve Size	**Percent Passing by Weight**
3/4 inch	100
1/2 inch	99-100
3/8 inch	90-100
No. 4	60-90
No. 8	40-70
No. 30	15-35
No. 200	5-12

BP-3 in accordance with Sec 401.3 is an allowable substitution.

402.3.1 Mixture Characteristics. Bituminous surface leveling mixture shall have the following properties, when tested in accordance with AASHTO T 245 or AASHTO T 312. The number of blows with the compaction hammer shall be 35 or the number of gyrations shall be 35 with the gyratory compactor. The mixture shall have a minimum voids filled with asphalt (VFA) of 75 percent. The dust to effective binder ratio shall be 0.8 to 1.6.

Percent Air Voids	AASHTO T 245 Stability lb	Voids in Mineral Aggregate (VMA)
3.5	750	14.5

402.4 Job Mix Formula. The mixture shall be in accordance with Sec 401.4.

402.5 Gradation and Deleterious Content Control. In producing mixture for the project, the plant shall be operated such that no deviations from the job mix formula are made. The contractor shall determine on a daily basis, at a minimum, the gradation on the aggregate reclaimed from the RAP by either extraction or binder ignition. The gradation results shall be used to determine the daily specification compliance for the combined gradation. Mixture as produced will be subject to the following tolerances and control:

(a) The total aggregate gradations shall be within the master range specified in Sec 402.3.

(b) Material passing the No. 200 sieve shall not vary from the job mix formula by more than ± 2.0 percentage points.

(c) The deleterious content of the material retained on the No. 4 sieve shall not exceed the limits specified in Sec 1004.2.

(d) If the plasticity index of any fraction exceeds that of the material approved for the mix design, additional testing may be required.

(e) The quantity of asphalt binder introduced into the mixer shall be that quantity specified in the job mix formula. No changes may be made to the quantity of asphalt binder specified in the job mix formula without written approval from the engineer. The quantity of asphalt binder determined by calculation or tests on the final mixture shall not vary more than ± 0.3 percent from the job-mix formula.

402.6 Sample Location. The gradations of the total aggregate will be determined from samples taken from the hot bins on the batch-type plants, or from hot bins or combined hot aggregate flow on continuous mixing plants, or from the combined cold feed on dryer-drum plants. The deleterious content of the total aggregate will be determined from the samples taken from the combined cold feed belt. Samples for plasticity index will be taken from the stockpile. The RAP shall be sampled from the RAP feeding system on the asphalt plant.

402.7 Moisture Content. The bituminous mixture, when sampled and tested in accordance with AASHTO T 329, shall contain no more than 0.5 percent moisture by weight of the mixture.

402.8 Contamination. The bituminous mixture shall not be contaminated with deleterious agents such as unburned fuel, objectionable fuel residue or any other material not inherent in the job mix formula.

402.9 Field Laboratory. The contractor shall provide a Type 3 field laboratory in accordance with Sec 601.

402.10 Construction Requirements.

402.10.1 Weather Limitations. Bituminous mixtures shall not be placed (1) when either the air temperature or the temperature of the surface on which the mixture is to be placed is below 50 F or (2) on any wet surface or frozen pavement. Temperatures shall be obtained in accordance with MoDOT Test Method TM 20.

402.10.2 Bituminous Mixing Plants. Bituminous mixing plants and preparation of material and mixtures shall be in accordance with Sec 404.

402.10.3 Application of Prime or Tack. Application of prime or tack coat shall be in accordance with Sec 403.12.

402.10.4 Hauling Equipment. Trucks used for hauling bituminous mixtures shall be in accordance with Sec 404.

402.10.5 Spreading. The existing surface shall be cleaned of all dirt, packed soil or any other foreign material prior to spreading the bituminous mixture. The mixture shall be spread in the quantity required to obtain the compacted thickness and cross section shown on the plans. The paver shall be operated at a speed that will give the best results. The rate of delivery of the mixture to the paver shall be coordinated to provide, where practical, a uniform rate of placement without intermittent operation of the paver. On small areas and on areas that are inaccessible to mechanical spreading and finishing equipment, the mixture may be spread and finished by hand methods when permitted by the engineer.

402.10.5.1 Irregularities. The mixture shall be spread without tearing the surface and struck off such that the surface is smooth and true to cross section, free from all irregularities and of uniform density throughout. Care shall be used in handling the mixture to avoid segregation. Areas of segregated mixture shall be removed and replaced with suitable mixture. The outside edge alignment shall be uniform and any irregularities shall be corrected by adding or removing mixture before compacting.

402.10.5.2 Pavement Edge Differential. No pavement edge differential shall be left in place for more than seven days, without written approval from the engineer.

402.10.6 Joints. Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the layer. When a transverse vertical edge is to be left and opened to traffic, a temporary depth transition shall be built as approved by the engineer. The longitudinal joint shall be at the lane lines of the traveled way except that the placement width of bituminous surface may be adjusted such that temporary raised pavement markers will not fall on a longitudinal joint. Each side of the joint shall be flush and along true lines.

402.10.7 Compaction. The mixture shall be thoroughly compacted by at least three complete coverages over the entire area with either a pneumatic tire roller or a tandem-type steel wheel roller each weighing no less than 10 tons. All rollers used shall be in satisfactory condition, capable of reversing without backlash, and steel wheel rollers shall be equipped with scrapers. Rollers shall have a system for moistening each roll or wheel. Rolling shall begin as soon after spreading the mixture as the new surface will bear the weight of the roller without undue displacement. Final rolling shall be done by the steel wheel roller. Rolling shall be performed at proper time intervals and shall be continued until there is no visible evidence of further consolidation and until all roller marks are eliminated.

402.10.8 Surface Condition. The surface of the mixture after compaction shall be smooth and uniform. Any mixture showing an excess of asphalt binder or that becomes loose and broken, mixed with dirt or is in any way defective shall be removed and replaced at the contractor's expense with a satisfactory mixture, which shall be immediately compacted to conform to the surrounding area.

402.10.9 Hauling Over Completed Surface. Hauling of plant mix bituminous mixture over any completed portion of the project will not be permitted unless allowed by special provision.

402.11 Method of Measurement. The weight of the mixture will be determined from the batch weights if a batch-type plant is used. If other types of plants are used, the weight of the mixture will be determined by weighing each truck load on scales in accordance with Sec 310. Measurement will be made to the nearest 0.1 ton for the total tonnage of material accepted.

402.12 Basis of Payment. The accepted quantities of plant mix bituminous surface leveling will be paid for at the contract unit price for each of the pay items included in the contract.

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SECTION 403
ASPHALTIC CONCRETE PAVEMENT

403.1 Description. This work shall consist of providing a bituminous mixture to be placed in one or more courses on a prepared base or underlying course as shown on the plans or as directed by the engineer. The contractor shall be responsible for QC of the bituminous mixture, including the design, and control of the quality of the material incorporated into the project. The engineer will be responsible for QA, including testing, to assure the quality of the material incorporated into the project.

403.1.1 Naming Convention. The nomenclature of Superpave bituminous mixture names, such as SP125CLP, will be as follows. When only the aggregate size is shown, such as SP125, the specifications shall apply to all variations of that size, such as SP125B, SP125C, SP125CLP, etc. When "x" is indicated, such as SP125xLP, specifications shall apply to all variations of mixture designs. Stone Matrix Asphalt will be generally referred to as SMA and designated by SM or SMR.

Superpave Nomenclature	
SP	**Superpave**
048	4.75mm (No. 4) nominal aggregate size
095	9.5 mm (3/8 inch) nominal aggregate size
125	12.5 mm (1/2 inch) nominal aggregate size
190	19.0 mm (3/4 inch) nominal aggregate size
250	25.0 mm (1 inch) nominal aggregate size
x	Mixture design: B, C, E or F (as described below)
LP	Limestone porphyry (when designated)
SM	Stone Matrix Asphalt (when designated)
SMR	Stone Matrix Asphalt limestone/non-carbonate (when designated)

403.1.2 Design Levels. The following cumulative equivalent single axle loads (ESALs) shall be used for the specified mix design. The same size aggregate mix design at a higher design traffic may be substituted at the contractor's expense for the contract specified mixture design with the approval from the engineer. Substitutions shall be done uniformly and project mixing of various designs for the same work will not be permitted. For example, an SP125B mixture may be substituted for an SP125C mixture, or SP190C for SP190E, etc. Mixture design substitution will be limited to one design level higher than that specified in the contract.

Design Traffic (ESALs)	Design
< 300,000	F
300,000 to < 3,000,000	E
3,000,000 to < 30,000,000	C
≥ 30,000,000	B

403.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follow:

Item	Section
Aggregate	1002
Asphalt Binder, Performance Graded (PG)[a]	1015
Fiber Additive	1071
Anti-Strip Additive	1071

[a]The grade of asphalt binder will be specified in the contract.

403.2.1 Fine Aggregate Angularity. Fine aggregate angularity (FAA) shall be measured on the fine portion of the blended aggregate. When tested in accordance with AASHTO T 304 Method A, aggregate particles passing the No. 8 sieve shall meet the following criteria for the minimum percent air voids in loosely compacted fine aggregate:

Design	FAA
F	--[a]

E	40
C	45
B	45

[a]For SP048 Mixtures the FAA shall be a minimum of 40.

403.2.2 Coarse Aggregate Angularity. Coarse aggregate angularity (CAA) shall be measured on the coarse portion of the blended aggregate. When tested in accordance with ASTM D 5821, the coarse aggregate shall meet the following criteria. Crushed limestone, dolomite, steel slag and porphyry will be considered as having 100 percent two fractured faces unless visual observations indicate an undesirable particle shape is being produced.

Design	CAA[a]
F	55/None
E	75/None
C	95/90
B	100/100

[a]The criteria denotes the minimum allowable percentage of the coarse aggregate with "one/two" fractured faces, such as a "95/90" requirement, means that the coarse aggregate shall have a minimum of 95 percent particles by weight with one fractured face and a minimum of 90 percent particles by weight with two fractured faces.

403.2.3 Clay Content. When tested in accordance with AASHTO T 176, blended aggregate particles passing the No. 4 sieve shall meet the following minimum sand equivalent criteria:

Design	Sand Equivalent
F	40
E	40
C	45
B	50

403.2.4 Thin, Elongated Particles. For all mixtures except SMA, the blended aggregate particles retained on the No. 4 sieve shall not exceed 10 percent, based on a ratio of 5:1 when tested for flat and elongated particles in accordance with ASTM D 4791.

403.2.5 Stone Matrix Asphalt. In addition to other requirements, material for SMA mixtures shall meet the following. Coarse aggregate shall consist of crushed limestone and either porphyry or steel slag in accordance with the quality requirements of Sec 1002, except as follows. The Los Angeles (LA) abrasion, when tested in accordance with AASHTO T 96, shall not exceed 40 percent based on initial ledge approval and source approval. The percent absorption, when tested in accordance with AASHTO T 85, shall not exceed 3.5 percent based on the individual fractions. The amount of flat and elongated particles, measured on material retained on a No. 4 sieve, of the blended aggregate shall not exceed 20 percent based on a 3:1 ratio or 5 percent based on a 5:1 ratio.

403.2.5.1 Filler Restriction. Rigden void content determined in accordance with MoDOT Test Method TM-73 shall be no greater than 50 percent.

403.2.5.2 Fibers. A fiber additive shall be used as a stabilizer in SMA Mixtures. Fibers shall be uniformly distributed by the end of the plant mixing process. The dosage rate for fibers shall be no less than 0.3 percent by weight of the total mixture for cellulose and no less than 0.4 percent by weight for mineral fibers.

403.2.6 Reclaimed Asphalt. A maximum of 30 percent virgin effective binder replacement may be used in mixtures without changing the grade of binder. The asphalt binder content of recycled asphalt materials shall be determined in accordance with AASHTO T 164, ASTM D 2172 or other approved method of solvent extraction. A correction factor for use during production may be determined for binder ignition by burning a sample in accordance with AASHTO T 308 and subtracting from the binder content determined by extraction. The aggregate specific gravity shall be determined by performing AASHTO T 209 in accordance with Sec 403.19.3.1.2 and calculating the G_{se} to use in lieu of G_{sb} as follows:

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}}$$

403.2.6.1 Reclaimed Asphalt Pavement. Reclaimed Asphalt Pavement (RAP) may be used in any mixture, except SMA mixtures. Mixtures may be used with more than 30 percent virgin effective binder replacement provided testing according to AASHTO M 323 is included with the job mix formula that ensures the combined binder meets the grade specified in the contract. All RAP material, except as noted below, shall be tested in accordance with AASHTO T 327, Method of Resistance of Coarse Aggregate Degradation by Abrasion in the Micro-Deval Apparatus. Aggregate shall have the asphalt coating removed either by extraction or binder ignition during production. The material shall be tested in the Micro-Deval apparatus at a frequency of once per 1500 tons . The percent loss shall not exceed the Micro-Deval loss of the combined virgin material by more than five percent. Micro-Deval testing will be waived for RAP material obtained from MoDOT roadways. All RAP material shall be in accordance with Sec 1002 for deleterious and other foreign material.

403.2.6.2 Reclaimed Asphalt Shingles. Reclaimed Asphalt Shingles (RAS) may be used in any mixture specified to use PG 64-22 in accordance with AASHTO PP 53 except as follows: When the ratio of virgin effective binder to total binder in the mixture is between 60 and 70 percent, the grade of the virgin binder shall be PG 52-28 or PG 58-28. Shingles shall be ground to 3/8-inch minus. Waste, manufacturer or new, shingles shall be essential free of deleterious materials. Post-consumer RAS shall not contain more than 1.5 percent wood by weight or more than 3.0 percent total deleterious by weight. Post-consumer RAS shall be certified to contain less than the maximum allowable amount of asbestos as defined by national or local standards. The gradation of the aggregate may be determined by solvent extraction of the binder or using the following as a standard gradation:

Shingle Aggregate Gradation	
Sieve Size	**Percent Passing by Weight**
3/8 inch	100
No. 4	95
No. 8	85
No. 16	70
No. 30	50
No. 50	45
No. 100	35
No. 200	25

403.3 Composition of Mixtures.

403.3.1 Gradation. Prior to mixing with asphalt binder, the combined aggregate gradation, including filler if needed, shall meet the following gradation for the type of mixture specified in the contract. A job mix formula may be approved which permits the combined aggregate gradation during mixture production to be outside the limits of the master range when the full tolerances specified in Sec 403.5 are applied.

Percent Passing by Weight							
Sieve Size	**SP250**	**SP190**	**SP125**	**SP095**	**SP048**	**SP125xSM(R)**	**SP095xSM(R)**
1 1/2 inch	100	---	---	---	---	---	---
1 inch	90 - 100	100	---	---	---	---	---
3/4 inch	90 max.	90 - 100	100	---	----	100	---
1/2 inch	---	90 max.	90 - 100	100	---	90-100	100

3/8 inch	---	---	90 max.	90-100	100	50-80	70-95
No. 4	---	---	---	90 max.	90-100	20 - 35	30-50
No. 8	19 - 45	23 - 49	28 - 58	32-67	---	16 - 24	20-30
No. 16	---	---	---	---	30-60	---	21 max.
No. 30	---	---	---	---	---	---	18 max.
No. 50	---	---	---	---	---	---	15 max.
No. 100	---	---	---	---	---	---	---
No. 200	1 - 7	2 - 8	2 - 10	2-10	7-12	8.0-11.0	8.0-12.0

403.3.2 Anti-Strip Agent. An anti-strip will be allowed by the engineer to improve resistance to stripping. Anti-strip agents and application rates shall be from a list approved in accordance with Sec 1071.

403.3.3 Porphyry Mixtures. For LP and SMA mixtures, at least 50 percent by volume of the aggregate shall be crushed porphyry retained on the following sieves: No. 30 for SP048, No. 16 for SP095 and No. 8 for SP125. Depending on the actual gradation of porphyry aggregate furnished, the amount of crushed porphyry required may vary, however at least 40 percent by weight of crushed porphyry will be required. Steel slag may be substituted for porphyry in LP and SM mixtures, except at least 45 percent by weight of crushed porphyry and/or slag will be required. The engineer may approve the use of other hard, durable aggregate in addition to porphyry and steel slag. . When an SMR mixture is designated, the mixture shall contain aggregate blends with at least 30 percent non-carbonate material in accordance with Sec 403.3.5.

403.3.4 Minimum Stone Matrix Asphalt Binder. The percent asphalt binder for SMA mixtures shall not be less than 6.0 percent unless otherwise allowed by the engineer.

403.3.5 Surface Mixtures. Design level B surface mixtures and SP048NC, except as described in Sec 403.15.3, containing limestone coarse aggregate shall contain a minimum amount of non-carbonate aggregate. The LA abrasion values, AASHTO T 96, of the limestone will determine the type and amount of non-carbonate aggregate required as shown in the table below. The LA abrasion value will be determined from the most recent source approval sample. In lieu of the above requirements, the aggregate blend shall have an acid insoluble residue (AIR), MoDOT Test Method TM 76, meeting the plus No. 4 criteria of crushed non-carbonate material. Non-carbonate aggregate shall have an AIR of at least 85 percent insoluble residue.

Coarse Aggregate (+ No. 4)	Minimum Non-Carbonate by Volume
Limestone, LA $\leq$ 30	30% Plus No. 4
Limestone, LA > 30	20% Minus No. 4[a]
Dolomite	No Requirement

[a] Use for all SP095 and SP048NC containing limestone.

403.4 Job Mix Formula. At least 30 days prior to placing any mixture on the project, the contractor shall submit a mix design for approval to Construction and Materials. The mixture shall be designed in accordance with AASHTO R 35 or R 46 and shall be tested in accordance with AASHTO T 312 except as noted herein. A detailed description of the mix design process shall be included with the job mix formula (JMF). Representative samples of each ingredient for the mixture shall be submitted with the mix design. Aggregate fractions shall be provided in the same proportions as the proposed job mix formula. A minimum of 150 pounds will be required for any individual fraction. The amount of each ingredient submitted shall be as follows for each mix design to be verified:

Ingredient	Minimum Amount
Aggregate	750 Pounds
Hydrated Lime, Mineral Filler and/or Baghouse Fines	20 Pounds
Asphalt Binder	10 Gallons

403.4.1 Proficiency Sample Program. Laboratories that participate in and achieve a score of three or greater in the AASHTO proficiency sample program for T 11, T 27, T 84, T 85, T 166, T 176, T 209, T 304 (ASTM C 1252), T 308 and T 312 will have the mixture verification process waived. The mix design shall be submitted to Construction and Materials for approval at least seven days prior to mixture production.

403.4.2 Required Information. The mix design shall include raw data from the design process and contain the following information:

(a) All possible sources intended for use, and grade and specific gravity of asphalt binder.

(b) Source, type (formation, etc.), ledge number if applicable, gradation, and deleterious content of each aggregate fraction.

(c) Bulk and apparent specific gravities and absorption of each aggregate fraction in accordance with AASHTO T 85 for coarse aggregate and AASHTO T 84 for fine aggregate including all raw data.

(d) Specific gravity of hydrated lime, mineral filler or baghouse fines, if used, in accordance with AASHTO T 100.

(e) Percentage of each aggregate component.

(f) Combined gradation of the job mix.

(g) Percent asphalt binder, by weight, based on the total mixture and percent asphalt binder contributed by reclaimed asphalt materials.

(h) Bulk specific gravity (G_{mb}) by AASHTO T 166 Method A of a laboratory compacted mixture compacted at N_{design} gyrations.

(i) Percent air voids (V_a) of the laboratory compacted specimen compacted to Ndesign gyrations.

(j) Voids in the mineral aggregate (VMA) and voids in the mineral aggregate filled with asphalt binder (VFA) at N_{design} gyrations.

(k) Theoretical maximum specific gravity (G_{mm}) as determined by AASHTO T 209, in accordance with Sec 403.19.3, after the sample has been short term aged in accordance with AASHTO R 30.

(l) The tensile strength ratio as determined by AASHTO T 283 including all raw data.

(m) The gyratory sample weight to produce a 115 mm minimum height specimen.

(n) Mixing temperature and gyratory molding temperature.

(o) Number of gyrations at $N_{initial}$, N_{design}, and $N_{maximum}$.

(p) Dust proportion ratio (-200/P_{be}).

(q) Bulk specific gravity (G_{sb}) of the combined aggregate.

(r) Percent chert contained in each aggregate fraction.

(s) Percent of G_{mm} at $N_{initial}$ and $N_{maximum}$.

(t) Blended aggregate properties for clay content, angularity, and thin and elongated particles.

(u) Voids in coarse aggregate (VCA) for both the mixture and dry-rodded condition for SMA mixtures.

(v) Draindown for SMA mixtures.

(w) Baghouse fines added for design.

(i) Batch and continuous mix plants – Indicate which aggregate fraction to add baghouse percentage during production.

(ii) Drum mix plants – Provide cold feed settings with and without baghouse percentage.

403.4.3 Approval. No mixture will be accepted for use until the JMF for the project is approved by Construction and Materials.

403.4.4 Job Mix Formula Modification. The JMF approved for each mixture shall be in effect until modified in writing by the engineer. When unsatisfactory results occur or should a source of material be changed, a new JMF may be required.

403.4.5 Design Gyrations. The number (N) of gyrations required for gyratory compaction shall be as follows:

Design	[b] $N_{initial}$	[a] N_{design}	[a,b] $N_{maximum}$
F	--	50	--
E	7	75	115
C	8	80 or 100	160
B	9	125	205

[a]SMA mixtures shall have N_{design} equal to 100 and no $N_{maximum}$ requirement.

[b]Design Level C mixtures designed at 80 gyrations shall have no $N_{initial}$ or $N_{maximum}$ requirements.

In addition, the compaction level, as a percent of theoretical maximum specific gravity, shall be less than or equal to 91.5 percent for Design F, 90.5 percent for Design E and 89.0 percent for Designs C and B at $N_{initial}$, equal to 96.0 percent at N_{design} and less than or equal to 98.0 percent at $N_{maximum}$.

403.4.6 Mixture Characteristics. When compacted in accordance with AASHTO T 312, the mixture shall meet the following criteria.

403.4.6.1 Air Voids (V_a). Design air voids for all mixtures at all traffic levels shall be 4.0.

403.4.6.2 Voids in the Mineral Aggregate (VMA).

Mixture	VMA Minimum (percent)
SP250	12.0
SP190	13.0
SP125 (except for SMA)	14.0
SP095 (except for SMA)	15.0
SP048	16.0
SMA	17.0

403.4.6.3 Voids Filled With Asphalt (VFA).

Design	VFA (percent)[a]
F	70 - 80
E	65 – 78
C	65 – 75[b]
B	65 – 75[b]

[a]SMA and SP048 mixtures shall have a minimum VFA of 75 percent.

[b]Maximum 76 percent for SP095 and 78 percent for SP048.

403.4.7 Dust to Binder Ratio. For all mixtures except SMA and SP048, the ratio of minus No. 200 material to effective asphalt binder (Pbe) shall be between 0.8 and 1.6. For SP048, the ratio of minus No. 200 material to effective asphalt binder (Pbe) shall be between 0.9 and 2.0.

403.4.8 Moisture Susceptibility. For all mixtures except SMA, the mixture shall have a tensile strength ratio (TSR) greater than 80 percent when compacted to 3.7 inches with 7 ±0.5 percent air voids and tested in accordance with AASHTO T 283. SMA mixtures shall have a TSR greater than 80 percent when compacted to 3.7 inches with 6 ±0.5 percent air voids and tested in accordance with AASHTO T 283.

403.4.9 Draindown. AASHTO T 305, Draindown Test, shall be performed on all SMA mixtures prior to job mix approval. The mixture shall be stabilized in such a way that the draindown of the asphalt binder shall not exceed 0.3 percent by weight of mixture.

403.4.10 Voids in Coarse Aggregate. The percent VCAMIX of SMA mixtures shall be less than or equal to the VCADRC as determined using AASHTO T 19. This may be calculated using the following equations:

$$VCA_{DRC} = 100 \times (G_{CA}\gamma_w - \gamma_s) / G_{CA}\gamma_w$$

$$VCA_{MIX} = 100 - (P_{bp} \times G_{mb} / G_{CA})$$

$$P_{bp} = P_s \times PA_{bp}$$

Where: G_{CA} = bulk specific gravity of the combined coarse aggregate (AASHTO T 85),
γ_s = unit weight of coarse aggregate in the dry-rodded condition (DRC) (lb/ft3) (AASHTO T 19),
γ_w = unit weight of water (62.34 lb/ft3) ,
P_{bp} = percent aggregate by total mixture weight retained on No. 4 sieve and
PA_{bp} = percent aggregate by total aggregate weight retained on No. 4 sieve*.

*Use No. 8 sieve for SP095xSM

403.5 Mixture Production Specification Limits.

403.5.1 Gradation and Deleterious Content Control. The gradation of the aggregate shall be determined from samples taken from the hot bins on batch-type or continuous mixing plants or from the composite cold feed belt on drum mix plants. The gradation may also be obtained by sampling the mixture and testing the residual aggregate. The deleterious content of the aggregate shall be determined from samples taken from the composite cold feed belt. The RAP shall be sampled from the RAP feeding system on the asphalt plant. The contractor shall determine on a daily basis at minimum, the gradation on the aggregate reclaimed from the RAP by either extraction or binder ignition. The results shall be used to determine the daily specification compliance for the combined gradation.

403.5.1.1 Stone Matrix Asphalt Tolerances. In producing mixtures for the project, the plant shall be operated such that no intentional deviations from the job mix formula are made. The maximum deviation from the approved job mix formula shall be as follows for SMA mixtures:

Sieve	Max. Tolerance	
	SP095	SP125
3/4 inch	---	---
1/2 inch	---	±4
3/8 inch	±4	±4
No. 4	±3	±3
No. 8	±3	±3
No. 200	±2	±2

403.5.1.2 Mixture Tolerance. For all other SP mixtures, the percent passing the first sieve size smaller than the nominal maximum size shall not exceed 92.0 percent, a tolerance not to exceed 2.0 percent on the No. 8 sieve from the table in Sec 403.3.1, and within the range listed in Sec 403.3.1 for the No. 200 sieve The deleterious content of the material retained on the No. 4 sieve shall not exceed the limits specified in Sec 1002.2.

403.5.2 Density. The final, in-place density of the mixture shall be 94.5 ± 2.5 percent of the theoretical maximum specific gravity for all mixtures except SMA. SMA mixtures shall have a minimum density of 94.0 percent of the theoretical maximum specific gravity. The theoretical maximum specific gravity shall be

determined from a sample representing the material being tested. Tests shall be taken not later than the day following placement of the mixture. The engineer will randomly determine test locations.

403.5.2.1 Shoulder Density. Density on non-integral shoulders shall be in accordance with Sec 403.15.3.

403.5.2.2 Integral Shoulder. When shoulders are placed integrally with the traveled way, tests shall be taken on the traveled way.

403.5.2.3 Longitudinal Joint Density. Density along longitudinal joints shall be in accordance with Sec 403.16.1.

403.5.3 Asphalt Content. The asphalt content (AC) shall be within ±0.3 percent of the approved mix design.

403.5.4 Voids in the Mineral Aggregate. The VMA shall be within – 0.5 and + 2.0 percent of the minimum required for each type of mixture at N_{des} gyrations.

403.5.5 Air Voids. Air voids shall be within ±1.0 percent of the approved mix design at N_{des} gyrations.

403.5.6 Tensile Strength Ratio. The TSR shall be greater than or equal to 75 percent as determined from loose mixture taken from the roadway and tested in accordance with AASHTO T 283.

403.5.7 Aggregate Properties. Aggregate properties from Sec 403.2 on the combined aggregate during production shall be no less than 2 percent below the minimum for FAA, no less than 5 percent below the minimum for CAA, no less than 5 percent below the minimum for clay content and no more than 2 percent above the maximum for thin, elongated particles.

403.5.8 Fibers. The fiber proportioning and delivery system for SMA mixtures shall have an accuracy of 10 percent by weight of the material actually being measured in any given period of time.

403.5.9 Moisture Content. The asphaltic concrete mixture, when sampled and tested in accordance with AASHTO T 329, shall not contain more than 0.5 percent moisture by weight of the mixture.

403.5.10 Contamination. The asphaltic concrete mixture shall not be contaminated with deleterious agents such as unburned fuel, objectionable fuel residue or any other material not inherent to the job mix formula.

403.6 Field Laboratory. The contractor shall provide a Type 3 field laboratory in accordance with Sec 601. The contractor shall furnish the bituminous mixture equipment to perform all required test methods for QC and QA work. The gyratory compactor shall be evaluated in accordance with AASHTO PP 35. An approved list will be maintained by Construction and Materials. All other equipment shall be capable of performing tests in accordance with the approved test methods.

403.7 Bituminous Mixing Plants. Bituminous mixing plants and preparation of material and mixtures shall be in accordance with Sec 404.

403.8 Hauling Equipment. Trucks used for hauling bituminous mixtures shall be in accordance with Sec 404.

403.9 Pavers. Bituminous pavers shall be self-contained units, provided with an activated screed or strike-off assembly, heated if necessary, and capable of spreading and finishing asphaltic concrete in lane widths applicable to the specified typical sections and thicknesses shown on the plans.

403.10 Construction Requirements.

403.10.1 Weather Limitations. No mixture shall be placed on any wet or frozen surface. Temperatures shall be obtained in accordance with MoDOT Test Method TM 20.

403.10.2 Substitutions. With approval from the engineer, the contractor may substitute a smaller nominal maximum size mixture for a larger sized mixture. Specifications governing the substitute mixture shall apply. Except for a single surface layer, the total pavement thickness shall be maintained when the substitute mixture layer is reduced as allowed in Sec 403.13 by increasing the thickness of other layers or courses. The contract unit price for the original mixture shall be used.

403.11 Field Adjustments of Job Mix Formulas. When test results indicate the mixture produced does not meet the specification requirements, the contractor may field adjust the job mix formula as noted herein. Field adjustments may consist of changing the percent binder as listed on the original approved job mix by no more than 0.3 percent. Additional fractions of material or new material will not be permitted as field adjustments. The engineer shall be notified immediately when any change is made in the cold feed settings, the hot bin settings or the binder content. A new Gsb shall be calculated using the new aggregate percentages. The gradation of the adjusted mixture shall meet the requirements of the mixture type specified in the contract. When the binder content is adjusted more than 0.3 percent, the mixture will be considered out of specification, and a new mix design shall be established.

403.11.1 Field Mix Redesign. When a new mix design will be required, the contractor will be permitted to establish the new mix design in the field. The mixture shall be designed in accordance with AASHTO R 35 or AASHTO R 46 and shall meet the mix design requirements, including TSR. A representative sample of the mixture shall be submitted with the new mix design to the Central Laboratory for mixture verification. The amount of mixture submitted for verification shall weigh at least 50 pounds.

403.11.1.1 Approval. New mix designs established in the field shall be submitted for approval to Construction and Materials. Upon approval, Construction and Materials will assign a new mix number to the mixture.

403.11.1.2 Resume Production. No mixture shall be placed on the project until the new field mix design is approved.

403.12 Application of Prime or Tack. The prime coat, if specified, shall be applied in accordance with Sec 408. A tack coat is required on all existing pavement and shoulder surfaces that will be overlaid with a bituminous mixture. A tack coat is also required between all lifts of bituminous pavements placed within the driving and turn lanes, unless otherwise specified in the contract. All construction requirements of a tacked surface shall be in accordance with Sec 407, and specified herein. The tack coat shall be applied uniformly and shall completely cover the surface upon which the bituminous mixture is to be placed. Placement of a bituminous mixture shall not be placed upon a tacked surface that is not uniformly covered or surfaces that have experienced excessive loss of tack due to tracking. Re-application of tack due to excess tracking or non-uniform coverage shall be at the contractor's expense.

403.13 Spreading and Finishing. The base course, primed or tacked surface, or preceding course or layer shall be cleaned of all dirt, packed soil or any other foreign material prior to spreading the asphaltic mixture. If lumps are present or a crust of mixture has formed, the entire load will be rejected. The thickness and width of each course shall conform to the typical section in the contract. The contractor may elect to construct each course in multiple layers. The minimum compacted thickness shall be 0.75 inches for SP048, 1.25 inches for SP095, 1.75 inches for SP125, 2 inches for SP190, and 3 inches for SP250.

403.13.1 Paving Widths. The following shall apply for roadways constructed under traffic. For pavements having a width of 16 to 24 feet, inclusive, the asphaltic concrete pavement shall be laid in lanes approximately one half the full width of the completed pavement, and the full width shall be completed as soon as practical. Unless otherwise permitted, a single lane of any course shall not be constructed to a length that cannot be completed to full width of the pavement the succeeding operating day. For pavements greater than 24 feet wide, single lane width construction shall be limited to one day's production and completion to full width shall be accomplished as soon as practical. Uneven pavement shall be left in place for no more than seven days, unless approved by the engineer. Removal of pavement to be in accordance with this specification shall be at the contractor's expense.

403.13.2 Segregation. No segregation will be permitted in handling the mixture at the plant, from the truck or during spreading operations on the roadbed. All layers shall be feathered out, by hand raking if necessary, in transitioning the depth of the surface to meet present grades at bridges or ends of projects, to provide a uniform, smooth riding surface free of irregularities. Where only the top layer of the surfacing continues across a bridge, the bottom layers shall be feathered out. In situations where there is a dispute in the existence of segregation, the area in question will be tested in accordance with MoDOT Test Method TM 75. Mixture production shall immediately cease if either criteria of MoDOT Test Method TM 75 fail. Segregated mixture shall be removed and replaced to the limits determined by the engineer.

403.13.3 Release to Traffic. If the asphaltic concrete construction consists of more than a single layer, each

layer shall be compacted as specified and allowed to cool to the ambient temperature before the next layer is placed. The contractor shall keep traffic off the asphaltic concrete until the surface of the asphaltic concrete is 140 F or below and the asphaltic concrete has cooled sufficiently to prevent flushing of the asphalt binder to the surface, marking or distorting the surface or breaking down the edges.

403.13.4 Draindown. Evidence of asphalt binder separation or draindown at delivery will be cause for rejection.

403.13.5 Shoulder Substitution. When a Sec 403 mixture is specified for traffic lanes, the same mixture may be used for the adjacent shoulder, subject to the density requirements in Sec 403.5.2.

403.14 Spot Wedging and Leveling Course. The engineer will specify the locations and thickness of spot wedging and the thickness of leveling course to obtain the smoothest possible riding surface. This procedure may result in spot wedging operations over small areas with feather-edging at high points and ends of wedge areas. Rigid control of the placement thickness of the leveling course shall be required. Leveling course, consisting of a layer of asphaltic concrete of variable thickness used to superelevate curves and eliminate irregularities in the existing base, shall be spread uniformly to the specified profile grade and cross section. The mixture shall be uniformly spread and compacted, with only minor segregation as accepted by the engineer. Type SP125 or finer mixtures, as applicable, shall be used for the spot wedging and for the leveling course.

403.15 Compaction. After the asphaltic mixture has been spread, struck off and surface irregularities adjusted, the asphaltic mixture shall be compacted thoroughly and uniformly by rolling to obtain the required compaction while the mixture is in a workable condition. Excessive rolling, to the extent of aggregate degradation, will not be permitted. A pneumatic tire roller shall be used as the initial or intermediate roller on any course placed as a single lift, as a wedge or leveling course. Rollers shall not be used in the vibratory mode when the mixture temperature is below 225 F. When warm mix technology is used, as approved by the engineer, rollers shall not be used in the vibratory mode when the mixture temperature is below 200 F .

403.15.1 Rolling. Any displacement occurring as a result of starting, stopping or changing direction of a roller, or from other causes, shall be avoided. Excess liquid, to prevent adhesion of the mixture to the rollers, will not be permitted. Diesel fuel, fuel oil or other detrimental products shall not be used as wetting agents. Along forms, curbs, headers, walls and other places not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers, smoothing irons or with mechanical tampers.

403.15.2 Defective Mixture. Any mixture that becomes loose and broken, mixed with dirt or is in any way defective shall be removed and replaced with fresh, hot mixture, which shall be compacted to conform with the surrounding area. Any area showing an excess or deficiency of asphalt binder shall be removed and replaced.

403.15.3 Non-Traffic Areas. Sec 403 mixtures used for surfacing medians and similar areas, shoulders adjacent to rigid or flexible pavement and shoulders adjacent to resurfaced pavement shall be compacted to the specified densities for the mixture. Once an established rolling pattern has been demonstrated to provide the required density for shoulders, at the engineer's discretion, the pattern may be used in lieu of density tests provided no changes in the material, typical location or temperatures are made. Regardless of the method, density will still be required and subject to testing as deemed necessary by the engineer. In lieu of roller and density requirements, temporary bypasses to be maintained at the expense of the contractor shall be thoroughly compacted. The rolling shall be performed at proper time intervals and shall be continued until there is no visible evidence of further consolidation.

403.15.4 Density Measurement. Measurements for determining the in-place density of the mixture shall be taken no later than the day following placement. Measurements not obtained within the prescribed time limits shall be subject to the requirements of Sec 403.22. If a core is taken, material from underlying layers that remain adhered to the core shall be removed in a manner that does not harm the integrity of the specimen. If the contractor elects to place a lift of mixture greater than six times the nominal maximum aggregate size, cores shall be cut in half and the density of each half determined separately.

403.16 Joints. Transverse joints shall be formed by any method that will produce a dense, vertical section for use when laying is resumed. When a transverse vertical edge is to be left and opened to traffic, a temporary depth transition shall be built as approved by the engineer. The joint formed when the fresh mixture is placed shall be dense, well sealed, and the grade, line and surface texture of the succeeding surface shall conform to that of the joined surface. If directed by the engineer, the transverse joint shall be painted with a light coating of liquid asphalt. Hand manipulation of the mixture shall be minimized to avoid unsightly surface texture.

403.16.1 Joint Composition. Longitudinal joints shall be formed by the use of an edging plate fixed on both sides of the finishing machine. Care shall be taken to obtain a well bonded and sealed longitudinal joint by placing the hot mixture in a manner ensuring maximum compaction at this point. If directed by the engineer for properly sealing the longitudinal joint, a light coating of bituminous material shall be applied to the exposed edge before the joint is made. The minimum density of all traveled way pavement within 6 inches of a longitudinal joint, including the pavement on the traveled way side of the shoulder joint, shall not be less than 2.0 percent below the specified density when unconfined. The density of the longitudinal joint when confined will be included in the evaluation of the remainder of the mat. Each side of the joint shall be flush and along true lines.

403.16.2 Joint Offset. The longitudinal joint in any layer shall offset that in the layer immediately below by a minimum of 6 inches; except, the joints in the completed surfacing shall be at the lane lines of the traveled way or other required placement width outside the travel lane. The placement width shall be adjusted such that pavement marking shall not fall on a longitudinal joint.

403.17 Quality Control.

403.17.1 Quality Control Operations. The contractor shall maintain equipment and qualified personnel to perform all QC field inspection, sampling and testing as required by this specification. All contractor personnel included in the QC operation shall be qualified by the MoDOT Technician Certification Program. Under no circumstances will unqualified personnel be allowed to perform QC sampling or testing. Personnel will be disqualified if acceptable methods and procedures are not followed.

403.17.1.1 Asphalt Test Results. The contractor shall record all test results and furnish a copy, including all raw data, to the engineer no later than the beginning of the day following the test. The contractor shall maintain all test results in an organized format and shall be available to the QA inspector at all times. Scale readings and other measurements not directly recorded by electronic media shall be recorded in an organized format. Printouts from gyratory compactors and asphalt content devices shall be retained as part of the testing records.

403.17.2 Bituminous Quality Control Plan. Prior to approval of the trial mix design by the engineer, the contractor shall submit a QC Plan to Construction and Materials for approval. The QC Plan shall include:

(a) The contractor representative in charge of QC and the project level representative if different from the contractor representative. Contact information should be recorded for these individuals.

(b) Lot and sublot sizes and how they will be designated.

(c) The test method for determining asphalt content and number of cores to be cut for density determination.

(d) A proposed independent third party name, contact, address, and phone number for dispute resolution.

403.17.2.1 Third Party. The third party shall be independent of the contractor, MoDOT consultants and all project subcontractors or suppliers on each specific project. All testing of material for dispute resolution shall be performed by an approved laboratory. Approved laboratories shall be AASHTO Accreditation Program certified in the areas of the material being tested.

403.17.2.2 Plant Calibration. Plant calibration shall be performed by the contractor in accordance with Sec 404, and records shall be made available to the engineer.

403.17.2.3 Retained Samples. All samples taken by the contractor, including but not limited to tested aggregate, volumetric and density samples, shall be retained for the engineer for a minimum of seven days after the contractor's tests are complete and accepted unless otherwise instructed. These samples shall be maintained in clean covered containers, without contamination, readily accessible to the engineer. The retained sample's identification shall consist of, but is not limited to:

(a) Time and date sampled.

(b) Product specification number.

(c) Type of sample, i.e. belt, bin, stockpile.

(d) Lot and sublot designation.

(e) Sampler/Tester.

(f) Project Job Number.

403.17.2.3.1 Gradation and Deleterious Content Samples. For each gradation and deleterious sample taken, the contractor shall retain for the engineer, the portion of the sample not tested after reducing the original sample to testing size.

403.17.2.3.2 Loose Mix Sample. All loose mix samples for determination of volumetrics, asphalt binder content and TSR shall be taken from the roadway at random locations designated by the engineer. A companion loose mix sample shall be taken, identified and retained for the engineer.

403.17.3 Quality Control Laboratory. All QC mixture testing shall be performed in an approved laboratory.

403.17.3.1 Calibration Schedule. The contractor shall calibrate or verify all significant test equipment associated with tests covered in this specification. Intervals as set by the contractor shall not exceed the following limits:

Equipment - Test Method (AASHTO)	Requirement	Interval (Month)
Gyratory Compactor - T 312	Calibrate – 1.16 ± .02° internal angle	12[a]
Gyratory Compactor - T 312	Verify	Daily
Gyratory Molds - T 312	Check Critical Dimensions	12
Thermometers - T 209, T 166, T 312	Calibrate	6
Vacuum System - T 209	Check Pressure	12
Pycnometer (Flask) - T 209	Calibrate	Daily
Binder Ignition Oven - T 308	Verify	12[b]
Nuclear Content Gauge – T 287 or MoDOT TM 54	Drift & Stability – Manuf. Recommendation	1
Mechanical Shakers - T 27	Check Sieving Thoroughness	12
Sieves	Check Physical Condition	6
Weighted Foot Assembly - T 176	Check Weight	12
Mechanical Shaker - T 176	Check Rate & Length of Throw	12
Liquid Limit Device - T 89	Check Wear & Critical Dimensions	12
Grooving Tool - T 89	Check Critical Dimensions	12
Ovens	Verify Temp. Settings	4
Balances	Verify	12[b]
Timers	Check Accuracy	6

[a]Calibrate and/or verify after each move.
[b]Verify after each move.

403.17.3.1.1 Inventory. An inventory of all major sampling, testing, calibration and verification equipment, including the serial number or other identifying number shall be maintained.

403.17.3.1.2 Calibration Records. Calibration and verification records shall include but are not limited to:

(a) Detailed results of the work performed (dimensions, mass, force, temperature, etc.)

(b) Description of the equipment calibrated including identifying number.

(c) Date the work was performed.

(d) Identification of the individual performing the work.

(e) Identification of the calibration or verification procedure used.

(f) The previous calibration or verification date and next due date.

(g) Identification of any in-house calibration or verification device used (including identification to establish traceability of items such as standard masses, proving rings, standard thermometers, balances, etc.).

403.17.3.2 Record Retention. Test records shall be maintained to permit verification of any test report. Records pertaining to testing, equipment calibration and verification, test reports, internal quality systems review, proficiency sample testing, test technician training and evaluation and personnel shall be retained in a secure location for a minimum of three years.

403.17.3.3 Test Method Availability. A current copy of all test methods and procedures shall be maintained in the QC laboratory at all times for reference by the technicians. Examples of report formats and procedures may be found in AASHTO R 18.

403.18 Quality Assurance. All QA field inspection, sampling and testing will be performed by a qualified MoDOT technician. The QA inspector shall have free access to any and all testing equipment used by the mixture producer and any workbooks, records or control charts maintained by the mixture producer for the QC process. The QA inspector shall also have sufficient access to the plant grounds to assure compliance with the approved QC Plan.

403.18.1 Assurance Testing. The engineer will independently sample and test the mixture from the roadway at the frequency listed in Sec 403.19.3. The independent sample will be of sufficient size to retain half for possible disputes. Further testing of this sample will be under the direction of the engineer. The retained portion of the QC samples for mixture properties, gradation, and deleterious content will be tested at a frequency no less than once per week. The engineer's test results, including all raw data, will be made available to the contractor when completed and no later than the next working day.

403.18.2 Core Chain of Custody. QA density cores that are not in possession of the engineer for the entire time from extraction till testing shall be sealed in tamper proof bags after extraction.

403.18.3 Aggregate Comparison. Comparison for aggregate will be considered favorable when the contractor's QC results and the engineer's QA test results of a retained sample compare within the following limits.

403.18.3.1 Gradation.

Sieve Size	Percentage Points
3/4 inch and larger	5.0
1/2 inch	5.0
3/8 inch	4.0
No. 4	4.0
No. 8	3.0
No. 10	3.0
No. 16	3.0
No. 20	3.0
No. 30	3.0
No. 40	2.0
No. 50	2.0
No. 100	2.0
No. 200	1.0

403.18.3.2 Coarse Aggregate Angularity. Angular particles shall be within 5 percentage points.

403.18.3.3 Fine Aggregate Angularity. Void content shall be within 2 percentage points.

403.18.3.4 Sand Equivalent. Sand equivalency shall be within 8 percentage points.

403.18.3.5 Thin, Elongated Particles. Flat, elongated particle content shall be within one percentage point.

403.18.3.6 Deleterious. The total and individual deleterious content shall not exceed the specification limits.

403.18.4 Federal Highway Administration Requirements. Performance and acceptance of QC/QA testing under these specifications shall not eliminate any FHWA requirements for acceptance of the material.

403.19 Acceptance of Material. Acceptance of bituminous mixture will be based on lots. Material will be sampled from the roadway behind the paver in lots or sublots on a random basis through the use of a random number system and evaluated using a Quality Level Analysis (QLA). A QLA will determine payment based on a combination of the total PWL (PWLt) determined for each pay factor item for each lot of material produced.

403.19.1 Random Numbers. The engineer will generate random numbers.

403.19.2 Lots. The lot size shall be designated in the contractor's QC Plan. Each lot shall contain no less than four sublots with a maximum sublot size of 1,000 tons. Sublots from incomplete lots shall be combined with the previous complete lot for determination of pay factors. When no previous lot exists, the mixture shall be treated in accordance with Sec 403.23.7.4.1. A new lot shall begin when the asphalt content of a mixture is adjusted in accordance with Sec 403.11.

403.19.3 Test and Pay Factor Items. As a minimum, the contractor and engineer shall test in accordance with the following table. Where multiple test methods are allowed, the contractor shall designate the test method to be used in the QC Plan. Final payment will be based on the indicated pay factor items.

Tested Property	Pay Factor	Test Method	Contractor Frequency	Engineer Frequency
Mixture temperature	No	----	1/Sublot	1/day
Temperature of base and air	No	----	As needed	As needed
Mat Density (% of theoretical maximum density) by contractor	Yes	MoDOT Test Method TM-41 or AASHTO T 166[e]	1 Sample[b]/Sublot As needed for joints & shoulders.	1 Sample/4 Sublots
Unconfined Joint Density	No	MoDOT Test Method TM-41 or AASHTO T 166[e]	1 Sample[b]/Sublot	1 Sample/4 Sublots
Cold feed or hot bin gradation and deleterious content	No	AASHTO T 27 and AASHTO T 11	1/2 Sublots	1/4 Sublots
Ground shingles	No	AASHTO T 27	1/10,000 tons with a minimum of 1/project	1/project
FAA, CAA, Clay Content and Thin, Elongated Particles from material sampled from the cold feed or hot bin	No	AASHTO T 304, ASTM D 5821, AASHTO T 176 and ASTM D 4791	1/10,000 tons with a minimum of 1/project/mix type	1/project
Asphalt content	Yes	AASHTO T 164, or MoDOT Test Method TM-54, or AASHTO T 287, or AASHTO T 308	1/Sublot	1/4 Sublots
Asphalt content of RAP	No	AASHTO T 164[d]	1/4 Sublots	1/project
VMA @ N_{des} gyrations	Yes[a]	AASHTO T 312 and R 35[e]	1/Sublot	1/4 Sublots
V_a @ N_{des} gyrations	Yes[a]	AASHTO T 312 and R 35[e]	1/Sublot	1/4 Sublots
VFA @ N_{des} gyrations	No[a]	AASHTO T 312 and R 35[e]	1/Sublot	1/4 Sublots

Theo. max SG of the mixture	No	AASHTO T 209	1/Sublot	1/4 Sublots
TSR of the in place mixture	No[c]	AASHTO T 283	1/10,000 Tons or fraction thereof	1/50,000 Tons or 1/project combination

[a]Based on the average of a minimum of two compacted specimens.
[b]Core samples shall consist of one core. Up to two additional cores, as stated in the QC Plan, may be obtained at the same offset within one foot of the randomly selected location. If more than one core is obtained, all cores shall be combined into one sample.
[c]Payment will be based on the table in Sec 403.23.5.
[d]Other methods may be approved by establishing correction factors for RAP from the same source.
[e]AASHTO T 331 may be substituted for AASHTO T 166.

403.19.3.1 Test Method Modification.

403.19.3.1.1 Binder Ignition Modification. Asphalt content determination in accordance with AASHTO T 308, Section 6.9.1 shall be modified by adding the following: If the calibration factor exceeds 1.0 percent, lower the test temperature to 800 ± 8 F and repeat test. Use the calibration factor obtained at 800 F even if it exceeds 1.0 percent. If RAP is used, the binder ignition oven shall be calibrated in accordance with MoDOT Test Method TM 77. At the engineer's discretion, testing may be waived when production does not exceed 200 tons per day. The contractor shall certify the proper proportions of a previously proven mixture were used.

403.19.3.1.2 Rice Test. When the water absorption of any aggregate fraction is greater than 2.0 percent, the test method for determining theoretical maximum specific gravity, AASHTO T 209, shall be modified as follows: After completing the procedure in accordance with Section 9.5.1 or 9.5.2, drain water from the sample. To prevent loss of fine particles, decant the water through a paper towel held over the top of the container. Spread the sample before an electric fan to remove surface moisture. Weigh at 15-minute intervals, and when the loss in mass is less than 0.05 percent for this interval, the sample may be considered to be surface dry. This procedure requires about 2 hours and shall be accompanied by intermittent stirring of the sample. Break conglomerations of mixture by hand. Take care to prevent loss of particles of mixture. Calculate the specific gravity of the sample by substituting the final surface-dry mass for A in denominator of Equations 2 or 3.

403.19.3.1.3 Mixture Bulk Specific Gravity. Determining bulk specific gravity using paraffin-coated specimens, AASHTO T 275, shall not be used when required by AASHTO T 166. Alternate methods are AASHTO T 331 and ASTM D1188. The surface of specimens prepared for testing by these methods may have the surface texture removed by sawing a minimal amount. Specimens shall be securely held in a jig or other clamping device to eliminate distortion and retain a face parallel to the original surface. Measurements for lift thickness shall be made prior to sawing.

403.19.3.2 Miscellaneous Applications.

403.19.3.2.1 Small Quantities. Small quantities are less than 4000 tons for each separate mixture. This applies to individual projects, individual projects in combination contracts or projects with short discontinuous sections. The contractor has the option to use all testing frequencies in accordance with Sec 403.19.3 or the following shall apply:

(a) A field laboratory will not be required for monitoring mixtures. All required QC and QA testing shall be performed in an approved laboratory.

(b) QC tests required in Sec 403.19.3 shall be performed at a frequency of no less than one per day if production does not exceed 750 tons and at a frequency of no less than two per day if production exceeds 750 tons. Independent or retained sample QA tests shall be performed at least once per 1500 tons, as indicated.

403.19.3.2.2 Base Widening and Entrances. For base widening mixture and entrance work, the following will apply:

(a) All base widening shall be constructed in accordance with Sec 401.7 and subsections.

(b) The minimum density of these mixtures shall be attained as specified herein, except, compaction may be performed in accordance with Sec 403.15.3.

403.19.4 Dispute Resolution. When there are significant discrepancies between the engineer's and the contractor's test results, dispute resolution procedures will be used.

403.19.4.1 Cease Work. The contractor's operations may be required to cease until the dispute is resolved if the test results indicate the mixture is subject to failure.

403.19.4.2 Third Party Resolution. The first step in dispute resolution will be to identify differences in procedures and correcting inappropriate procedures before moving to third party resolution. If that does not resolve the dispute, either the contractor or the engineer may request the approved QC Plan third party involvement. The recommendations of the approved third party shall be binding on both the engineer and contractor.

403.19.4.3 Third Party Payment. The contractor shall be responsible for the cost associated with the third party testing and resolution if the final result indicates the engineer's test results were correct. Likewise the Commission will be responsible for the cost associated with the third party testing and resolution when the final result indicates the contractor's results were correct.

403.19.4.4 Other Adjustments. The contractor shall not be entitled to any additional payment for costs incurred due to use of the dispute resolution procedures such as, but not limited to, those for delay, cessation of operations, costs to subcontractors, etc. The engineer may give consideration to adjustment of working days if warranted.

403.20 Surface Smoothness. The finish of the pavement surface shall be substantially free from waves or irregularities and shall be true to the established crown and grade. The pavement surface shall be thoroughly tested for smoothness by profiling or straighedging in accordance with Sec 610.

403.21 General Requirements.

403.21.1 Sequence of Operations. To reduce inconvenience to the traveling public during widening or surfacing, the contractor will not be permitted to place any final surface course until the base widening, the leveling course and the binder course have been completed throughout the entire combination of sections, unless otherwise authorized by the engineer. The proper condition of the base widening, the leveling course and the binder course, at the time of placing the surface course, shall be the contractor's responsibility.

403.21.2 Pavement Marking. If the contractor's work has obliterated the existing pavement marking on resurfacing projects open to through traffic, the pavement marking shall be replaced in accordance with Sec 620.

403.21.3 Surfaced Approaches. At locations designated in the contract or as specified by the engineer, approaches shall be primed in accordance with Sec 408 and surfaced with Type SP125 asphaltic concrete. The asphaltic concrete surface shall be placed in accordance with the details shown on the plans or as specified by the engineer. Approaches shall not be surfaced until after the surface course adjacent to the entrance is completed. Any work required to condition and prepare the subgrade on the approaches will be at the contractor’s expense.

403.21.4 Filling Drain Basins. If shown on the plans, existing drain basins shall be filled to the top of the lip with plant mix bituminous base course or asphaltic concrete from the pavement edge to the edge of the shoulder. Any difficulty or delay created by this requirement will be at the contractor’s expense.

403.21.5 Pavement Repairs (Blow-Ups). A blow-up will be considered that area where excessive expansion has resulted in distress to the existing pavement. Blow-ups occurring prior to the application of the tack coat on the existing surface will normally be repaired by the Commission. Blow-ups occurring after the application of the tack coat shall be repaired by the contractor by removing the distressed concrete and replacing the pavement in accordance with Sec 613.

403.22 Method of Measurement.

403.22.1 Weight Determination. The weight of the mixture will be determined from the batch weights if a

batch-type plant is used, and will be determined by weighing each truck load on scales in accordance with Sec 310 if other types of plants are used. Measurement will be made to the nearest 0.1 ton for the total tonnage of material accepted.

403.22.2 Full Depth.

403.22.2.1 The final driving surface area, for the full depth of the pavement, will be used as the area for all underlying bituminous lifts and will not include the additional quantity needed to construct the 1:1 slope.

403.22.2.2 Final measurement of the completed pavement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. Where required, measurement of the pavement complete in place will be made to the nearest 0.1 square yard. The revision or correction will be computed and added to or deducted from the contract quantity.

403.22.3 Alternate Overlay.

403.22.3.1 Field Established Quantity. When bid as an alternate to a Portland cement concrete overlay, the contractor shall establish the existing roadway profile and set the final overlay profile. The engineer may adjust the final profile as needed. The tons of hot mix asphalt required will be determined by the engineer from the set or adjusted profile. This quantity will be the field established plan quantity.

403.22.3.2 Overlay Measurement. Final measurement of the completed pavement will be based on the field established plan quantity except for authorized changes during construction. The revision or correction will be computed and added to or deducted from the contract quantity. Measurement of the pavement complete in place will be made to the nearest 0.1 ton.

403.22.4 Pavement Testing. The finished courses shall have the nominal thickness shown on the plans. Tests will be conducted to ensure that each course is being constructed to proper thickness, composition and density. The contractor shall cut samples from any layer of the compacted mixture at locations designated by the engineer. QA samples shall be cut and delivered to the engineer no later than the end of the next day following the laydown operation. If the samples are not cut and delivered as stated, the asphaltic laydown operation may be suspended and a deduction of 5 percent per day of the contract unit price of the representative material may be applied, until samples are cut and delivered to the engineer. Samples may be obtained by either sawing or drilling 4-inch minimum diameter cores. Each sawed sample shall consist of a single piece of the pavement of the size designated by the engineer, but no larger than 12 inches square.

403.22.4.1 Pavement Thickness. Lift thickness may be determined by the average thickness of cores taken for density measurements for each lot. Total thickness samples for new full depth asphalt pavements shall be obtained after all bituminous construction is completed on the project and shall be taken at locations specified by the engineer. For the purpose of determining the constructed thickness of full depth pavement, cores shall be taken at random intervals in each traffic lane at the rate of one core per 1000 feet or increment thereof, or at any other locations as may be determined by the engineer and measured in accordance with AASHTO T 148. Sections of any asphaltic concrete determined to be 0.5 inches or more, less than the thickness shown on the plans, shall be corrected by the contractor. No payment will be made for any costs incurred by the contractor in correcting pavement deficient in thickness. Each core is representative of the pavement thickness for a distance extending one-half the distance to the next core, measured along centerline, or in the case of a beginning or ending core, the distance will extend to the end of the pavement.

403.22.4.2 Surface Restoration. The surface from which samples have been taken, including those for density measurements, shall be restored by the contractor with the mixture then being produced no later than the next day of plant operation, if construction is still active. If bituminous construction has been completed, the surface from which samples have been taken shall be restored within 48 hours with an approved commercial mixture or with cold patch mixtures acceptable to the engineer.

403.23 Basis of Payment.

403.23.1 Aggregate Variation. Due to possible variations in the specific gravity of the aggregates, the tonnage of mixture used may vary from the proposal quantities. No adjustment in contract unit price will be made because of such variation.

403.23.2 Compacted Samples. Payment for obtaining and delivering samples of compacted mixture from the pavement and replacing the surface will be made per sample at the fixed price specified in Sec 109. No direct payment will be made for samples taken for QC testing.

403.23.3 Payment for Pavement Repairs (Blow-ups). Payment for repairing blow-ups will be made in accordance with Sec 104.

403.23.4 Smoothness Adjustment. The contract unit price for all mixes, except wedge or level course, will be adjusted in accordance with Sec 610.5. The contract unit prices for asphaltic concrete pavement will be considered full compensation for all materials entering into the construction of the pavement and for the cost of the smoothness testing and correction.

403.23.5 Tensile Strength Retained Adjustment. The contract unit price of each 10,000 tons or fraction thereof for all mixtures shall be adjusted based on TSR according to the following:

TSR	Percent of Contract Price
90% and above	103
75-89%	100
70-74%	98
65-69%	97
<65%	Remove

403.23.6 Density Adjustment. Pay adjustments due to longitudinal joint density will apply to the full width of the lane paved. The average of joint cores from each lot will determine specification compliance. Adjustments will be in accordance with Sec 403.23.7.4.1(b). If payment reductions are necessary, the lower adjusted contract unit price of the PWL or unconfined joint density adjustment will apply. Adjustments due to joint density will apply to the lot from which the cores are obtained.

403.23.7 Percent Within Limits. PWL will be based on the mean, standard deviation and quality index of each lot's test results. The upper PWL (PWL_u) and lower PWL (PWL_l) is determined from the table in Sec 502.15.8. Total percent within limits, PWL_t, is: $PWL_t = (PWL_u + PWL_l) - 100$.

The mean is: $x_a = (\sum x_i)/n$

Where: x_a = Average of the individual values being considered

$\sum x_i$ = The summation of all the individual values being considered

n = The number of individual values under consideration

The Standard Deviation is: $s = (\sum(x_i - x_a)2/(n - 1))^{1/2}$

The Upper Quality Index is: $Qu = (USL - x_a)/s$

The Lower Quality Index is: $Q1 = (x_a - LSL)/s$

Where: Q_u = Upper Quality Index

Q_l = Lower Quality Index

USL = Pay Factor Item Upper Spec Limit

LSL = Pay Factor Item Lower Spec Limit

403.23.7.1 Quality Level Analysis. The engineer will make the QLA no more than 24 hours after receipt of the contractor's test results, by determining the PWLt for each designated pay factor item.

403.23.7.1.1 Acceptance. The contractor's test results will be used when applicable to determine the PWL, provided the contractor's QC tests and the engineer's QA tests compare favorably, and provided the engineer's inspection and monitoring activities indicate the contractor is following the approved QC Plan.

403.23.7.1.2 Comparison. Favorable comparison will be obtained when the engineer's QA test results on a production sample are within two standard deviations, or one-half the specification tolerance, whichever is greater, from the mean of the contractor's test results for that particular lot.

403.23.7.1.3 Outliers. No test result shall be discarded, except individual test results on a lot basis may be

checked for an outlier in accordance with the statistic T in ASTM E 178, at a significance level of 5 percent. If an outlier is found, material from the retained QA sample may be tested, in the presence of the engineer, to determine a replacement test value. The replacement test value shall be used in the PWL determination.

403.23.7.1.4 Roadway/Shoulder Lots. For the purpose of QLA, mixture placed on the traveled way and placed on the traveled way and shoulders integrally, shall be accounted for in a regular lot/sublot routine. Mixture placed on shoulders only shall be accounted for in a shoulder lot/sublot routine.

403.23.7.1.5 Random Sampling. For the purpose of QLA, all mixture placed on the roadway shall be subject to random testing, except mixture placed within 6 inches of an unconfined longitudinal joint shall not be subject to evaluation. Random samples taken in the same day may be separated by 200 tons.

403.23.7.2 Pay Factors. The total pay factor (PF_T) for each lot will be equal to the weighted sum of the pay factors (PF) for each pay factor item for each lot, and is determined as follows:

$$PF_T = + (0.25)\ PF_{density} + (0.25)\ PF_{AC} + (0.25)\ PF_{VMA} + (0.25)\ PF_{Va}$$

The PF_T for each lot, on the shoulder or otherwise when the density pay factor is not directly included, will be equal to the weighted sum of the PF for each pay factor item for each lot, and will be determined as follows:

$$PF_T = + (0.3333)\ PF_{AC} + (0.3333)\ PF_{VMA} + (0.3333)\ PF_{Va}$$

The PF for each pay factor item for each lot will be based on the PWL_t of each pay factor item of each lot and will be determined as follows:

When PWL_t is greater than or equal to 70: $PF = 0.5\ PWL_t + 55$
When PWL_t is less than 70: $PF = 2\ PWL_t - 50$

403.23.7.2.1 Density Pay Factor. The theoretical maximum specific gravity of the mixture, as determined for each sublot and the bulk specific gravity of no less than one core from each sublot, will be used to perform the QLA for the percent of theoretical maximum density. Thick cores required to be cut in half in accordance with Sec 403.15.4 shall effectively double the number of sublots for cores. When density is not used as a pay factor, additional adjustment of the contract unit price will be based on the table in Sec 403.23.7.4.1(b).

403.23.7.2.2 Asphalt Content Pay Factor. The QLA will be performed using the asphalt content test results from each lot.

403.23.7.2.3 Voids in the Mineral Aggregate and Air Voids Pay Factor. Two gyratory specimens shall be compacted for each sublot and the average of the two specimens will be used to calculate the volumetrics of the sublot. The VMA, VFA, and air voids shall be determined from the gyratory compacted specimens. The VMA and air voids for the QLA shall be those calculated using the combined bulk specific gravity of the aggregate as listed on the approved job mix formula, the average bulk specific gravity of the gyratory compacted specimens and the theoretical maximum specific gravity of the mixture determined for the sublot of material. The aggregate content used for the calculation shall be that determined from field asphalt content testing for that sublot.

403.23.7.3 Removal of Material. All lots of material with a PFT less than 50.0 shall be removed and replaced with acceptable material by the contractor. Any sublot of material with a percent of theoretical maximum density of less than 90.0 percent or greater than 98.0 percent shall be removed and replaced with acceptable material by the contractor. For SMA mixtures, any sublot of material with a percent of theoretical maximum density of less than 92.0 percent shall be removed and replaced with acceptable material by the contractor. Any sublot of material with air voids in the compacted specimens less than 2.5 percent shall be removed and replaced with acceptable material by the contractor. No additional payment will be made for such removal and replacement. The replaced material will be tested at the frequencies listed in Sec 403.19. Pay for the material will be determined in accordance with the applicable portions of Sec 403.23 based on the replacement material.

403.23.7.4 Miscellaneous Applications.

403.23.7.4.1 Small Quantities. Small quantities are defined in Sec 403.19.3.2.1. Unless the contractor has elected to use the normal evaluation in the Bituminous QC Plan for small quantities, the following shall apply for each separate mixture qualifying as a small quantity:

(a) QLA and PWL will not be required.

(b) Mixtures shall be within the specified limits for VMA, Va, AC and density. In addition to any adjustments in pay due to profile, the contract unit price for the mixture represented by each set of cores will be adjusted based on actual field density above or below the specified density using the following schedule:

Field Density (Percent of Laboratory Max. Theoretical Density)			Pay Factor (Percent of Contract Unit Price)
For all SP mixtures other than SMA:			
		92.0 to 97.0 inclusive	100
97.1 to 97.5	or	91.5 to 91.9 inclusive	90
	or	91.0 to 91.4 inclusive	85
97.6 to 98.0	or	90.5 to 90.9 inclusive	80
	or	90.0 to 90.4 inclusive	75
Above 98.0	or	Below 90.0	Remove and Replace
For SMA mixtures:			
		>94.0	100
		93.5 to 93.9 inclusive	90
		93.0 to 93.4 inclusive	85
		92.5 to 92.9 inclusive	80
		92.0 to 92.4 inclusive	75
		Below 92.0	Remove and Replace

403.23.7.4.2 Base Widening and Entrances. For base widening mixtures and entrance work, QLA and PWL will not be required. Payment for these mixtures will be made at 100 percent of contract unit price for material that otherwise meets the specifications.

403.23.7.4.3 Single Lift or Leveling Course Work. For resurfacing projects specifying a single lift, surface mixture of 3,000 tons or more, or for leveling course work, the following shall apply to the traveled way mixture. All bituminous mixture QC/QA requirements shall apply, except the density pay factor designated in Sec 403.23.7.2 will not be directly included in the total pay factor. In lieu of that, one density sample shall be taken per sublot and the pay adjustment for density will be made using the table in Sec 403.23.7.4.1(b).

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SECTION 404
BITUMINOUS MIXING PLANTS

404.1 Description. This specification covers the requirements for mixing plants and equipment used in the production of bituminous mixtures.

404.2 Requirements for All Plants.

404.2.1 Aggregate. Sufficient storage space shall be provided for each size of aggregate. The different aggregate sizes shall be kept separated until delivery to the combined cold feed belt. The storage yard shall be maintained in a neat and orderly condition and the separate stockpiles shall be readily accessible for sampling.

404.2.2 Asphalt Binder. An asphalt binder storage tank shall be provided at the proportioning and mixing plant. If more than one storage tank is used to deliver asphalt binder to the proportioning unit, piping and valve arrangements shall permit material to be used from any one of the tanks without using from another at the same time.

404.2.2.1 Storage. Each tank used for storage from which asphalt binder is delivered to the proportioning unit shall be equipped for heating the material under effective and positive control at all times to the temperature requirements set forth in Sec 1015. Heating shall not allow contact of flame with the heating tank. The contractor shall furnish a tank capacity chart calculated in increments suitable for verifying quantities used during a normal production period.

404.2.2.2 Circulation. A circulating system of adequate capacity shall provide proper and continuous circulation of the asphalt binder between the storage tank and proportioning units during the entire operating period. The discharge end of the circulating pipe shall be maintained below the surface of the asphalt binder in the storage tank to prevent discharging into the open air. All pipe lines and fittings shall be properly insulated to prevent heat loss.

404.2.2.3 Binder Sampling. The contractor shall provide a sampling outlet in the asphalt binder feed lines connecting the plant storage tanks to the proportioning or injection system. The sampling outlet shall be installed in a readily accessible location such that representative samples may be withdrawn safely and slowly at any time during plant operation. A drainage receptacle shall be provided for flushing the outlet prior to sampling. When all of the chemical admixtures are added to the plant storage tank prior to use, the engineer may allow the contractor to sample the asphalt binder from the storage tanks located at the mixing facilities. Sampling procedures shall be approved by the engineer prior to samples being taken.

404.2.3 Cold Aggregate Feeder. The plant shall be provided with an accurate mechanical means for uniformly feeding the aggregate into the drier to provide uniform production and temperature. A synchronized method of proportioning the aggregate at the cold feeder shall be provided.

404.2.3.1 Cold Feed Calibration. For all plants producing bituminous mixtures composed of more than one fraction of aggregate, the aggregate cold feeds shall be calibrated as required by the engineer. On the basis of the calibration, aggregate cold feeds shall be adjusted to ensure the proper percentage of the various aggregate fractions of the mix, as required by the job mix formula.

404.2.3.2 Aggregate Sampling. Safe, adequate and convenient facilities shall be provided for obtaining representative aggregate samples from the full width and length of the discharge flow of the combined cold feed, or from each hot bin on batch-type plants.

404.2.4 Drier. A drier of any satisfactory design for drying and heating the aggregate shall be provided. The drier shall be capable of drying and heating the aggregate to a temperature within the limits of the range specified in Sec 1015 for the grade of asphalt binder used, without leaving any visible unburned oil or carbon residue on the aggregate. The mixture may be tested for contamination. Absorbed moisture in the aggregate shall be reduced to such a quantity that there is no visible segregation of asphalt binder resulting from escaping water vapor in the prepared mixture.

404.2.5 Dust Collector. An efficient dust collecting system shall be provided to prevent the loss of fine material into the surrounding environment. The material collected may be returned to the mixture at a uniform rate through a metering device or the dust may be wasted.

404.2.6 Filler Storage. If mineral filler or hydrated lime, or both, are required, adequate dry storage shall be provided and provisions shall be made for accurate proportioning.

404.2.7 Asphalt Control Unit. Satisfactory means, either by weighing or metering, shall be provided to obtain the proper quantity of asphalt binder. Metering pumps for asphalt shall deliver accurately to within plus or minus 2.0 percent of the required quantity when tested for accuracy. Asphalt scales shall be in accordance with Sec 404.3.4. If the quantity of asphalt binder is controlled by metering, provisions shall be made whereby the delivery meter may be readily checked by actual weight.

404.2.8 Thermometric Equipment. A thermometer of suitable range shall be fixed in the asphalt feed line at a suitable location near the discharge at the mixer unit. The thermometer included in the asphalt metering unit shall be displayed in a location readily accessible to the engineer. An approved recording thermometer, pyrometer or other recording thermometric instrument shall be installed in plants in such manner that the temperature of the heated mixture or aggregate is automatically registered and recorded. The terminal shall be maintained free of accumulated mixture or aggregate to ensure accuracy. The thermometric instrument shall be installed in the discharge chute of drum mix plants and in at least one hot aggregate bin of batch plants. The terminals shall be located where the hot material will flow around the terminals during the proportioning operation and shall not be located near the corners of the bins or at points where the material will collect or pack around the terminals. This instrument shall be located in clear view of the plant operator. A chart shall continuously record both time and temperature. The smallest interval of time shall be a maximum of 15 minutes and the temperature graduations shall be no more than 10 F. The chart shall be furnished to the engineer at the end of each day's operation.

404.2.9 Plant Calibration. Personnel, scales and equipment necessary for calibrating the plant and for verifying the accuracy of proportions shall be furnished by the contractor and shall be available at all times. All scales used in the final measurement of the mixture shall be in accordance with Sec 310. Records of all calibration shall be provided to the engineer.

404.2.10 Safety Requirements. A conveniently located, easily opened gate or door shall be provided in the mixer cover for observation of pugmill mixing operations. Adequate and safe stairways to the pugmill mixer platform and sampling points shall be provided. Guarded ladders to other plant units shall be placed at all points where accessibility to plant operations is required. Accessibility to the top of truck bodies shall be provided by a platform or other suitable device to enable the engineer to obtain samples and mixture temperature data. All gears, pulleys, chains, sprockets and other dangerous moving parts shall be thoroughly guarded and protected. Ample and unobstructed space shall be provided on the pugmill mixing platform. A clear and unobstructed passage shall be maintained at all times in and around the truck loading area. This area shall be kept free from drippings from the mixing platform.

404.2.11 Surge Bins. Surge bins used in the production of bituminous mixtures shall maintain the temperature of the mixture within 25 F of the contractor’s designated temperature. Mixture shall not be stored more than 8 hours.

404.2.12 Automatic Ticket Printer. The asphalt plant shall be equipped with an automatic ticket printer connected to the weighing system in such a manner that the printer automatically detects and prints the weight determined by the system. The printer shall store and recall the tare weight when the operator enters the vehicle identification. The weight shall be shown to at least the nearest 20 pounds or nearest one one-hundredth of a ton.

404.2.13 Ticket Information. The printer shall be capable of keeping and printing cumulative totals for each project for each type of bituminous mixture. The printer shall produce a ticket in triplicate to accompany each load delivered to the project and shall be furnished to the engineer. The ticket shall show the following: (as a minimum)

(a) Gross and tare and/or net weights.

(b) Current date and time.

(c) MoDOT mix number assigned to the mix being placed.

(d) Unique ticket number (may be preprinted on the ticket).

(e) Job number, route and county.

(f) License plate number of the delivery vehicle (Must be displayed legibly on the ticket).

404.2.13.1 Net Weight. The gross and tare weights will not be required when the net weight of bituminous mixture is determined by batch weights.

404.2.13.2 Gross Weight. When the net weight of bituminous mixture is determined from the gross weight of the loaded delivery vehicle, the empty delivery vehicle weight shall be determined daily or from time to time during the day as directed by the engineer.

404.2.13.3 Daily Total. At the end of each day's operation, the contractor shall furnish to the engineer a total tonnage of mixture produced by the asphalt plant in sufficient detail to determine the amount of asphalt binder used in that day's operation.

404.2.13.4 Printer Failure. In the event of automatic ticket printer failure, the contractor may be permitted, without approval from the engineer, to furnish manually written tickets to complete that day's operation.

404.3 Requirements for Batch-Type Plants.

404.3.1 Automatic Batching. For all contracts containing no more than 10,000 tons of bituminous mixture, standard manual batching methods approved by the engineer will be permitted. For contracts containing more than 10,000 tons of bituminous mixture, in accordance with Sec 401 or Sec 403, batching plants shall be equipped to operate automatically to the extent that the only manual operation required for the proportioning of all ingredients for one batch shall be a single actuation of a switch or starter. The equipment shall include devices capable of automatically proportioning each ingredient of the mixture in the selected sequence and quantity. Interlocks shall be provided which will hold or delay the automatic batch cycling whenever the batched quantity of any ingredient is not within the specified tolerance. The weight setting and timing controls shall be suitably equipped so the controls may be locked when specified by the engineer. Manual operation will not be permitted beyond 24 hours after breakdown in the automatic equipment, except with written approval from the engineer.

404.3.2 Aggregate Scales. Scales for weighing aggregate and mineral filler or hydrated lime, or both, may be beam, springless dial or electronic digital weigh meter type, and shall be of standard make and design having tolerances on overregistration and underregistration not exceeding 0.4 percent of the indicated weight when tested for accuracy. Each aggregate fraction shall be measured within one percent of the total batch weight of the mixture. Mineral filler or hydrated lime, or both, shall be measured within 0.5 percent of the total batch weight of the mixture. The total weight of the batch shall be within 2.0 percent of the desired batch weight. The change in load required to change the position of the rest of the indicating element or elements of a non-automatic indicating scale an observable amount shall be no greater than 0.1 percent of the nominal scale capacity. If manual batching methods are used, beam-type scales shall be equipped with a device to indicate to the operator that the required load is being approached. This device shall indicate at least the last 5 percent of the load weighed on any beam, except that this increment will not be required to be greater than 200 pounds. Multiple beam-type scales shall be equipped with a tare beam and a separate beam for each size of aggregate. Dial scales shall be equipped with adjustable pointers for marking the weight of each material to be weighed (incorporated) into the batch. Graduation intervals for either beam or dial scales shall be no greater than 0.1 percent of the nominal scale capacity. Quantity indicators necessary for batching shall be in full view of the operator.

404.3.3 Asphalt Bucket. If a bucket is used for weighing the asphalt binder, the filling system and bucket shall be of such design, size and shape that asphalt will not overflow, splash or spill outside the confines of the bucket during filling and weighing.

404.3.4 Asphalt Scales. Scales for weighing asphalt binder shall be in accordance with Sec 404.3.2, except a device to indicate at least the last 20 pounds of the approaching total load shall be provided. Asphalt binder shall be measured within 0.1 percent of the total batch weight of the mixture. Beam-type scales shall be equipped with a tare beam or adequate counter-balance for balancing the bucket and compensating periodically for the accumulation of asphalt on the bucket. Springless dial scales used for weighing asphalt binder shall have a tare beam and a dial graduated in increments not to exceed 0.1 percent of the nominal scale capacity and the

maximum dial capacity shall be no more than 15 percent of the nominal capacity of the mixer.

404.3.5 Mixer Unit. The plant shall be capable of producing a uniform mixture. The mixer shall be heated and shall have a minimum capacity of 2000 pounds per batch. The mixer shall be constructed to prevent leakage of the contents and the mixer box shall be equipped with a hood to prevent loss of dust.

404.3.5.1 Time Lock. The mixer shall have an accurate time lock to control the operation of a complete mixing cycle by locking the weigh box gate after the charging of the mixer until the closing of the mixer gates at the completion of the cycle. The time lock shall lock the asphalt bucket throughout the dry mixing period and shall lock the mixer gate throughout the dry and wet mixing periods.

404.3.5.2 Mixer Rating Plate. A rating plate designating the manufacturer's rated capacity shall be attached to the mixer. The quantity of mixture produced per batch shall not exceed the manufacturer's rated capacity.

404.3.5.3 Mixing Times. The mineral aggregate for mixtures specified in Secs 401 and 402 shall be mixed dry for at least 10 seconds and for mixtures specified in Sec 403 shall be mixed dry for at least 15 seconds. The dry mixing period shall start when all of the mineral aggregate has been charged into the mixer, and end when the introduction of the asphalt binder begins. After dry mixing, the asphalt binder shall be charged into the mixer in a manner that will uniformly distribute the asphalt over at least 3/4 of the full length of the mixer. The time required to add the asphalt binder shall not exceed 15 seconds. Wet mixing shall begin at the introduction of the asphalt binder and shall continue for at least 30 seconds, or longer if necessary, to produce a complete and uniform coating of the particles and a thorough distribution of the asphalt binder throughout the aggregate. The wet mixing period shall end when the discharge gate is opened.

404.4 Requirements for Drum Mix Plants.

404.4.1 Drum Plant. The plant shall be specifically designed for drum mixing and shall be capable of satisfactorily heating, drying and mixing bituminous mixtures. Heating shall be controlled to prevent damage to the aggregate or the asphalt binder. The temperature of the mixture when discharged from the mixer shall be within the range specified in Sec 1015 for the grade of asphalt binder being used. The rate of flow through the drum shall be controlled such that the bituminous material and aggregate shall be mixed until a homogeneous mixture with all particles uniformly coated is obtained, and in no case shall the quantity of mixture produced exceed the manufacturer's rated capacity.

404.4.2 Feed Indicators. Each feeding orifice shall have an adjustable gate with an indicator provided to reference the opening setting. A device shall be installed on each aggregate feeder to indicate when the flow of material from the bin is below the point where accurate proportioning through the feeder gates can be accomplished. These indicators shall be positive in action and shall actuate a clearly visible or audible signal to the plant operator, or stop the flow of material to the drum when the level of material in the bin is too low for accurate proportioning. A scalping screen mounted independent of other proportioning or weighing equipment shall be provided if directed by the engineer. The total daily asphalt binder quantity numbers for the project shall be provided ot the engineer.

404.4.3 Asphalt Meter. Asphalt binder shall be introduced through a continuously registering cumulative indicating meter by a pump specifically designed for drum mix plants. The meter shall be located in the asphalt line so that the meter will continuously register the asphalt discharge to the mixer and such that the discharge through the meter can be readily diverted into a container for measurement. The meter shall be equipped with a nonsetback register and shall have an accuracy within 2 percent by weight of the material actually being measured in any given period of time. The nonsetback register shall register only the asphalt discharged to the mixer and shall not record asphalt circulated back to the storage tank. A device shall be provided in the asphalt storage tank to indicate when the supply of asphalt to the pump and metering device is such that accurate proportioning is not accomplished. The accuracy of the pump and meter shall be verified at periodic intervals as designated by the engineer. The total daily asphalt binder quantity number for the project shall be provided to the engineer.

404.4.4 Mineral Filler. If mineral filler or hydrated lime, or both, are used, a separate bin and feeder for each material shall be furnished and each material shall be dispensed by weight by continuous batching device. The batching device shall have a continuous weight display in clear view of the plant operator. The delivery system shall be variable speed and interlocked with the aggregate weigh belt so the total dry aggregate weight, including mineral filler or hydrated lime, or both, is indicated to the asphalt proportioning system. A

continuously registering, cumulative, nonsetback register shall record the quantity of mineral filler or hydrated lime, or both, discharged into the mixer. Mineral filler and hydrated lime shall be introduced and uniformly dispersed into the drum mixer at the point of introduction of the asphalt binder without loss to the dust collection system. The mineral filler and hydrated lime proportioning and delivery system shall have an accuracy of 10 percent by weight of the material actually being measured in any given period of time. The total daily mineral filler and hydrated lime quantity numbers for the project shall be project shall be provided to the engineer.

404.4.5 Belt Scales. Positive weight measurement of the combined cold feed aggregate shall be by use of belt scales. The combined cold feed aggregate shall be continuously recorded on a nonsetback register. The belt scale shall have an accuracy within 2 percent by weight of the material actually being measured in any given period of time. The accuracy of the belt scales shall be verified at periodic intervals as directed by the engineer. The total daily aggregate quantity numbers for the project shall be provided to the engineer.

404.4.6 Reclaimed Asphalt Pavement Weighing. Positive weight measurement of reclaimed asphaltic pavement shall be by use of belt scales in accordance with Sec 404.4.5.

404.4.7 System Interlocks. The aggregate feed system, reclaimed asphaltic pavement feed system if recycling is permitted, mineral filler or hydrated lime, or both if specified, and the asphalt flow shall be interlocked by a blending system which will automatically regulate the asphalt binder, mineral filler, hydrated lime and reclaimed asphaltic pavement flow, and shall cause synchronized corrections for variations in aggregate flow. The blending system shall include a moisture-compensating device to correct for moisture in the aggregate passing over the belt scales. Moisture determinations shall be made periodically during each day's operation. The blending system shall include a device to correct for changes in the specific gravity of the asphalt binder.

404.4.8 Sampling. Safe, adequate and convenient facilities shall be provided for obtaining representative samples of asphalt binder, cold aggregate and bituminous mixture. The plant shall be equipped with sampling devices capable of providing a sample of sufficient size from the full width of the combined aggregate flow and from the full width of the mixer discharge flow. Sampling devices shall be designed such that samples may be taken while the plant is operating at normal production rates.

404.4.9 Calibration. Safe, adequate and convenient facilities shall be provided for calibrating or verifying the asphalt binder, mineral filler, hydrated lime, reclaimed asphaltic pavement and the aggregate nonsetback registers. The manufacturer's recommendations shall be followed for calibration unless specified otherwise. The quantities of aggregate and asphalt binder measured in any given period of time shall vary no more than 2.0 percent by weight from the required quantity of each.

404.5 Stone Matrix Asphalt Mixtures. A homogeneous mixture shall be produced.

404.5.1 Fibers in Batch Plants. For batch plants, fibers shall be added to the mineral aggregate either in the weigh hopper or in the pugmill. The fibers shall be accurately added by weight, either manually by bag or other measure, or by an approved weight metering device. If fibers are added in the weigh hopper, no fiber shall be added until mineral aggregate from at least one hot bin has been placed in the weigh hopper. If fibers are added in the pugmill, the fiber shall be added immediately after the mineral aggregate and before the asphalt binder is added.

404.5.1.1 Dry Mixing. The mineral aggregate and the fibers shall be dry mixed for at least 20 seconds.

404.5.1.2 Wet Mixing. The wet mixing time shall be no less than 35 seconds to allow the cellulose fibers to expand and to ensure adequate distribution of the fibers and asphalt binder.

404.5.1.3 Uniformity. Dry and wet mixing times and batch mixing temperatures shall be adjusted as necessary to achieve a uniform mixture.

404.5.2 Fibers in Drum Plants. For drum plants, fibers shall be introduced into the plant in either loose or pelletized form.

404.5.2.1 Metering. Equipment for metering fibers into the plant shall ensure a consistent, uniform blending of the fibers into the mixture. The metering system shall be variable speed, shall proportion the fibers by weight, shall be accomplished as specified by the equipment manufacturer and be to the satisfaction of the engineer.

404.5.2.2 Pelletized Fibers. If used in a drum mix plant, pelletized fiber shall be added directly into the drum mixer through the recycle asphalt inlet.

404.6 Liquid Anti-Strip Additive Systems. Type I liquid anti-strip additives shall be blended into the asphalt binder. Type II additives shall be sprayed on the combined cold feed aggregate. Both shall be incorporated in a consistent and uniform manner.

404.6.1 Calibration. The method of adding an additive into the mix shall be accurate to within ± 10 percent of the amount to be added. Calibration of the blending system shall be provided to the engineer.

404.6.2 Flow Interruption. The feed system shall be equipped with a flow meter that signals if the additive is or is not being added. It shall be interlocked so that the operation will cease if the additive flow is interrupted or not within the allowable limits.

404.6.3 Interlock. The rate of application shall be interlocked with the plant to coincide with plant production rates when the additive is incorporated during mixture production.

404.6.4 Type I Addition. For Type I liquid anti-strip additive used in drum mix plants, the blending system shall add the material into a static in-line mixer between the asphalt binder storage tank and the asphalt binder flow meter. For batch plants, the blending system shall add the material into a static in-liner mixer between the asphalt binder storage tank and the mixing plant injection point. Controls shall be in place so that blended material is not permitted to recirculate back to the asphalt binder storage tank.

404.6.5 Type II Addition. For Type II liquid anti-strip blending systems, the blending system shall uniformly apply the material to the cold feed prior to the drum for continuous, batch and drum plants.

404.7 Hauling Equipment. Trucks used for hauling bituminous mixtures shall have tight, clean, smooth, metal beds that have been thinly coated with a minimum quantity of lime solution or an approved bituminous mixture release agent in accordance with Sec 1071 to prevent the mixture from adhering to the beds. The release agent shall not be diluted less than the minimum rate specified by the manufacturer and shall be applied with equipment recommended by the manufacturer. Use of diesel fuel, fuel oil or other detrimental products as a bed coating or dilution agent will not be permitted. Each truck shall have a cover of canvas or other suitable material of such size to protect the mixture from the weather. The cover shall be securely fastened over all sides of the truck bed. Truck beds shall be insulated, when necessary, such that the mixture will be delivered on the road at the specified temperature.

SECTION 407
TACK COAT

407.1 Description. This work shall consist of preparing and treating an existing bituminous or concrete surface with bituminous material, in accordance with these specifications.

407.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Emulsified Asphalt or Performance Graded Asphalt Binder	1015

407.3 Equipment. The contractor shall provide a system for heating and applying the bituminous material. The system shall be designed, equipped, maintained and operated such that emulsified asphalt or liquid asphalt, at even heat, may be applied uniformly on variable widths of surface up to 15 feet with uniform pressure and an allowable variation from any specified rate of ±0.01 gallon per square yard. The system shall include a calibrated tank and a thermometer for measuring temperature of tank contents. The system shall be equipped with instrumentation that continuously verifies application rates. The calibration of the system shall be approved by the engineer prior to use, and the contractor shall furnish all equipment, material and assistance if calibration is required.

407.4 Construction Requirements.

407.4.1 Preparation of Surface. The existing surface shall be free of all dust, loose material, grease or other foreign material at the time the tack is applied. Any excess bituminous surface mixture or bituminous joint material will be removed by MoDOT without cost to the contractor before the tack is applied.

407.4.1.1 Coldmilled Surface. All coldmilled surfaces shall be in accordance with Sec 622.10, except modified herein. Coldmilled surfaces shall be swept or vacuumed prior to tack coat application. The sweeping or vacuuming requirement may be waived, if traffic is allowed onto the coldmilled surface and is considered clean by the engineer.

407.4.1.2 Pre-wetting. Existing surfaces may be pre-wetted just prior to the tack coat application. Pre-wetting shall consist of misting the surface with controlled spraying equipment to achieve a damp condition with no standing water or shiny appearance.

407.4.2 Asphalt Emulsion Application. Asphalt emulsion shall be applied uniformly with a pressure distributor or spray paver at the target rates indicated in the following table. Upon approval by the engineer, the target application rate may be varied by +/- 0.02 gal/sy in the field, based upon the existing pavement condition. The tack coat material shall be heated at the time of application to a temperature in accordance with Sec 1015. When an asphalt emulsion is applied through a pressure distributor, the tack coat shall be properly set and the tacked surface shall be clean of all dirt before the next course is placed.

Tack Coat Application Rates		
Surface Type	**Target Application Rate; Undiluted (gal/yd^2)**	**Target Application Rate; 20% Diluted (gal/yd^2)**
New Asphalt Surfaces	0.05	0.06
Existing Asphalt or Concrete Surfaces	0.08	0.10
Coldmilled Asphalt or Concrete Surfaces	0.10	0.13

407.4.2.1 Dilution of Asphalt Emulsions. Water may be added only by the tack coat manufacturer and shipped to the jobsite. No dilution shall be allowed in the field. When water is added to the asphalt emulsion, the resulting mixture shall contain no more than 20 percent of added water. The contractor shall notify the engineer of the use of a diluted emulsion. The exact quantity of added water shall be indicated on the manufacturer's bill of lading, manifest or truck ticket. The target application rate shall be adjusted to the diluted target application rate as specified in the table under Sec 407.4.2.

407.4.2.2 Performance Graded (PG) Asphalt Binder. Hot applied PG graded asphalt binders may be used as tack coat in lieu of emulsified asphalt. The PG graded binders shall be applied uniformly with a pressure

distributor to provide complete coverage of the preceding course or layer. Safety procedures of hot applied asphalt shall be addressed in the contractor's safety plan. A pre-construction meeting shall be held to address all safety procedures and protocols of hot applied asphalt prior to tack coat application.

407.4.3 Tack. The tack coat shall be applied in such a manner as to cause the least inconvenience to traffic and to permit one-way traffic without tracking of asphalt emulsion. A bituminous mixture shall not be placed upon a tacked surface that is not uniformly covered or surfaces that have experienced excessive loss of tack due to tracking. Re-application of tack due to excess tracking or non-uniform coverage shall be at the contractor's expense. All exposed tack coat shall be covered with bituminous mixture prior to opening to traffic.

407.5 Method of Measurement. Measurement of asphalt emulsion to the nearest gallon will be made in accordance with Sec 1015. If water is added to asphalt emulsion, the quantity to be paid for will be determined prior to the addition of water.

407.6 Basis of Payment. The accepted quantity of tack coat will be paid for at the contract unit price. No direct payment shall be made for water added to the asphalt emulsion.

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SECTION 408
PRIME COAT

408.1 Description. This work shall consist of preparing and treating an existing surface with bituminous material in accordance with these specifications, as shown on the plans or as directed by the engineer.

408.2 Material. The type and grade of bituminous material will be specified in the contract. Liquid asphalt may be changed one grade by the engineer during construction at no change in the contract unit price. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Type RC and MC Liquid Asphalts	1015
Emulsified Asphalt	1015

408.3 Equipment. Equipment shall be in accordance with Sec 407.

408.4 Construction Requirements.

408.4.1 Preparation of Surface. The surface to be primed shall be shaped to the required grade and cross section, shall be free from all ruts, corrugations, segregated material or other irregularities, and shall be uniformly compacted by rolling. The surface shall be firm and slightly damp when primer is applied. Delays in priming may necessitate reprocessing or reshaping to provide a smooth compacted surface.

408.4.2 Application. Bituminous material shall be applied to the width of the section to be primed by means of a pressure distributor in a uniform, continuous spread. The application rate shall be as specified in the contract, or as revised by the engineer between 0.2 and 0.5 gallon per square yard. The primer shall be heated at the time of application in accordance with the limits provided in Sec 1015.

408.4.2.1 There shall be no overlapping of bituminous material. Pools of primer material remaining on the surface after the application shall be removed. As soon as the bituminous material has been absorbed by the surface and will not track, traffic may be routed onto the treated traveled way. Any damage caused to the prime coat due to the contractor's equipment or decision to allow traffic on the roadway too soon shall be primed again at the contractor's expense.

408.4.2.2 The primer shall be properly cured and the primed surface shall be cleaned of all dirt and surplus sand before the next course is placed.

408.5 Method of Measurement. Bituminous material will be measured to the nearest gallon in accordance with Sec 1015.

408.6 Basis of Payment. The accepted quantities of prime coat will be paid for at the contract unit price for each of the pay items included in the contract. No direct payment will be made for furnishing or applying any water required for dampening the surface to be primed.

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SECTION 409
SEAL COAT

409.1 Description. This work shall consist of placing bituminous material followed by placing cover aggregate material.

409.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Aggregate for Seal Coats[a]	1003

[a]The grade of aggregate will be specified in the contract

409.2.1 All limestone and dolomite shall be either pre-coated as specified herein or fog sealed in accordance with Sec 413.

409.2.2 Emulsified asphalt or polymer modified emulsions shall be in accordance with Sec 1015, with the following exceptions:

Asphalt Emulsion Requirements			
Tests on Asphalt Binder[a]	**Test Method**	**Minimum**	**Maximum**
Penetration @ 77°F	ASTM D 5	60	150
Elastic Recovery @ 50°F, %	AASHTO T 301	65	---

[a]These tests shall be done on the asphalt residue for emulsions and cutbacks.

409.2.3 Pre-coating binder shall be in accordance with Sec 1015 for PG binder or emulsions.

409.3 Job Mix Formula. The contractor shall submit the mix design to the laboratory for approval no less than two weeks prior to placing the seal coat.

409.3.1 The mix design shall contain the following information:

(a) All possible sources intended for use, grade and certified test results for the asphalt binder.

(b) Source, type (formation, etc.), ledge number if applicable, and gradation of the aggregate.

(c) The grade and certified test results for the aggregate.

(d) The application rate used to pre-coat the aggregate as allowed in Sec 1003.

(e) The percent binder application rate, gallons per square yard. The adjustment factor shall be included if specified in the contract plans.

(f) The aggregate application rate, pounds per square yard.

409.3.1.1 The target binder application rates for each aggregate grade, as found in Sec 1003, shall be:

Grade	A1	A2	B1	B2	C
Target Binder Application Rate, gal/sy[a]	0.38	0.28	0.38	0.28	0.38

[a]Corrections to the rate listed may be included in the plans

409.3.2 A surface condition, aggregate properties and traffic volume correction may be provided in the plans. This assessment will contain an allowable variance from the binder application rate. The aggregate application rates shall not vary from the mix design by more than ± 5 pounds per square yard.

409.4 Equipment. Equipment shall be capable to perform the following:

(a) Heating and applying bituminous material, measuring temperature of tank contents and

continuously verify application rates. The calibration of the system shall be accomplished by the contractor and approved by the engineer prior to use. The contractor shall furnish all equipment, material, labor and supervision necessary to perform this calibration. Equipment shall be calibrated subsequent to any repair that may affect calibration.

(b) Removal of loose aggregate from applied surface.

(c) Seating of aggregate without causing aggregate fracture.

(d) Accurately measuring and uniformly spreading of the aggregate over the full width of the bituminous material and have ability to vary the application width depending upon road width. It shall also be able to have verifiable application rates. The calibration of the system shall be accomplished by the contractor and approved by the engineer prior to use. The contractor shall furnish all equipment, material, labor and supervision necessary to perform this calibration. Equipment shall be calibrated subsequent to any repair that may affect calibration.

409.5 Construction Requirements.

409.5.1 Weather Limitations. Bituminous material shall not be placed on any wet surface. Seal coat shall only be placed when the ambient temperature and the temperature of the pavement on which it is to be placed is above 60 F. Temperatures shall be obtained in accordance with MoDOT Test Method TM 20.

409.5.1.1 Forecasted Weather. No seal coat shall be placed when the forecast from the National Weather Service predicts ambient temperatures falling below 40 F within 24 hours of construction.

409.5.2 Surface Preparation. The surface shall be thoroughly cleaned or swept to remove all dirt, packed soil, or any other foreign material prior to spraying the bituminous material.

409.5.3 Application of Bituminous Material.

409.5.3.1 Bituminous material shall be uniformly applied within the temperature range recommended by the manufacturer. Any bituminous material applied on adjacent Portland cement or asphaltic concrete pavements, curbs, bridges or any areas not specified to be sealed shall be removed by the contractor, at the contractor's expense.

409.5.3.2 When pre-coating is required, the cover aggregate shall be pre-coated at a minimum rate of 0.5 percent residual asphalt by weight of aggregate.

409.5.4 Compaction. All aggregate shall be uniformly seated over the entire area being sealed in a manner which minimizes aggregate loss and prevents crushing of aggregate.

409.5.5 Dust Control. The contractor may be required to control dust should airborne dust become a concern, or as directed by the engineer.

409.5.6 Loose Aggregate. Loose aggregate shall be removed from curbs, gutters, sidewalks, driveways, and other areas designated by the engineer.

409.6 Traffic Control.

409.6.1 During application of the seal coat, the contractor shall control traffic through the work zone by means of pilot vehicles traveling at a maximum speed of 35 miles per hour. The contractor shall designate a responsible person for receiving and resolving damage claims made by the public. This person shall be available by telephone during the contractor's normal business hours Monday through Friday.

409.6.2 The contractor shall provide contact information signs with their company name and phone number on a variable width by 24 inch tall sign with black lettering on an orange background. The first line shall state "CONTRACTOR" in uppercase 4 inch C highway font, the second line shall contain the contractor name in upper/lower case 4 inch B highway font and the third line shall contain the contractor's phone number in 4 inch C highway font. Signs shall be posted near the beginning and end of the project limits as approved by the engineer.

409.7 Basis of Acceptance. Acceptance shall be made no less than 14 days from completion of the route. Seal coat will be evaluated for acceptance by the engineer based on the following criteria:

(a) No location having bleeding of binder in excess of two square feet or a combined area of bleeding greater than 10 square feet on any 50 foot length of two lane roadway.

(b) No continued or ongoing tracking from seal coat onto other roadways or adjacent driveways.

(c) No transverse and longitudinal construction joints from the seal coat application that are not straight, create a bump, or produce a poor riding surface.

(d) Longitudinal construction joints that are straight and contain no gaps.

(e) No asymmetric appearance stemming from longitudinal grooves or ridges in the surface.

(f) A pavement treatment having complete aggregate coverage with full adherence to the roadway.

The contractor is responsible for any damage claims that are associated with the seal coat until the route is accepted by the engineer.

409.8 Method of Measurement.

409.8.1 Final measurement for aggregate in the completed seal coat will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity.

409.8.2 Where required, measurement of seal coat, complete in place, will be made to the nearest square yard for aggregate.

409.8.3 Final measurement for binder will be made to the nearest gallon in accordance with Sec 1015. Any revision or correction will be computed and added to or deducted from the contract quantity.

409.9 Basis of Payment. The accepted quantities of seal coat aggregate and binder, in place, will be paid for at the contract unit price. No separate payment will be made for pre-coating aggregate, fog sealing, dust control, or for providing and installing contract information signs. If the binder application rate includes a correction factor, it is included in the plan quantities.

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SECTION 413
SURFACE TREATMENTS

SECTION 413.10 MICRO-SURFACING.

413.10.1 Description. This work shall consist of producing and placing a mixture of cationic polymer-modified asphalt emulsions, mineral aggregate, mineral filler, water, and other additives as needed at locations shown on the plans or as directed by the engineer.

413.10.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Emulsified Asphalt	1015
Aggregate	1002

413.10.2.1 Aggregate.

413.10.2.1.1 The mineral aggregate shall be flint chat from the Joplin area, an approved crushed porphyry or an approved crushed steel slag. Blast furnace slag may be used from sources with a documented history of satisfactory use and that have been previously approved by MoDOT for use in micro-surfacing. For non-traffic areas such as shoulders, the mineral aggregate may be crushed limestone or crushed gravel in accordance with Sec 1002.1. The aggregate shall be free of cemented or conglomerated material and shall not have any coating or detrimental material.

413.10.2.1.2 Blends of approved aggregate may be supplied provided:

(a) The individual aggregates are reasonably uniform in gradation and other qualities.

(b) The aggregates are uniformly blended with designated proportions into a separate stockpile prior to use. Aggregate may be blended directly into the supply truck provided the blending device has been calibrated, gate settings are unchanged, and belt samples indicate material gradation compliance.

(c) The proportion is not changed from the job mix formula during the course of placement.

413.10.2.1.3 The final aggregate, or blend of aggregates, shall be in accordance with one of the following gradations. In addition, the aggregate shall be ± 5 percent of the designated job mix gradation for all plus No. 200 material and within ± 2 percent for the minus No. 200 material.

Aggregate Gradation Requirements			
Type II		Type III/Type IIIR	
Sieve	Percent Passing	Sieve	Percent Passing
3/8 inch	100	3/8 inch	100
No. 4	90 - 100	No. 4	70 - 90
No. 8	65 - 90	No. 8	45 - 70
No. 16	45 - 70	No. 16	28 - 50
No. 30	30 - 50	No. 30	19 - 34
No. 50	18 - 30	No. 50	12 - 25
No. 100	10 - 21	No. 100	7 - 18
No. 200	5 - 15	No. 200	5 - 15

413.10.2.1.4 The final aggregate mixture shall have no oversize material when deposited at the stockpile site. If the stockpile area contains any particles exceeding the specified maximum sieve, all aggregate shall be screened again as the aggregate is loaded into the final placement machine.

413.10.2.2 Mineral Filler. Mineral filler shall be Type 1 Portland cement or hydrated lime, and shall be free of lumps or any other deleterious material.

413.10.2.3 Water. Water shall be potable and free of harmful soluble salts.

413.10.2.4 Additives. Any other material added to the mixture or to any of the component materials to provide the required properties shall be supplied by the emulsion manufacturer.

413.10.2.5. Material Acceptance. All aggregate shall be sampled, tested and approved by the engineer prior to use. Portland cement and hydrated lime may be accepted for use based on visual examination.

413.10.3 Job Mix Formula. The manufacturer of the emulsion shall develop the job mix formula and shall present certified test results for the engineer's approval. The job mix formula shall be designed in accordance with the International Slurry Surfacing Association (ISSA) recommended standards by an ISSA recognized laboratory. Mix acceptance will be subject to satisfactory field performance. The job mix formula, all possible emulsion sources intended for use, all material, the methods and the proportions shall be submitted for approval prior to use. Proportions to be used shall be within the limits provided in the table below. If more than one aggregate is used, the aggregates shall be blended in designated proportions as indicated in the job mix formula, and those proportions shall be maintained throughout the placement process. If aggregate proportions are changed, a new job mix formula shall be submitted for approval.

Material	Requirement
Type II Mineral aggregate, lbs/yd^2 dry mass, min.	10 - 20
Type III Mineral aggregate, lbs/ yd^2 dry mass, min.	15 - 30
Type IIIR	As necessary
Polymer Modified Emulsion (residual), percent	5.5 to 10.5 by dry weight of aggregate
Mineral Filler, percent by mass of dry aggregate	0.0 to 3.0 by dry weight of aggregate
Additive	As required

413.10.3.1 All Types. The minimum dry mass per unit area will be based on a bulk specific gravity (BSG) of 2.65. In the event that crushed steel slag aggregate is used as a part of the blended aggregate or as the entire aggregate, the BSG of the final aggregate blend shall be determined and shown as part of the job mix formula criteria. If the BSG is different from 2.65 by more than 0.05, the above minimum masses shall be adjusted by dividing the specified unit mass by 2.65 and multiplying by the new BSG. (For example, for a new BSG = 3.15, the new minimum would be 3.15(10.8/2.65) = 23.8 lbs./sy). These adjusted values shall be designated on the job mix formula and will apply in the field.

413.10.3.2 Type II. For Type II, if a specified thickness will be required, the amount of mineral aggregate per square yard shall be increased as necessary to obtain the thickness.

413.10.3.3 Type III. When specified, Type III shall be applied in two passes of approximately equal quantities, the first of which shall be to fill depressions and level the surface for the final pass.

413.10.3.4 Type IIIR. For Type IIIR mixes, there will be no minimum or maximum unit quantities. The contractor shall make the determination as to the amount necessary, except all depressed areas shall be filled level as specified. Type IIIR may be applied in more than one pass at the contractor's expense. Type IIIR shall not be added to Type II or Type III applications in the field, but shall be a separate application.

413.10.4 Equipment.

413.10.4.1 Mixing Equipment. The micro-surfacing mixture shall be mixed and laid by a self-propelled mixing machine. The mixing machine shall be able to accurately deliver and proportion the aggregate, mineral filler, water, additive and emulsion to a revolving
multi-blade dual mixer and to discharge the thoroughly mixed product. The machine shall have sufficient storage capacity for all components to maintain an adequate supply to the proportioning controls.

413.10.4.1.1 Individual volume or weight controls for proportioning each item to be added to the mix shall be provided. Each material control device shall be calibrated and properly marked. The calibration shall be approved by the engineer prior to proportion. Each device shall be accessible for ready calibration and placed such that the engineer may determine the amount of each material used at the time.

413.10.4.1.2 The mixing machine shall be equipped with a water pressure system and nozzle-type spray bar to provide a water spray to dampen the surface when required immediately ahead of and outside the spreader box as required. No free flowing water shall be present.

413.10.4.2 Spreading Equipment. The micro-surfacing mixture shall be spread uniformly by means of a mechanical-type spreader box attached to the mixer. The spreader box shall be equipped with paddles or augers to agitate and spread the material uniformly throughout the box. The paddles or augers shall be designed and operated so all the fresh mix will be agitated to prevent the mixture from setting up in the box, causing side buildup and lumps.

413.10.4.2.1 The spreader box used for surface course construction shall be equipped with flexible seals in contact with the road to prevent loss of mixture from the box. The box shall be equipped with devices to adjust the thickness or grade of the surface and shall have a squeegee strike-off rear plate.

413.10.4.2.2 A secondary strike-off shall be provided to improve surface texture. The secondary strike-off shall have the same adjustments as the spreader box.

413.10.4.2.3 The spreader box used for rut-filling shall have two metal strike-offs, angled from each side toward the center at approximately 45 degrees. Interrupted flight augers shall be used ahead of the first strike-off plate to spread the mix and maintain laminar flow. The second strike-off plate shall be adjusted to produce the desired grade and depth. The first strike-off and augers shall be adjustable up and down in order to maintain a fairly uniform flow or roll of material in front of the second strike-off. A rubber squeegee shall be attached to the adjustable metal plate at the rear of the spreader box, behind the second strike-off, to texture the surface. The adjustable metal plate shall have sufficient clearance not to affect the grade established by the second strike-off.

413.10.5 Construction Requirements.

413.10.5.1 Test Strip. A test strip 500 feet long and the width of one lane shall be provided. The test strip will be evaluated for 24 hours after placement and will be subject to approval from the engineer before any further production. If unsatisfactory, the test strip shall be removed and another strip placed for evaluation at the contractor's expense.

413.10.5.2 Surface Preparation. The surface shall be thoroughly cleaned of all vegetation, loose material, dirt, mud, and other objectionable material and shall be pre-wetted as required immediately prior to application of the micro-surfacing. All pavement marking shall be removed, maintained, and compensated for in accordance to Sec 620.

413.10.5.3 Application. The micro-surfacing mixture shall be spread to fill cracks and minor surface irregularities, and shall leave a uniform surface. No lumping, balling or unmixed aggregate will be permitted. Longitudinal joints shall be placed on lane lines. Excessive overlap will not be permitted. The finished micro-surfacing shall have a uniform texture free of scratches, tears and other surface irregularities. The contractor shall repair the surface if any of the following conditions exist:

(a) More than one surface irregularity that is 1/4 inch or wider and 10 feet or longer in any 100-foot section of the micro-surfacing.

(b) More than three surface irregularities that are 1/2 inch or wider and more than 6 inches long in any 100-foot section of the micro-surfacing.

(c) Any surface irregularity that is one inch or wider and more than 4 inches long. The finished longitudinal and transverse joints in the micro-surfacing shall be complete and uniform.

413.10.5.3.1 The contractor shall repair joints if any of these conditions exist:

(a) Build-up of micro-surfacing material at the joints.

(b) Uncovered areas at the joints.

(c) Longitudinal joints with more than 1/2 inch vertical space between the surface and a 4-foot straightedge placed perpendicular to the joint.

(d) Transverse joints with more than 1/4 inch vertical space between the surface and a 4-foot straightedge placed perpendicular to the joint.

413.10.5.3.2 The edges of the micro-surfacing shall follow the centerline, lane lines, shoulder lines and curb lines. The edges shall be repaired if the edges vary more than 3 inches from a 100-foot straight line or from a 100-foot arc on a curved section. The repaired surface shall be dense with a uniform texture.

413.10.5.3.3 Any successive passes shall be separated such that each layer placed undergoes approximately 12 hours of traffic for compaction and curing.

413.10.5.3.4 Type IIIR applications to raise shoulders or fill ruts shall be applied with the rut spreader box, and the contractor shall place a strip as designated in the contract documents to raise an area to match the surroundings. Rutting or traffic-bearing applications, excluding shoulders, shall be crowned 1/8 to 1/4 inch per inch of depth, to allow for compaction. Shoulder applications shall drain and slope uniformly downward to the shoulder point. A Type II or Type III application may follow as a surface course if specified in the contract documents.

413.10.5.3.5 Micro-surfacing shall not be placed over steel expansion plates.

413.10.5.3.6 When micro-surfacing is placed on concrete, a tack coat shall be applied first in accordance with Sec 407 and shall be given adequate time to break.

413.10.5.3.7 The micro-surfacing shall permit traffic operations on a 1/2 inch thick surface within one hour after placement at 75 F and 50 percent humidity.

413.10.5.4 Weather Limitations. Micro-surfacing shall not be placed when either the air temperature or the temperature of the surface on which the mixture is to be placed is below 50 F, when it is raining, or when there is a chance of temperatures below 32 F within 24 hours after placement. Temperatures shall be obtained in accordance with MoDOT Test Method TM 20.

413.10.5.5 Repair of Damaged Areas. Any traffic-damaged, marred areas or deficiencies as defined in Sec 413.10.5.3 shall be repaired by the contractor at the contractor's expense.

413.10.5.6 Incidental Construction. Areas that cannot be reached with the mixing machine shall be surfaced using hand squeegees to provide complete and uniform coverage. Utilities shall be protected from coverage by a suitable method. Work at intersections shall be done in stages, or blotter material shall be used to allow crossing or turning movements. Regardless of the method, no marred sections will be permitted.

413.10.6 Method of Measurement. Final measurement of completed Type II and Type III surface will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. Where required, measurement of Type II, Type III and Type IIIR micro-surfacing, complete in place, will be made to the nearest square yard. Final measurement of Type IIIR surface may be made as necessary to determine the actual areas placed. Field measurement will be based on the estimated width and length dimensions necessary to bring a designated area to a level plane, and not necessarily for the full rutted area. The revision or correction will be computed and added to or deducted from the contract quantity.

413.10.7 Basis of Payment. The accepted quantities of micro-surfacing will be paid for at the contract unit price for each of the pay items included in the contract. No additional payment will be made for removing and replacing test strips.

SECTION 413.20 SCRUB SEAL.

413.20.1 Description. This work shall consist of producing and placing a polymer modified asphalt (scrub seal) emulsion intended for use as a surface rejuvenation treatment and to fill and seal cracks.

413.20.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Aggregate[a]	1005.3
Emulsion	1015

[a]Aggregate substitutions may be allowed as approved by the engineer.

413.20.3 Equipment.

413.20.3.1 Aggregate Spreader. The aggregate spreader shall be self-propelled and capable of evenly spreading aggregate.

413.20.3.2 Pneumatic Tire Roller. The pneumatic tire roller shall be in accordance with Sec 401.

413.20.3.3 Brooms. Brooms shall be capable of adequately scrubbing the mixture into the cracks and surface.

413.20.4 Construction Requirements.

413.20.4.1 Surface Preparation. The surface shall be thoroughly cleaned of all vegetation, loose material, dirt, mud and other objectionable material immediately prior to application of the scrub seal emulsion.

413.20.4.2 Application. The scrub seal emulsion shall be uniformly applied with a pressure distributor at the rate specified in the contract or as designated by the engineer. The mixture shall be spread to fill cracks and minor surface irregularities and shall leave a uniform surface.

413.20.4.3 Physical Characteristics for Scrub Seal Emulsion.

Properties	Minimum	Maximum
Application rate of emulsion, gallons/sq. yard[a]	0.18	0.22
Emulsion Temperature, F	110	160
Application rate of aggregate, lb./sy[a]	16	22
Time of set prior to opening, hours[b]		2

[a]Application rate may change, final decision will be made by the engineer.
[b]The final decision for opening will be made by the engineer.

413.20.4.4 Method of Placement. After proper surface preparation, a distributor truck shall place the scrub seal emulsion at the prescribed rate. The distributor truck shall pull the broom assembly to sweep and spread the emulsion uniformly on the surface and into the cracks of the pavement.

413.20.4.4.1 Fine aggregate shall be placed immediately after the application of the emulsion and prior to the emulsion breaking. Immediately following the aggregate spreader, a second broom assembly shall be pulled to combine the aggregate with the emulsion.

413.20.4.4.2 The pneumatic tire roller shall immediately follow the second broom and shall make a minimum of two passes.

413.20.4.4.3 All excess sand shall be removed from the roadway, paved shoulders and paved side roads within 24 hours of application or as directed by the engineer.

413.20.4.5 Weather Limitations. The scrub seal emulsion shall not be placed on any wet surface or when the ambient temperature or the temperature of the pavement on which the mixture is to be placed is below 60 F. Temperatures shall be obtained in accordance with MoDOT Test Method TM 20.

413.20.4.6 Damaged or Marred Areas. Any traffic damaged or marred areas shall be repaired by the contractor at the contractor's expense.

413.20.5 Method of Measurement. Final measurement of the completed surface will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. Where required, measurement of scrub seal emulsion and mineral aggregate, complete in place, including multiple passes or courses, will be made to the nearest square yard. Measurement of individual passes or courses will not be made. The revision or correction will be computed and added to or deducted from the contract quantity.

413.20.6 Basis of Payment. The accepted quantity of scrub seal, in place, will be paid for at the contract unit price.

SECTION 413.30 ULTRATHIN BONDED ASPHALT WEARING SURFACE.

413.30.1 Description. This work shall consist of producing and placing an ultrathin bonded asphalt wearing surface.

413.30.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows, except as modified herein:

Item	Section
Coarse Aggregate	1002.2
Fine Aggregate	1002.3
Mineral Filler	1002.4

413.30.2.1 Coarse Aggregate. Coarse aggregate may consist of crushed gravel, limestone, dolomite, porphyry, steel slag, flint chat, or blends of two or more of these aggregates will be acceptable. When coarse aggregate for these mixes are from more than one source or of more than one type of material, the coarse aggregate shall be proportioned and blended to provide a uniform mixture. Coarse aggregate shall be material predominantly retained above the No. 4 sieve and shall be in accordance with the following requirements:

Coarse Aggregate Modified Requirements			
Test	**Method**	**Min**	**Max**
Los Angeles Abrasion Value, % Loss[a]	AASHTO T 96		35
Soundness, % Loss, Sodium Sulfate[a]	AASHTO T 104		12
Flat & Elongated Ratio, % @ 3:1[b]	ASTM D 4791		25
% Crushed, single face[b]	ASTM D 5821	95	
% Crushed, two faces[b]	ASTM D 5821	85	
Micro-Deval, % loss[a]	AASHTO T 327		18

[a]Tests shall be determined on each individual ledge basis.
[b]Tested on the coarse portion of the blended aggregate

413.30.2.2 Fine Aggregate. Fine aggregate shall be material predominantly passing the No. 4 sieve and shall be in accordance with the following requirements:

Fine Aggregate Modified Requirements			
Tests	**Method**	**Min**	**Max**
Sand Equivalent[a]	AASHTO T 176	45	
Methylene Blue[a]	AASHTO T 330		10
Uncompacted Void Content[a]	AASHTO T 304	40	

[a]Tested on the fine portion of the blended aggregate

413.30.2.3 Reclaimed Asphalt Pavement. The RAP shall be in accordance with Sec 403.2.6 and shall have 100 percent passing the 3/8 inch and no less than 70 percent passing the No. 4 sieve. The mixture shall contain no less than 80 percent effective virgin binder.

413.30.2.4 Asphalt Binder. The asphalt binder shall be in accordance with Sec 1015, including all subsections pertaining to PG76-22 or PG70-28.

413.30.2.5 Polymer Modified Emulsion Membrane. The emulsion shall be polymer modified and shall be in accordance with Sec. 1015.

413.30.3 Job Mix Formula. At least 30 days prior to placing any mixture on the project, the contractor shall submit a mix design to Construction and Materials for approval. Representative samples from each ingredient for the mix shall be submitted with the mix design.

413.30.3.1 Proficiency Sample Program. Laboratories that participate in and achieve a score of three or greater in the AASHTO proficiency sample program for T 11, T 27, T 84, T 85, T 166, T 176, T 209, T 304 (ASTM C 1252), T 308 and T 312 will have the mixture verification process waived. The mix design shall be submitted to Construction and Materials for approval at least seven days prior to mixture production.

413.30.3.2 Required Information. The mix design shall include raw data from the design process and contain the following information:

(a) All possible sources intended for use, and grade and specific gravity of asphalt binder.

(b) Source, type (formation, etc.), ledge number if applicable, and gradation of the aggregate.

(c) Bulk and apparent specific gravities and absorption of each aggregate fraction in accordance with AASHTO T 85 for coarse aggregate and AASHTO T 84 for fine aggregate including all raw data.

(d) Specific gravity of hydrated lime, mineral filler or baghouse fines, if used, in accordance with AASHTO T 100.

(e) Percentage of each aggregate component.

(f) Combined gradation of the job mix.

(g) Percent asphalt binder, by weight, based on the total mixture.

(h) Theoretical maximum specific gravity (G_{mm}) as determined by AASHTO T 209, in accordance with Sec 403.19.3.1, after the sample has been short term aged in accordance with AASHTO R 30.

(i) The tensile strength ratio as determined by AASHTO T 283 including all raw data.

(j) Mixing temperature and gyratory molding temperature.

(k) Bulk specific gravity (G_{sb}) of the combined aggregate.

(l) Percent chert contained in each aggregate fraction.

(m) Percent deleterious contained in each aggregate fraction.

(n) Blended aggregate properties for clay content, angularity, and thin and elongated particles.

(o) Draindown for mixture.

(p) Film thickness for mixture

413.30.4 Composition of Mixture.

413.30.4.1 Asphalt Amount. The amount of asphalt binder in the mixture shall meet the following limits for the type of mixture specified in the contract.

Mix Design Criteria			
	Type A	**Type B**	**Type C**
Asphalt Content, %	5.4 – 5.8	5.3 – 5.7	5.2 – 5.6

413.30.4.2 Gradation. Prior to mixing with asphalt binder, the combined aggregate gradation, including filler if needed, shall meet the following gradation for the type of mixture specified in the contract.

Mix Design Criteria			
Composition by Weight Percentages			
	Type A	**Type B**	**Type C**
Sieves	**% Passing**	**% Passing**	**% Passing**

3/4 in.		100	100
1/2 in.		97 – 100	85 – 100
3/8 in.	100	75 – 100	50 – 80
No. 4	40 – 55	25 – 41	25 – 41
No. 8	22 – 32	17 – 27	17 – 27
No. 16	15 – 25	23 max.	23 max.
No. 30	18 max.	18 max.	18 max.
No. 50	13 max.	13 max.	13 max.
No. 100	10 max.	10 max.	10 max.
No. 200	4.0 – 6.0	4.0 – 6.0	4.0 – 6.0

413.30.4.3 Film Thickness. The film thickness shall be a minimum 10.0 microns when calculated using the effective asphalt content in conjunction with the surface area for the aggregate in the Job Mix Formula. The surface area factors can be found in Table 6.1 of the Asphalt Institute MS-2, Mix Design Methods for Asphalt Concrete and Other Hot Mix Types, Sixth Edition.

413.30.4.4 Non-Carbonate Aggregate Requirement. Mixtures containing limestone coarse aggregate shall contain a minimum amount of non-carbonate aggregate as shown in the table below, or the aggregate blend shall have an acid-insoluble residue (A.I.R.), MoDOT Test Method TM 76, meeting the plus No. 4 sieve criteria of crushed non-carbonate material. Non-carbonate aggregate shall have an A.I.R. of at least 85 percent insoluble residue.

Coarse Aggregate (+ No. 4)	Minimum Non-Carbonate by Volume
Limestone	30% Plus No. 4
Dolomite	No Requirement

413.30.4.5 Drain Down. Drain down from the loose mixture shall not exceed 0.10 percent when tested in accordance with AASHTO T 305.

413.30.4.6 Moisture Susceptibility. The mixture shall have a tensile strength ratio (TSR) of 80 percent or greater when compacted to 3.7 inches with 7 ± 0.5 percent air voids and tested in accordance with AASHTO T 283.

413.30.5 Construction Requirements.

413.30.5.1 Weather Limitations. A damp pavement surface may be acceptable for placement if free of standing water and favorable weather conditions are expected to follow. Mix shall not be placed if the air temperature or the temperature of the surface on which the mixture is to be placed is below 50 F, the surface is wet or frozen, or weather conditions prevent the proper handling or finishing of the mixture. Temperatures shall be obtained in accordance with MoDOT Test Method TM 20.

413.30.5.2 Paver. The paver shall be capable of spraying the polymer modified asphalt emulsion membrane, applying the hot mix asphalt overlay and leveling the surface of the mat in one pass. Wheels or other parts of the paving machine shall not come in contact with the polymer modified emulsion membrane before the hot mix asphalt concrete wearing course is applied. The screed shall have the ability to crown the pavement at the center and shall have vertically adjusted extensions to accommodate the desired pavement profile.

413.30.5.3 Surface Preparation. Immediately prior to placing the ultrathin bonded asphalt wearing surface, the roadway surface shall be thoroughly cleaned of all vegetation, loose material, dirt, mud and other objectionable material. All non-working surface cracks with an opening size exceeding 1/4 inch and any size working crack shall be sealed prior to placement of the ultrathin bonded asphalt wearing surface. Immediately prior to spraying the polymer modified emulsion membrane, the surface shall be free of fresh bituminous mix. The ultrathin bonded asphalt wearing surface shall not be placed until the sealant has cured. Curing time of sealant shall be in accordance with the manufacturer's recommendations.

413.30.5.4 Application of Membrane. The polymer modified emulsion membrane application shall be applied in accordance with the manufacturer's recommendations. The sprayer shall accurately and continuously monitor the rate of spray and shall provide a uniform application across the entire width to be overlaid.

413.30.5.4.1 Adjusting Membrane Rate. The engineer may make adjustments to the spray rate based on the

existing pavement surface conditions and the recommendations of the polymer modified emulsion membrane manufacturer.

413.30.5.4.2 Application Rate of Membrane. Unless otherwise shown on the plans, the target field application rate of the asphalt emulsion shall be as follows for the type of mixture specified in the contract.

Membrane Application Rate	
Mixture Type	**Field Application Rate (gal/sy)**
Type A	0.17
Type B and C	0.20

413.30.5.4.2.1 Tolerance for Membrane Application Rate. At any given time during placement, the application rate of the asphalt emulsion shall be within 0.02 gal/sy of the target field application rate in the table or as indicated in the plans. The yield of the application rate over the entire project area shall be within 0.01 gal/sy of the target field application rate given in the table or as indicated in the plans.

413.30.5.5 Application of Mixture. The hot mix asphalt concrete shall be applied at a temperature of 290 to 330 F and shall be spread over the polymer modified emulsion membrane immediately after application of the polymer modified emulsion. The hot asphalt concrete wearing course shall be placed over the full width of the polymer modified emulsion membrane with a heated vibratory-tamping bar screed.

413.30.5.5.1 Handwork. For handwork, the hot mix asphalt shall be applied within five minutes after the application of the polymer modified emulsion.

413.30.5.5.2 Application Rate of Mixture. The target application rate of the ultrathin bonded asphalt wearing course shall be as shown on the plans. The application rate shall be adjusted to minimize fracturing of the top size aggregate by the screed. The engineer will determine the acceptable extent of fracturing at the edges for tapering purposes.

413.30.5.6 Rolling. Rolling of the wearing course shall consist of no more than three passes immediately following placement of the ultrathin bonded asphalt wearing course with a steel, double-drum, asphalt roller with a minimum weight of 10 tons. All rolling shall be completed before the material temperature has fallen below 195 F. Rollers shall be equipped with a functioning water system and scrapers to prevent adhesion of the fresh mix onto the roller drums. An acceptable release agent approved by the engineer may be added to the water system to prevent adhesion of the fresh mix to the roller drum and wheels. Rolling shall be done in the static mode. Excessive rolling to the extent of aggregate degradation will not be permitted. The engineer will determine the acceptable extent of fracturing at the edge of the pavement from the rolling operation. New pavement shall not be opened to traffic nor shall any roller sit idle on the pavement until the rolling operation is complete and the material has been cooled below 140 F.

413.30.5.7 Bituminous Mixing Plants. Bituminous mixing plants and preparation of materials and mixtures shall be in accordance with Sec 404.

413.30.5.8 Hauling Equipment. Trucks used for hauling bituminous mixtures shall be in accordance with Sec 404.

413.30.5.9 Wearing Course. The finished wearing course shall have a minimum thickness of 1/2 inch for Type A, 3/4 inch for Type B, and 3/4 inch for Type C.

413.30.5.10 Pavement Marking. Pavement marking shall be replaced in accordance with Sec 620.

413.30.5.11 Acceptance. Acceptance will be based on test results indicating that the ultrathin bonded asphalt wearing surface meets the specification requirements, the contractor following the approved QC Plan, and favorable comparison of the contractor's QC test and the engineer's QA test.

413.30.6 Quality Control.

413.30.6.1 Quality Control Operations. Quality control shall be conducted in accordance with Sec 403.17, except as follows.

413.30.6.1.1 Aggregate Gradation. Sieve analysis shall be performed for every 600 tons of mixture produced Test shall be performed in accordance with AASHTO T 27 from randomly sampled material taken from the composite cold feed belt or the hot bins.

413.30.6.1.2 Asphalt Content. The asphalt binder content shall be determined for each 600 tons of mixture produced. Test shall be performed in accordance with AASHTO T 287 or AASHTO T 308. Samples for determination of the asphalt binder content shall be retrieved from the hot elevator at the asphalt plant or from the transport truck at the plant by random sampling.

413.30.6.1.3 Deleterious Content. Deleterious content shall be determined for every 600 tons of mixture produced. Test shall be performed in accordance with MoDOT Test Method TM 71 from randomly sampled material taken from the composite cold feed belt.

413.30.6.2 Gradation and Asphalt Binder Tolerances. The total aggregate gradation shall be within the range specified in Sec 413.30.4.2 and the maximum variations from the approved job mix formula shall be within the following tolerances:

Gradation and Asphalt Binder Tolerances			
	Percent Passing		
Sieves	Type A	Type B	Type C
3/4 in.	-	-	-
1/2 in.	-	-	± 5.0
3/8 in.	-	± 5.0	-
No. 4	± 5.0	± 4.0	± 4.0
No. 8	± 4.0	± 4.0	± 4.0
No. 16	± 4.0	-	-
No. 200	± 1.0	± 1.0	± 1.0
Asphalt Content, %	± 0.3	± 0.3	± 0.3

413.30.6.3 Deleterious Content Tolerance. The deleterious content of the material retained on the No. 4 sieve shall not exceed the limits specified in Sec 1002.2.

413.30.6.4. Verifying Membrane Rate. The application rate of the polymer emulsion membrane shall be verified by dividing the volume of polymer modified emulsion membrane used by the area of paving for that day.

413.30.6.5 Mix Adjustments. The contractor may make field adjustments to the job mix formula as noted herein. The adjusted job mix formula shall be in accordance with the mix design requirements of Sec 413.30.4. The engineer shall be notified prior to making any change in the cold feed settings, the hot bin settings or the binder content. No additional fractions of material or new material will be permitted for field adjustments.

413.30.6.6 Defective Areas. The contractor shall remove and replace defective areas at the contractor's expense with material meeting specification requirements as directed by the engineer.

413.30.7 Quality Assurance. Quality assurance will be conducted in accordance with Sec 403 except as follows.

413.30.7.1 Sampling Frequency. Corrective action shall be taken by the contractor if any QA tests are outside the QC tolerances shown in Sec 413.30.6.2. The engineer will, at a minimum, independently sample and test at the following frequency:

Sample	Frequency
Aggregate Gradation	1 per day
Asphalt Binder Content	1 per day
Deleterious Content	1 per day

413.30.7.2 Testing Retain Samples. The engineer will test, at a minimum, one retained QC gradation sample and one retained QC asphalt binder content sample per calendar week. The engineer's test results, including all raw data, will be made available to the contractor by the next working day.

413.30.7.2.1 Aggregate Comparison. A favorable aggregate comparison will be achieved when test results are within the specified tolerances shown in Sec 403.18.2.

413.30.7.2.2 Asphalt Content Comparison. A favorable asphalt content will be achieved when test results are within 0.3 percent.

413.30.8 Method of Measurement. Final measurement of the completed surface will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. Where required, measurement of ultrathin bonded asphalt wearing surface, complete in place, will be made to the nearest square yard. The revision or correction will be computed and added to or deducted from the contract quantity.

413.30.9 Basis of Payment. The accepted quantity of ultrathin bonded asphalt wearing surface will be paid for at the contract unit price.

SECTION 413.31 BONDED HOT MIX ASPHALT USING POLYMER MODIFIED EMULSION MEMBRANE.

413.31.1 Description. This work shall consist of the placement of a Polymer Modified Emulsion Membrane prior to a bituminous overlay of hot asphaltic concrete pavement. The Polymer Modified Emulsion Membrane shall be spray applied immediately prior to the application of the hot asphaltic concrete pavement so as to produce a homogeneous surface in accordance with Secs 401, 402, or 403.

413.31.2 Materials. The Polymer Modified Emulsion Membrane shall be in accordance with Sec 1015.20.6.2.

413.31.3 Construction Requirements. The asphaltic concrete pavement shall be placed in accordance with Secs 401, 402, or 403, except as modified herein.

413.31.4 Equipment. No wheel, track or other part of the paving machine or any hauling equipment shall come in contact with the Polymer Modified Emulsion Membrane before the asphaltic concrete pavement mixture is applied.

413.31.5 Application of Polymer Modified Emulsion Membrane.

413.31.5.1 The Polymer Modified Emulsion Membrane shall be sprayed at a temperature of 120 - 180°. The sprayer shall accurately and continuously monitor the application rate and provide a uniform coverage across the entire width to be overlaid. The target application rate of the asphalt emulsion membrane shall be 0.20 gallons per square yard. The Engineer may make adjustments to the application rate based upon the existing pavement surface conditions and the recommendations of the Polymer Modified Emulsion Membrane supplier; however, the application rate shall be within +/- 0.05 gallon per square yard of the target application rate.

413.31.5.2 The application rate of the Polymer Modified Emulsion Membrane shall be verified by dividing the volume (of Polymer Modified Emulsion Membrane used) by the area of paving for that day.

413.31.5.3 No water shall be added to the Polymer Modified Emulsion Membrane.

413.31.6 Method of Measurement. Measurement of the Polymer Modified Emulsion Membrane shall be based on the volume in gallons in accordance with Sec 1015.

413.31.7 Basis of Payment. The accepted quantity of the Polymer Modified Emulsion Membrane will be paid for at the contract unit price.

SECTION 413.40 BITUMINOUS FOG SEALING.

413.40.1 Description. This work shall consist of furnishing diluted asphalt emulsion and preparing and sealing surfaces by means of a bituminous distributor.

413.40.2 Material. Asphalt emulsion grades SS-1, SS-1H, CSS-1, or CSS-1H shall be in accordance with Sec 1015 and shall be used unless otherwise directed by the engineer.

413.40.3 Equipment. The distributor shall be designed, equipped, maintained and operated such that liquid asphalt at even heat may be applied uniformly on variable widths of surface up to 15 feet at readily determined and controlled rates from 0.02 to 1.00 gallon per square yard, with uniform pressure, and with an allowable variation from any specified rate not to exceed 0.02 gallon per square yard. The distributor equipment shall include a tachometer, pressure gauges, a calibrated tank and a thermometer for measuring temperatures of tank contents. Distributors shall be equipped with a power unit for the pump, and with full circulation spray bars adjustable both laterally and vertically. The calibration of all distributors shall be approved by the engineer prior to use, and the contractor shall furnish all equipment, material and assistance necessary if calibration will be required.

413.40.4 Construction Requirements.

413.40.4.1 Asphalt emulsion shall be applied only during weather conditions under which satisfactory application and curing can be obtained. Asphalt emulsion shall not be placed on a damp or wet surface except as approved by the engineer. The surface shall be free of objectionable material prior to sealing.

413.40.4.2 The asphalt emulsion shall be diluted with water prior to application. The dilution rate shall be as shown on the plans or as directed by the engineer. The contractor shall provide documentation to the engineer that the specified coating system has been properly diluted.

413.40.4.3 The diluted asphalt emulsion shall be uniformly applied at the rate of 0.20 gallon per square yard surface. The application rate may be adjusted as directed by the engineer. Application widths shall be such that the entire surface is covered in one application.

413.40.4.4 Care shall be taken such that asphalt emulsion is applied only to designated areas. Sand dams or other approved means may be necessary to prevent emulsion from being applied outside of designated areas. Pavement marking obliterated by this operation shall be replaced by the contractor at the contractor's expense in accordance with Sec 620, unless otherwise provided for in the contract.

413.40.4.5 After application of the sealant, the surface shall be tack-free and capable of being open to traffic within four hours without tracking.

413.40.5 Method of Measurement. Measurement of the undiluted asphalt emulsion, complete in place and accepted by the engineer, will be made to the nearest gallon in accordance with Sec 1015.

413.40.6 Basis of Payment. The accepted quantity of bituminous fog seal will be paid for at the contract unit price for undiluted asphalt emulsion for seal that is mixed and used on the project. Diluted asphalt emulsion that is delivered to the job site, but not applied to the surface, will not be considered for payment. No direct payment will be made for sand.

SECTION 413.50 BITUMINOUS PAVEMENT CRACK SEALING.

413.50.1 Description. This work shall consist of preparing and sealing all working transverse and longitudinal cracks in bituminous pavement as shown on the plans or as directed by the engineer.

413.50.2 Material. The sealant shall be a single-component material in accordance with Type II sealant requirements in ASTM D 6690, except as herein modified.

413.50.2.1 The sealant shall be capable of being reheated to pouring temperatures at least once after the initial heating, while retaining the sealant's physical characteristics.

413.50.2.2 Penetration at 77 F, 50 grams, 5 seconds, shall be no less than 50 or greater than 90.

413.50.2.3 When tested at 77 F, the resilience recovery shall be a minimum of 50 percent.

413.50.2.4 The sealant shall meet all physical requirements after prolonged heating for six hours with constant mixing in a laboratory melter at the recommended field pouring temperature, complete cool down, and reheating to the recommended pouring temperature.

413.50.3 Construction Requirements.

413.50.3.1 The engineer will mark the cracks to be sealed. Sealant shall not be placed when the pavement is wet, or when the ambient or pavement temperature falls below 40 F. The contractor shall furnish to the engineer the manufacturer's recommendations for mixing and application, including temperature restrictions, and shall prepare and apply the crack sealant in accordance with the manufacturer's recommendations.

413.50.3.2 Cracks shall be routed or sawed to provide a reservoir centered over the existing crack. The reservoir shall be slightly larger than the existing crack, with a minimum size of 1/2-inch wide x 1/2-inch deep. The crack shall be clean, free from all loose and foreign material, and dry, prior to application of the sealant. Loose material on the surface within
2 inches of the crack shall be removed to permit proper adhesion.

413.50.3.3 The sealant shall be applied to the reservoir from the bottom up. The reservoir shall be slightly overfilled and excess material squeegeed with a V or U-shaped squeegee, level to the adjoining surface pavement forming a wipe zone 3 to 4 inches wide.

413.50.3.4 The contractor shall apply a light coating of sand or other blotting material to the surface of the newly placed sealant if traffic results in tracking of the crack sealing material.

413.50.4 Method of Measurement. Measurement of crack sealing will be made to the nearest linear foot of cracks sealed, complete in place, and accepted by the engineer.

413.50.5 Basis of Payment. The accepted quantity of pavement crack sealing will be paid for at the contract unit price.

SECTION 413.60 PORTLAND CEMENT CONCRETE PAVEMENT JOINT/CRACK SEALING.

413.60.1 Description. This work shall consist of preparing and resealing all existing transverse and longitudinal joints, and working transverse and longitudinal cracks in Portland cement concrete pavement (PCCP) as shown on the plans or as directed by the engineer.

413.60.2 Material. Sealant material shall be in accordance with Sec 1057.

413.60.3 Construction Requirements.

413.60.3.1 The engineer will mark the existing joints and cracks to be sealed. The sealant shall not be placed when the pavement is wet, or when the ambient or pavement temperature falls below 40 F. The contractor shall furnish to the engineer the manufacturer's recommendations for mixing and application, including temperature restrictions, and shall prepare and apply the crack sealant in accordance with the manufacturer's recommendations.

413.60.3.2 Cracks shall be routed or sawed to provide a reservoir centered over the existing crack. The reservoir shall be slightly larger than the existing crack, with a minimum size of 3/8-inch wide x d/4 deep, where d is the thickness of the pavement. The joint/crack shall be clean, free from all loose and foreign material, including existing sealant, and dry prior to application of the sealant.

413.60.3.3 Sealant shall be applied to the joint or reservoir uniformly from the bottom to 1/2 inch from the top. Any excess material shall be removed from the pavement surface.

413.60.4 Method of Measurement. Measurement of crack sealing will be made to the nearest linear foot of cracks sealed, complete in place, and accepted by the engineer.

413.60.5 Basis of Payment. The accepted quantity of pavement crack sealing will be paid for at the contract unit price.

SECTION 413.70 BITUMINOUS PAVEMENT CRACK FILLING.

413.70.1 Description. This work shall consist of preparing and filling all cracks in bituminous pavement as shown on the plans or as directed by the engineer.

413.70.2 Material. Filler material shall be in accordance with one of the following:

Item	Section
Asphalt Binder	1015.3
Polymer Modified Emulsion	1015.20.5
Crack Sealing Material	413.50.2

413.70.3 Construction Requirements.

413.70.3.1 The engineer will mark the cracks to be filled. Filler material shall not be placed when the pavement is wet, or when the ambient or pavement temperature falls below 40 F. The contractor shall furnish to the engineer the manufacturer's recommendations for mixing and application, including temperature restrictions, and shall prepare and apply the crack filler material in accordance with the manufacturer's recommendations.

413.70.3.2 The crack shall be clean, free from all loose and foreign material, and dry prior to application of the filler material. Loose material on the surface within 2 inches of the crack shall be removed to permit proper adhesion.

413.70.3.3 Filler material shall be applied to the crack from the bottom up. The crack shall be slightly overfilled and excess material squeegeed with a V or U-shaped squeegee, level to the adjoining surface pavement forming a wipe zone 3 to 4 inches wide.

413.70.3.4 The contractor shall apply a light coating of sand or other blotting material to the surface of the newly placed filler if traffic results in tracking of the crack sealing material.

413.70.4 Method of Measurement. Measurement of crack filling will be made to the nearest linear foot of cracks filled, complete in place, and accepted by the engineer.

413.70.5 Basis of Payment. The accepted quantity of pavement crack filler will be paid for at the contract unit price.

SECTION 413.80 PORTLAND CEMENT CONCRETE PAVEMENT CRACK FILLING.

413.80.1 Description. This work shall consist of preparing and filling all cracks in PCCP, as shown on the plans or as directed by the engineer.

413.80.2 Material. Filler material shall be in accordance with Sec 413.50.2 or Sec 1057.

413.80.3 Construction Requirements.

413.80.3.1 The engineer will mark the existing cracks to be filled. Filler material shall not be placed when the pavement is wet, or when the ambient or pavement temperature falls below 40 F. The contractor shall furnish to the engineer the manufacturer's recommendations for mixing and application, including temperature restrictions, and shall prepare and apply the crack filler material in accordance with the manufacturer's recommendations.

413.80.3.2 The crack shall be clean, free from any loose and foreign material, and dry prior to application of the filler material.

413.80.3.3 Filler material shall be applied to the crack uniformly from the bottom to 1/2 inch from the top. Any excess material shall be removed from the pavement surface.

413.80.4 Method of Measurement. Measurement of crack filling material will be made to the nearest linear foot of cracks sealed, complete in place, and accepted by the engineer.

413.80.5 Basis of Payment. The accepted quantity of pavement crack filler will be paid for at the contract unit price.

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SECTION 501
CONCRETE

501.1 Description. Concrete shall consist of a mixture of cement, fine aggregate, coarse aggregate and water, combined in the proportions specified for the various classes. Admixtures may be added as specifically required or permitted.

501.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Coarse Aggregate[a]	1005.2
Fine Aggregate[a]	1005.3
Ground Granulated Blast Furnace Slag	1017
Fly Ash	1018
Cement	1019
Concrete Admixture	1054
Concrete Tinting Material	1056
Water	1070

[a]Regardless of the gradation of the coarse and fine aggregate used in concrete for pavement or base, the aggregate shall meet the quality requirements of coarse and fine aggregate for concrete pavement.

501.2.1 Aggregate Acceptance. Quality control (QC) sampling and testing will be performed by the contractor and quality assurance (QA) sampling and testing will be performed by the engineer for aggregate in Portland cement concrete masonry in accordance with the following table at the last possible point of incorporation into the project. Aggregate samples may be taken either by sampling the flowing aggregate stream or upon approval by the engineer, from the stockpile.

Item	Property	QC Test Frequency	QA Test Frequency
Portland Cement Concrete Masonry	Gradation of Coarse Aggregate - AASHTO T 27 and T 11	One per 500 cubic yards per fraction per project.	One QC split per 2,500 cubic yards with a minimum of one per project. One independent QA per project.
	Gradation of Fine Aggregate - AASHTO T 27 and T 11		
	Deleterious Content - MoDOT Test Method TM 71		
	Absorption of Coarse Aggregate - AASHTO T 85		
	Thin or Elongated Pieces - ASTM D 4791 (+3/4 in., 5:1)	One per source per project.	One per source per year.

501.2.2 Retained Samples. The contractor shall retain the QC split sample, obtained as specified in Sec 502.11.2.1.5, for seven days until requested by the engineer for comparison testing. A comparison will be considered favorable when the QA results of a QC retained sample are within the applicable limits specified in Sec 403.18.2.

501.3 Mix Design. The proportions of cement, fine aggregate and coarse aggregate for concrete shall be approved by the engineer within the applicable limits of the specifications for the class of concrete specified in the contract. The contractor shall submit a mixture designed by absolute volume methods or an optimized mix design method such as Shilstone method or other recognized optimization method. Optimized will refer to aggregate gradations that produce lower water demands, as well as improved workability and finishing characteristics. The target and allowable gradation range of each fraction shall be included. The contractor may be required to submit representative samples of each ingredient to Construction and Materials for laboratory testing.

501.3.1 Required Information. The concrete mix design shall contain the following information:

(a) Source, type and specific gravity of Portland cement

(b) Source, type (class, grade, etc.) and specific gravity of supplementary materials, if used

(c) Source, name, type and amount of admixtures

(d) Source, type (formation, etc.), ledge number if applicable, and gradation of the aggregate

(e) Specific gravity and absorption of each fraction in accordance with AASHTO T 85 for coarse aggregate and AASHTO T 84 for fine aggregate, including raw data

(f) Unit Weight of each fraction in accordance with AASHTO T 19

(g) The percent of each aggregate component used for optimized concrete mixes

(h) The design air content and slump

(i) Batch weights of Portland Cement and supplemental cementitious materials

(j) Batch weights of coarse, intermediate and fine aggregates

(k) Batch weight of water

501.3.2 Paving Concrete. For PCCP mixes, the gradation requirements of Sec 1005 will not apply. For all fractions, 100 percent of each fraction shall pass the 2-inch sieve. When Grade F is required, 100 percent of each fraction shall pass the 3/4-inch sieve.

501.3.3 Optimized Masonry Concrete. For optimized PCCM mixes, the gradation requirements of Sec 1005.2 and Sec 1005.3 will not apply. For coarse aggregate, 100 percent of each fraction shall pass the one-inch sieve and no more that 2.5 percent shall pass the No. 200 sieve. This value may be increased to 3.0 percent passing, provided there is no more than 1.0 percent of the material passing the No. 200 sieve in the fine aggregate. For fine aggregate, no more than 2.0 percent shall pass the No. 200 sieve for natural sand, and no more than 4.0 percent shall pass the No. 200 sieve for manufactured sand.

501.3.4 Non-Optimized Masonry Concrete. When optimized aggregate gradations are not selected by the contractor, all provisions, including gradations requirements of Sec 1005 shall apply

501.3.5 Fine Aggregate Classes. Fine aggregates are grouped into four classes and a minimum cement factor has been established for each class.

501.3.6 Cement Factors. The minimum cement requirements in pounds per cubic yard of concrete for the various classes of sand shall be as follows:

Cement Requirements[a,b]							
Class of Sand	**Class A-1 Concrete**	**Class B Concrete**	**Class B-1 Concrete**	**Class B-2 Concrete**	**Class MB-2 Concrete[g,h]**	**Pavement Concrete**	**Seal Concrete**
A[c]	600	525	610	705	600	560	660
B[d]	640	565	640	735	620	560	695
C[e]	--	585	660	750	640	560	715
D[f]	--	620	695	790	660	560	735

[a]When used, Type IP, I(PM), IS or I(SM) cement shall be substituted on a pound for pound basis for Type I or Type II cement and adjustments in design mix proportions will be required to correct the volume yield of the mixture.
[b]The contractor may submit an optimized mix design which has a maximum 50 pounds per cubic yard reduction in cement from that shown in the tables. If the contractor chooses this option, the mixture will be subject to review, laboratory testing and approval by the engineer. All other requirements for the cement factor will apply.
[c]Class A sand will include all sand, except manufactured sand, weighing 109 pounds per cubic foot or more.
[d]Class B sand will include all chert, river and Crowley Ridge sand weighing from 106 to 108

pounds, inclusive, per cubic foot or glacial sand weighing 108 pounds or less per cubic foot.
[e]Class C sand will include all chert, river and Crowley Ridge sand weighing from 101 to 105 pounds, inclusive, per cubic foot.
[f]Class D sand will include all sand weighing 100 pounds or less per cubic foot and any manufactured sand that is produced by the process of grinding and pulverizing large particles of aggregate or which contains more than 50 percent of material produced by the reduction of coarser particles. Manufactured sand produced from limestone or dolomite shall not be used in Portland cement concrete for driving surfaces such as bridge decks, pavements and full depth shoulders.
[g]Modified B-2 (MB-2) concrete may be used in-place of Class B-2 Concrete.
[h]Modified B-2 (MB-2) concrete shall use at least one supplementary cementitious material in accordance with this specification. In no case shall MB-2 concrete use less than 15 percent fly ash or GGBFS when used as the individual supplementary cementitious material. In no case shall MB-2 concrete use less than 6 percent metakaolin when used as the individual supplementary cementitious material.

501.3.7 Unit Weight. The weight per cubic foot shall be the dry rodded weight per cubic foot of the aggregate, determined in accordance with AASHTO T 19.

501.3.8 Compressive Strength Requirements. Concrete classes shall meet the following compressive strength requirements in pounds per square inch:

Minimum Design Compressive Strength[1]						
Class A-1 Concrete	Class B Concrete	Class B-1 Concrete	Class B-2 Concrete	Class MB-2 Concrete	Pavement Concrete	Seal Concrete
6,000	3,000	4,000	4,000	4,000	4,000	3,000

[1]Minimum compressive strength required unless otherwise specified in the contract documents or approved by the engineer.

501.3.9 Absorptions. Coarse aggregate absorption tolerances shall be in accordance with Sec 502.11.3.3.

501.4 Sampling. Sampling of fresh concrete shall be in accordance with AASHTO R 60, except that for central or truck mixed concrete, the entire sample for slump and air tests and for molding compressive strength specimens may be taken at one time after approximately one cubic yard of concrete has been discharged, instead of at three or more regular intervals during the discharge of the entire batch. Acceptability of the concrete for slump and air content and, if applicable, for strength requirements, will be determined by tests on these samples.

501.5 Consistency. The slump of the concrete shall be within the limits for the respective classes of concrete. The concrete shall be uniform in consistency and shall contain the minimum quantity of water required to produce the designated slump. The slump of concrete mixes will be determined in accordance with AASHTO T 119. The quantity of mixing water in the concrete shall be considered the net quantity after proper allowance has been made for absorption by the aggregate. The slump and mixing water content of the concrete, when placed in the work, shall not exceed the following limits:

Slump and Maximum Water/Cementitious Materials Ratio			
Class of Concrete	Max. Slump, In.	Max. Pounds of Mixing Water Per Pound of Cementitious Materials	
		Air-Entrained	Non-Air-Entrained
A-1	3 1/2	0.46	0.51
B	4	0.51	0.55
B-1	4	0.44	0.53
B-2	3	0.40	----
MB-2	6	0.42	----
Pavement	----	0.50	0.53
Seal	8	----	0.53

501.6 Measurement of Material. The cement and aggregate for concrete shall be measured by weight. The weights of coarse and fine aggregates to be used will be calculated from the proportions approved by the engineer. Batches that do not contain the proper quantities of material shall be wasted at the contractor's expense.

501.6.1 Weighing Tolerances. The weighing and batching equipment shall be designed and maintained in such a condition that the material for each batch can be quickly and accurately weighed and shall be operated within a tolerance of plus or minus 0.5 percent for cement and plus or minus 1.0 percent for aggregate. The equipment used for delivery of material to the weigh hoppers shall not permit intermingling of material. Weighing hoppers shall discharge completely and there shall be no accumulation of tare material. Scales shall be accurate to within 0.4 percent of the net load applied. The change in load required to change the position of rest of the indicating element or elements of indicating scales an observable amount shall not be greater than 0.1 percent of the nominal scale capacity. If beam-type scales are used, a separate beam shall be provided for each type of material to be used and means shall be provided for adjustment of tare on a scale separate from those used for other material.

501.6.2 Water Meter Tolerances. Mixing water shall be measured by volume or by weight. If measured by weight, scales shall be in accordance with Sec 501.6.1. The device for the measurement shall be readily adjustable and under all operating conditions shall measure the required quantity within a tolerance of one quart or one percent, whichever is greater.

501.6.3 Calibration Frequency. Plant scales and water metering devices shall be calibrated and certified annually and after every plant move by an approved commercial scale service. Admixture metering devices shall be calibrated by a commercial scale company, the admixture company or the concrete plant company. Plant scales that have not been moved shall be verified six months after their calibration. A copy of the calibration and verification shall be provided to the engineer.

501.7 Mixing. The mixer shall produce concrete uniform in color, appearance and distribution of the material throughout the mixture. The cement, aggregate and no less than 60 percent of the water shall be mixed a minimum of one minute. The remaining water shall be added within 15 seconds after all other material for the batch is in the mixer. If mixers having multiple compartment drums are used, the time required to transfer material between compartments will be considered mixing time. The speed at which the drum rotates shall be as designated by the manufacturer. If such mixing does not result in uniform and smooth texture concrete, a sufficient number of additional revolutions at the same speed shall be performed until a thorough mixing of each batch of concrete is secured. The mixing time shall be measured from the time all cement, aggregate and 60 percent of the water are in the drum. The volume of concrete mixed in each batch shall not exceed the manufacturer's rated capacity. The mixer shall be equipped to automatically time the mixing of each batch of concrete. If the automatic timing device becomes inoperable, a manual timing device shall be provided to complete the day's operation.

501.8 Central and Truck Mixed Concrete. The following additional requirements will apply to central and truck mixed concrete.

501.8.1 Mixer Inspection. All central mixers, truck mixers and agitators shall be in accordance with of these specifications prior to use, and inspection of the equipment shall be made periodically during the work. Only equipment found acceptable in every respect and capable of producing uniform results will be permitted.

501.8.2 Uniformity Testing. A uniformity test in accordance with ASTM C 94 Annex A1, shall be performed during the annual calibration at a central mix drum plant and at the beginning of production for a project at a mobile paving plant.

(a) A uniformity test shall be performed for the largest and smallest proposed batch size.

(b) The two samples shall be obtained within an elapsed time of no more than 15 minutes.

(c) The air content, slump and mix proportions of the concrete tested shall be in accordance with these specifications for that class of concrete or the uniformity tests shall be invalid.

(d) The use of a one-quarter cubic foot measure will be permitted in determination of weight per cubic foot.

(e) Cylinders may be cured in damp sand after the first 48 hours.

(f) The contractor may designate the mixing time for which uniformity tests are to be performed. The mixing time shall be a minimum of 60 seconds. The maximum mixing time shall not exceed the mixing

time established by uniformity tests by more than 60 seconds for air-entrained concrete. The mixed concrete shall meet the uniformity requirements specified above before any concrete may be used for pavement or structures. The engineer may allow the use of the test concrete for appropriate incidental construction. Tests shall be performed by the contractor, in the presence of the engineer. No direct payment will be made for labor, equipment, material or testing. After operational procedures of batching and mixing are thus established, no changes in procedure will be permitted without re-establishing procedures by uniformity tests.

501.8.2.1 Measuring Mixing Time. Measurement of mixing time shall start at the time all the solid material is in the drum and shall end at the beginning of the next sequential operation.

501.8.2.2 Verification of Mixer. Mixer performance tests shall be repeated whenever the appearance of the concrete or the coarse aggregate content of samples selected in accordance with ASTM C 94, as modified above, indicates that adequate mixing is not being accomplished.

501.8.3 Truck Mixed Concrete. Truck mixed concrete shall be mixed at the proportioning plant and the mixer shall operate at agitating speed while in transit. Truck mixed concrete may be mixed at the point of delivery, provided the cement or cement and mixing water, are added at that point. Mixing of truck mixed concrete shall begin immediately after the introduction of the mixing water and cement to the aggregate or the introduction of the cement to the aggregate.

501.8.4 Truck Mixer Requirements. A truck mixer shall consist of a watertight revolving drum suitably mounted, fitted with adequate blades, and equipped with a device for determining the number of mixing revolutions. Truck mixers shall produce a thoroughly mixed and uniform mass of concrete and shall discharge the concrete without segregation. A truck agitator shall consist of a watertight revolving drum or a watertight container suitably mounted and fitted with adequate revolving blades. Truck agitators shall transport and discharge the concrete without segregation. Mixers and agitators shall be cleaned of accumulation of hardened concrete or mortar.

501.8.5 Rating Plate. Except as hereinafter permitted, each truck mixer shall have permanently attached to the truck a metal rating plate issued by and in accordance with the capacity requirements of the Truck Mixer Manufacturers Bureau (TMMB), as approved by NRMCA, on which is stated the maximum capacity in terms of volume of mixed concrete for the various uses to which the equipment is applicable. The truck shall also have attached a manufacturer's data plate that shall state the actual capacity as an agitator, and the maximum and minimum mixing and agitating speeds. If truck mixers are used for mixing or agitating, the volume of concrete in each batch shall not exceed the maximum capacity shown on the metal rating plate issued by the TMMB, as approved by NRMCA, except that if a lower capacity for agitating is shown on the manufacturer's data plate, that lower capacity shall govern. The minimum batch size for truck mixers shall be one cubic yard. The engineer may reduce the batch size or reject use of any truck mixer that does not produce concrete uniform in color, appearance and distribution of material throughout the mass. A quantity of concrete that results in axle and gross loads in excess of statutory limits will not be permitted.

501.8.6 Truck Mixing Requirements. Truck mixers and agitators shall be operated at the speed of rotation designated by the manufacturer of the equipment. Truck mixed concrete shall initially be mixed no less than 70 or more than 100 revolutions of the drum at mixing speed after all ingredients, including water, are in the mixer, except that when the batch volume does not exceed 57.5 percent of the gross volume of the drum or 91 percent of the rated maximum capacity, the number of revolutions required for mixing shall be no less than 50 or more than 100. When a truck mixer or truck agitator is used for transporting concrete that has been completely mixed, agitation of the concrete shall continue during transportation at the speed designated by the manufacturer of the equipment as agitating speed. Water may be added to the mixture no more than two times after initial mixing is completed. Each time water is added, the drum shall be turned an additional 30 revolutions, or more if necessary, at mixing speed, until uniform mixing is accomplished. All water added will be included in determining the effective water in the mixture.

501.8.7 Water Adjustments at Job Site. Each increment of water added at the job site shall be measured within a tolerance of one percent of the total effective water required for the batch. Water used to wash the drum of the mixer shall not be used as mixing water.

501.8.8 Handling and Discharge Requirements. Central or truck mixed concrete shall be delivered to the site of the work and shall meet the following conditions:

(a) The handling and discharge of concrete shall not cause segregation or damage to the concrete and will allow placement with a minimum of handling. All handling and discharge shall occur prior to initial set of the concrete.

(b) Truck mixed concrete shall not exceed 300 revolutions after the beginning of mixing.

501.8.9 Non-Agitating Equipment. The discharge of concrete transported in non-agitating equipment shall not cause segregation or damage to the concrete and will allow placement with a minimum of handling. All handling and discharge shall occur prior to initial set of the concrete. Bodies of non-agitating hauling equipment shall be smooth, mortar-tight metal containers capable of discharging the concrete at a satisfactory, controlled rate without segregation.

501.8.10 Testing Facilities. The contractor shall provide a Type 1 laboratory in accordance with Sec 601 at a paving plant for the engineer to inspect ingredients and processes used in the manufacture and delivery of the concrete. The contractor shall furnish the necessary equipment and personnel to assist the engineer in obtaining a representative QA sample. The ready mix producer shall notify the designated MoDOT representative every day that concrete is being supplied for a MoDOT project. A daily log of plant production shall be available for the engineer to review.

501.8.11 Delivery Tickets. The manufacturer of truck mixed concrete and of central mixed concrete for use in structures shall furnish to the engineer with each truck load of concrete before unloading at the site, a delivery ticket on which is shown information concerning the concrete as follows:

(a) Name of concrete plant.

(b) Serial number of the ticket.

(c) Truck number when a truck mixer is utilized.

(d) Name of contractor.

(e) Job Number, route and county designation.

(f) MoDOT mix identification number assigned to the mix.

(g) Specific class of concrete.

(h) Quantity of concrete in cubic yards.

(i) Date and time when batch was loaded or first mixing of cement and aggregate.

(j) Number of revolutions, when truck mixed.

501.8.12 Concrete Plant Documentation. The contractor shall complete the required concrete plant documentation once per working day at the central ready mix or paving plant. The documentation shall be made available to the engineer within 24 hours after concrete is batched.

501.9 Volumetric Batched and Continuous Mixed Concrete. Upon written request by the contractor, the engineer may approve the use of concrete proportioned by volume. If concrete is proportioned by volume, the other requirements of these specifications with the following modifications will apply.

501.9.1 Proportional Devices. Volume proportioning devices, such as counters, calibrated gate openings or flow meters, shall be available for controlling and determining the quantities of the ingredients discharged. In operation, the entire measuring and dispensing mechanism shall produce the specified proportions of each ingredient.

501.9.2 Controls. All indicating devices that affect the accuracy of proportioning and mixing of concrete shall be in full view of and near enough to be read by the operator while concrete is being produced. The operator shall have convenient access to all controls.

501.9.3 Calibration. The proportioning devices shall be calibrated by the contractor in the presence of and subject to approval from the engineer. Calibration of the cement and aggregate proportioning devices shall be accomplished by weighing each component. Calibration of the admixture and water proportioning devices shall be accomplished by weight or volume. Tolerances in proportioning the individual components will be as follows:

Item	Tolerance
Cement, Weight percent	0 to +4
Fine Aggregate, Weight percent	± 2
Coarse Aggregate, Weight percent	± 2
Admixtures, Weight or Volume percent	± 3
Water, Weight or Volume Percent	± 1

501.9.4 Verification of Yield. Verification of the proportioning devices may be required at any time by the engineer. Verification shall be accomplished as follows. With the cement meter set on zero and all other controls set for the designated mix, the activated mixer shall discharge mixed material into a 1/4 cubic yard container measuring 36 x 36 x 9 inches. When the container is level-struck full, making provisions for settling the material into all corners, the cement meter shall show a discharge equal to the design proportion of cement for 1/4 cubic yard. A tolerance of ± 1/8 inch from the top of the container will be permitted. If the correct yield is not obtained, the proportioning devices shall be adjusted to obtain the design mix or the proportioning devices shall be recalibrated as directed by the engineer.

501.9.5 Water Control. The rate of water supplied shall be measured by a calibrated flow meter coordinated with the cement and aggregate feeding mechanism and with the mixer. The rate shall be adjustable in order to control slump at the desired level.

501.9.6 Liquid Admixture. Liquid admixtures shall be dispensed through a controlled flow meter. A positive means to observe the continuous flow of material shall be provided. If an admixture requires diluting, the admixture shall be diluted and thoroughly mixed prior to introducing the admixture into the dispenser. When admixtures are diluted, the ratio of dilution and the mixing shall be approved by and performed in the presence of the engineer.

501.9.7 Concrete Mixer. The concrete mixer shall be approved by the engineer and shall be an auger-type continuous mixer used in conjunction with volumetric proportioning. The mixer shall produce concrete, uniform in color and appearance, with homogeneous distribution of the material throughout the mixture. Mixing time necessary to produce uniform concrete shall be established by the contractor and shall comply with other requirements of these specifications. Only equipment found acceptable in every respect and capable of producing uniform results will be permitted.

501.9.7.1 Material Storage Capacity. The continuous mixer shall be capable of carrying sufficient unmixed dry bulk cement, fine aggregate, coarse aggregate, admixtures and water, in separate compartments to produce no less than 6 cubic yards of concrete at the job site. Each batching or mixing unit or both, shall carry in a prominent place a metal plate or plates on which are plainly marked the gross volume of the unit in terms of mixed concrete, discharge speed and the weight-calibrated constant of the machine in terms of a revolution counter or other output indicator.

501.9.7.2 Measurement of Cement. The continuous mixer shall be capable of positive measurement of cement being introduced into the mix. A recording meter visible to the operator and equipped with a ticket printout shall indicate the quantity.

501.9.7.3 Measurement of Water. The continuous mixer shall provide positive control of the flow of water and admixtures into the mixing chamber. Water flow shall be indicated by a flow meter and be readily adjustable to provide for minor variations in aggregate moisture. The mixer shall be capable of continuously circulating or mechanically agitating the admixtures.

501.9.7.4 Scalping Screen. The continuous mixer shall have a one-inch maximum size scalping screen over the fine aggregate bin to screen out mud balls, conglomerate lumps or any other contaminant material that could interrupt the flow of fine aggregate during proportioning.

501.9.7.5 Batching Operations. The continuous mixer shall be capable of being calibrated to automatically proportion and blend all components on a continuous or intermittent basis as required, and shall discharge mixed material through a conventional chute.

501.9.8 Handling Materials. Storage facilities for all material shall be designed to permit the engineer to make necessary inspections prior to the batching operations. The facilities shall also permit identification of approved material at all times, and shall be designed to avoid mixing with or contaminating by, unapproved material. Coarse and fine aggregate shall be furnished and handled so variations in the moisture content affecting the uniform consistency of the concrete will be avoided.

501.10 Air-Entrained Concrete. Air content for all classifications of concrete shall be determined in accordance with AASHTO T 152. Air-entrained concrete shall be used for the construction of the following items:

(a) All retaining walls and bridge units, except culvert-type structures and seal courses.

(b) Concrete median barriers.

(c) All piles (not required for cast-in-place concrete piles).

(d) Concrete pavements.

(e) Approach slabs and paved approaches.

(f) Concrete medians and median strips.

(g) Sidewalks, curb ramps and steps.

(h) Curbs, gutters, curb and gutter and surface drain basins and drains.

(i) Concrete pedestals for signs, signals and lighting.

501.10.1 Other Concrete. All other concrete, except seal concrete, may be air-entrained but only in accordance with the requirements of these specifications.

501.10.2 Air Content Limitations. When air-entrained concrete is used, the mix design target range for quantity of air content by volume shall not be less than 4.5 percent or greater than 7.5 percent. When field measured air content exceeds 7.5 percent, but is less than or equal to 9.0 percent, the concrete may be placed if allowed by the contractor's quality control plan and at the contractor's risk that all other concrete requirements will be met, including strength. When field measured air content is less than 4.5 percent, the concrete may be re-dosed with air entrainment admixture in accordance with Section 501.10.4. Under no circumstances shall any concrete be incorporated into the work with an air content less than 4.5 percent or greater than 9.0 percent.

501.10.3 Incorporation Procedures. Air-entraining admixtures shall be added to the concrete during the mixing process. The admixture shall be of such volume and strength that the admixture can be accurately measured and dispensed in accordance with the manufacturer's recommendations. The dispenser shall consistently deliver the required quantity of admixture within a tolerance of ± 3 percent.

501.10.4 Re-Dosing. When the measured air content is below the minimum specified limit, the contractor will be allowed one attempt per mixer truckload to re-dose the concrete in the field. The contractor shall immediately contact the concrete supplier to make adjustments to all remaining truckloads so they arrive within specifications. If no adjustments are made, re-dosing will not be allowed for subsequent truckloads. The contractor shall obtain approval of the Re-Dosing Plan from the engineer prior to the start of work. The Re-Dosing Plan shall address the following:

(a) Field measurement of the air entrainment admixture

(b) Brand of air entrainment admixture being used

(c) Incorporation and mixing of the air entrainment admixture

(d) The use of additional water

501.11 Concrete Admixtures for Retarding Set. If specified in the contract, an approved retarding admixture shall be provided and incorporated into the concrete. If not specified in the contract, the use of an approved retarding admixture will be permitted upon written notification from the contractor. Any retarding admixture shall be added in accordance with Sec 501.10.3 by means of a dispenser conforming to the requirements of that section. No direct payment will be made for furnishing the retarding admixture or for incorporating the admixture into the mixture.

501.12 Water-Reducing Admixtures. Type A water-reducing admixtures may be used in any concrete. When Type A water-reducing admixture is added to pavement concrete for paving purposes, a reduction of cement up to 25 lbs per cubic yard will be permitted. The dosage rate of Type A water-reducing admixture shall be within the ranges recommended by the manufacturer and approved by the engineer. Any cementitious material substitution permitted by specification shall be based on the reduced cement content. Water-reducing admixtures shall be added in accordance with Sec 501.10.3 by means of a dispenser conforming to the requirements of that section. High range water-reducing admixtures may be used when specified or as approved by the engineer.

501.12.1 Modified B-2 Utilized. Modified B-2 concrete shall use a Type A or Type D water-reducer admixture.

501.12.2 Silica Fume and Metakoalin Utilized. Concrete utilizing silica fume or metakaolin shall use a water-reducer admixture that may be added by hand methods. The amount of water contained by the water-reducer admixture shall be included in the overall water content of the concrete.

501.12.3 Consistency Requirement. When a water-reducer admixture is used the maximum allowed slump may be increased to 6 inches for all concrete classes. The concrete shall be homogeneous with no aggregate segregation.

501.13 Accelerating Admixtures. The use of calcium chloride or other approved accelerating admixtures in concrete mixtures will not be permitted, except in concrete used for pavement repair in accordance with Sec 613.

501.13.1 Incorporating Calcium Chloride. Calcium chloride shall be incorporated into the concrete mix in solution form using water. The water used for the solution shall to be accounted for in the approved mix design.

501.13.2 Amount of Calcium Chloride. The amount of calcium chloride shall not exceed 2 percent by mass of the cementing material, unless otherwise approved by the engineer.

501.14 Supplementary Cementitious Materials in Concrete. The contractor may use fly ash, GGBFS, silica fume or metakaolin in the production of concrete in accordance with these specifications. Ternary mixes will be allowed for all concrete classes. Ternary mixes are mixes that contain a combination of Portland cement and two supplementary cementitious materials. Supplementary cementitious materials may be used to replace a maximum of 40 percent of the Portland cement. The amount of each supplementary cementitious materials used in a ternary mix shall not exceed the limits specified herein.

501.14.1 Fly Ash. Approved Class C or Class F fly ash may be used to replace a maximum of 25 percent of the Portland cement on a pound for pound basis in all concrete.

501.14.2 Ground Granulated Blast Furnace Slag. Approved GGBFS may be used to replace a maximum of 30 percent of the Portland cement on a pound for pound basis in all concrete.

501.14.3 Silica Fume. Approved silica fume may be used to replace a percent of the Portland cement on a pound for pound basis. The following limits shall apply when silica fume is used:

Silica Fume Replacement Limits, %		
Class of Concrete	**Minimum**	**Maximum**
MB-2	6	8
A-1, B, B-1, B-2, PCCP, Seal	----	8

501.14.3.1 Silica Fume Requirements. Silica fume shall be approved prior to use and be in accordance with ASTM C 1240, except as noted herein. If dry compacted form, the admixture shall be 100 percent silica fume with no admixtures. Silica fume slurries may contain other approved admixtures, such as water reducers or retarders, if the admixtures are included by the manufacturer of the silica fume admixture.

501.14.3.2 Manufacturer Certification. The contractor shall furnish to the engineer a manufacturer's certification along with the brand name, batch identification, quantity represented, percent solids and the type, name and quantity of any admixtures, that are provided in the silica fume admixture.

501.14.3.3 Silica Fume Test Results. The manufacturer's certification shall contain results of recent tests conducted on samples of the silica fume material taken during production or transfer and indicating conformance with Tables 1 and 3 of ASTM C 1240 and this specification. The supplier shall further certify that the material being furnished is in accordance with this specification.

501.14.3.4 Silica Fume Approval. For approval prior to use, the supplier shall furnish the same information to: Construction and Materials, P.O. Box 270, Jefferson City, MO 65102, along with any requested samples for testing.

501.14.3.5 Silica Fume Slurry. Liquid silica fume admixture shall be protected from freezing at all times.

501.14.3.6 Admixture Compatibility. All admixtures used shall be compatible with the silica fume admixture and shall be recommended or approved in writing by the manufacturer of the silica fume admixture.

501.14.4 Metakaolin. Approved metakaolin may be used to replace a maximum of 15 percent of the Portland cement on a pound for pound basis in all concrete.

501.14.4.1 Metakaolin Requirement. Metakaolin shall be approved prior to use and be in accordance with AASHTO M321.

501.14.4.2 Manufacturer Certification. The contractor shall furnish to the engineer a manufacturer's certification along with the brand name, batch identification and quantity represented.

501.14.4.3 Metakaolin Test Results. The manufacturer's certification shall contain results of recent tests conducted on samples of the metakaolin taken during production or transfer and indicating conformance with AASHTO M321 and this specification. The supplier shall further certify that the material being furnished is in accordance with this specification.

501.14.4.4 Metakaolin Approval. For approval prior to use, the supplier shall furnish the same information to: Construction and Materials, P.O. Box 270, Jefferson City, MO 65102, along with any requested samples for testing.

501.14.5 Source Changes. Changes in class or source of fly ash, grade and source of GGBFS, brand and source of silica fume or brand and source of metakaolin used in concrete structures will be permitted only with written approval from the engineer. Only fly ash, GGBFS, silica fume or metakaolin resulting in concrete of the same color shall be used in any individual unit of the structure.

501.14.6 Mix Proportions. When fly ash, GGBFS, silica fume or metakaolin is used, an adjustment in design mix proportions will be required to correct the volume yield of mixture. Approval shall be obtained from the engineer prior to any change in mix design or proportions.

501.14.7 Mixing Water. Maximum mixing water shall be based on total cementitious material. The quantity of mixing water in the concrete shall be considered the net quantity after proper allowance has been made for absorption by the aggregate.

501.14.8 Measuring Fly Ash and Ground Granulated Blast Furnace Slag. Fly ash or GGBFS shall be measured in the same manner and with the same accuracy as cement. Fly ash or GGBFS may be weighed separately on the same scale as cement, provided the scale increments are such that the specified weighing accuracy can be maintained. If the fly ash or GGBFS is weighed together with the cement, the cement shall be

weighed first and the accuracy shall apply to the combined weight.

501.14.9 Measuring Silica Fume and Metakaolin. Silica fume or metakolin shall be measured by weight or volume within a tolerance of plus or minus 2 percent.

501.14.10 Silica Fume and Metakaolin Batching Sequence. Silica fume or metakaolin shall be added at the plant at the same point in the batch sequence as recommended by the manufacturer of the material . The silica fume or metakaolin may be added by hand methods.

501.14.11 Calculating Silica Fume Solids. For silica fume solutions, the quantity of liquid silica fume admixture needed to furnish the required silica fume solids shall be calculated based on the weight per gallon and percent solids of the silica fume admixture being used.

501.14.12 Measuring Cementitious Materials. Fly ash, GGBFS, silica fume or metakaolin will be considered as cement when measuring mixing time.

501.15 Commercial Mixture. If specified in the contract that an approved commercial mixture of concrete may be used, the contractor shall notify the engineer in writing, setting out for approval the source and proportions of the mixture proposed to be furnished. The statement shall include the following:

(a) The types and sources of aggregate.

(b) Type and source of cement and other cementitious material.

(c) Scale weights of each aggregate proposed as pounds per cubic yard of concrete.

(d) Quantity of water proposed, as pounds or gallons per cubic yard of concrete.

(e) Quantity of cement proposed as pounds per cubic yard of concrete.

501.15.1 Minimum Cement Content. The concrete shall contain no less than 517 pounds of cement per cubic yard. The use of fly ash, GGBFS, silica fume or metakaolin shall be in accordance with Sec 501.14. The plant shall comply with other requirements of these specifications or be as approved by the engineer. The concrete will be subject to acceptance or rejection by visual inspection at the job site.

501.15.2 Certification. The supplier shall furnish certification with the first truck load of each day's production of concrete that the material and mix proportions used are in accordance with the approved mixture. Upon completion of the work, plant certification shall be furnished by the supplier for the total quantity delivered.

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SECTION 502
PORTLAND CEMENT CONCRETE BASE AND PAVEMENT

502.1 Description. This work shall consist of constructing a Portland cement concrete base or pavement, with or without reinforcement as specified, shown on the plans or directed by the engineer.

502.2 Material. All material, proportioning, air-entrainment, mixing, slump and transporting for Portland cement concrete shall be in accordance with Sec 501. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Emulsified Asphalt (SS-1, SS-1H, CSS-1 or CSS-1H)	1015
Steel Welded Wire Reinforcement for Concrete	1036
Concrete Curing Material	1055
Material for Joints	1057

502.3 Equipment. Equipment and tools necessary for handling material and performing all parts of the work shall be satisfactory to the engineer as to design, capacity and mechanical condition. The equipment shall be at the job site sufficiently ahead of the start of construction operations to be examined thoroughly by the engineer and shall be in accordance with the following:

502.3.1 Batching Plant, Mixer and Hauling Equipment. The batching plant, mixer, water measuring equipment, weighing and hauling equipment shall be in accordance with Sec 501.

502.3.2 Slip-Form Construction. Concrete base or pavement may be constructed by the use of sliding form methods. Slip-form construction shall be in accordance with these specifications.

502.3.2.1 Consolidating and Finishing Equipment. The concrete shall be consolidated and finished by a slip-form paver designed to spread, consolidate and shape the concrete in one complete pass of the machine in such a manner to provide a smooth, dense and homogeneous pavement in conformance with the plans and specifications. No apparent slumping of the concrete shall occur within 6 inches of the pavement edge. If necessary to stop the forward movement of the paver, the vibratory and tamping elements shall be stopped immediately.

502.3.3 Vibrators. Vibrators used for full width vibration of the concrete shall be of the internal type. Vibrating equipment shall be operated in accordance with the manufacturer's recommendation at a frequency to provide satisfactory results, but shall be no less than 4500 impulses per minute. Hand vibrators shall have a frequency of no less than 4500 impulses per minute. The contractor shall have a tachometer available at all times for checking the vibration frequency.

502.3.4 Concrete Saw. If sawed joints are required, equipment shall be capable of providing a groove of the specified dimensions in the concrete. Equipment shall be a wet-cut saw, referred to as a “conventional concrete saw” or a lighter weight dry-cut saw, referred to as an “early-entry concrete saw,” used to establish joints sooner than the conventional saw.

502.3.5 Equipment for Sealing Joints. An approved double boiler-type heating kettle equipped with a mechanical agitator and a satisfactory temperature indicating device shall be required. The equipment shall be capable of heating the joint sealing material uniformly without damage.

502.3.6 Auxiliary Equipment. Auxiliary equipment shall be available at all times as follows:

(a) A minimum of one footbridge designed to be readily transportable and having no contact with the concrete base or pavement.

(b) Metal dyes with beveled face numerals 3 inches to 5 inches high and thick enough to make an indentation of 1/4 inch. A satisfactory dye shall be used for marking the location of the station number.

502.3.7 Field Laboratory. The contractor shall provide a Type 1 field laboratory in accordance with Sec 601.

502.4 Construction Requirements.

502.4.1 Weather Limitations. Concrete shall not be placed upon frozen subgrade. All concrete shall be effectively protected from freezing until a minimum compressive strength of 3,500 psi has been attained. The contractor shall provide a method, meeting the approval from the engineer, of monitoring the concrete that demonstrates that the concrete has been protected from freezing. Regardless of precautions taken, the contractor shall assume all risks, and all frozen concrete shall be replaced at the contractor's expense.

502.4.2 Protection Against Rain. To protect against rain, the contractor shall have on location at all times material for the protection of the edges and surface of the unhardened concrete. The contractor shall protect the concrete from damage due to rain. Failure to properly protect unhardened concrete may constitute cause for the removal and replacement of defective concrete at the contractor's expense.

502.4.3 Setting Forms. Forms shall be sufficiently supported to avoid displacement during paving operations. Both straight and curved forms shall be supported in such position that the face of the form shall be vertical on tangents and perpendicular to the superelevated section on curves. The top of the form shall not vary more than 1/8 inch from the true grade line during placing, compacting and finishing operations. The form alignment shall not vary more than 1/4 inch from the true alignment.

502.4.4 Conditioning of Subgrade. When forms have been securely set to grade, the subgrade shall be brought to proper cross-section in accordance with Sec 209. Low areas of treated bases shall be filled only with concrete integral with the pavement. No direct payment will be made for the concrete used to fill these low areas.

502.4.5 Proportioning and Mixing Concrete. Concrete shall be proportioned and mixed by truck or central mixers in accordance with Sec 501. This shall consist of batching all aggregate, cement and water by means of automatic weighing or metering, with all additives dispensed automatically and interlocked with the automatic weighing or metering controls. For central mixed concrete, the mixing cycle shall be timed and interlocked with the weight batch cycle. The weight setting controls shall be equipped such that the controls may be locked when directed by the engineer. The automatic batching equipment shall be capable of conversion to manual operation if necessary. Manual operation shall not be permitted beyond 24 hours after breakdown in the automatic equipment, except by written approval of the engineer. When a project includes paving that cannot be performed in a normal sequence, the contractor will be permitted to place a maximum of 7000 square yards using manual batching methods. For all contracts having a total of no more than 20,000 square yards of concrete base course and concrete pavement combined, manual batching methods will be permitted.

502.4.6 Placing Concrete. The concrete shall be deposited over the entire width of the subgrade in such a manner as to prevent segregation and to minimize handling. Mixers, including truck mixers and trucks used for transporting concrete, will be permitted to discharge concrete by chute or by dumping directly on the subgrade or prepared base provided the underlying material is not damaged or distorted. Honeycomb in the concrete base or pavement edge may be cause for rejection of the concrete.

502.4.7 Tie Bar Placement. Tie bars shall be supported in the proper position by chairs driven into the subgrade, or may be placed by approved mechanical methods prior to the consolidation of the concrete after the concrete has been struck off. Tie bars shall be free from dirt, oil, paint and grease. Tie bars required at longitudinal construction joints shall be positioned before concrete base or pavement consolidation.

502.4.8 Final Strike-off, Consolidation and Finishing. Machine finishing by extrusion methods or by vibrating and screeding processes shall be required for all concrete except as permitted in accordance with Sec 502.4.8.6. After the final course of the concrete has been placed, the concrete shall be struck-off and thoroughly vibrated until concrete of a uniform and satisfactory density is attained. The surface of the pavement shall be of uniform texture and to the proper grade and typical section.

502.4.8.1 Consolidation. Vibrating tubes shall extend into the concrete the distance necessary to provide adequate consolidation. Vibrators shall be operated only when the machine to which the vibrators are attached is moving. Care shall be taken that the vibrator does not penetrate the subgrade or dislodge or move the joints. Vibrators shall not come in contact with the reinforcement, load transfer devices, subgrade or side forms.

502.4.8.2 Added Finishing Water. Moisture in any form shall not be applied to the surface of the concrete except for emergency conditions. When emergency conditions exist and it becomes necessary to apply additional moisture to the surface of the concrete in order to complete the final finishing operation, water may only be applied in the form of a fine pressure spray. Under such conditions, placement of additional concrete on

the subgrade shall be discontinued until the emergency conditions cease.

502.4.8.3 Surface Texture. After surface irregularities have been removed, the concrete surface shall be given a uniformly roughened finish. The surface texture shall be tested in accordance with ASTM E 965, except as modified herein, to ensure the texture is adequate for desired friction characteristics. The test locations will be the same locations as identified for strength and thickness determination.

502.4.8.3.1 Sample Container. Plastic sample containers for ASTM E 965 testing shall be of a rigid material that will crack or break if the container is deformed. Damaged or deformed containers shall not be used.

502.4.8.3.2 Required Texture Depth. The results of ASTM E 965 shall show a texture depth of any sublot, as defined in Sec 502.10.1, to have a minimum value of 1.00 mm. Any sublot showing a texture depth of less than 1.00 mm shall require diamond grinding of the pavement represented by this sublot to attain the necessary texture. All testing of the surface texture shall be completed no later than the day following pavement placement.

502.4.8.3.3 Minimum Diamond Grinding Length. Diamond grinding, except for bump correction, shall be across the entire width of the traveled way and shall be continuous for a minimum of 0.1 mile.

502.4.8.3.4 Wave Texture Testing. ASTM E 965 will be waived if the contractor elects to diamond grind or tine the concrete with a wire comb. The concrete may be tined either longitudinally or transversely.

502.4.8.3.4.1 Wire Comb. A wire comb shall be no less than 10 feet long with a single line of wires exposed to a length of approximately 4 inches. The wire shall be blue-tempered and polished spring steel with nominal dimensions of 0.028 inch thick and 0.100 to 0.125 inch wide. The wires shall be spaced to provide 1/2-inch clear space between wires and securely mounted in a rigid head. Except for concrete finished by hand methods, the wire comb shall be mechanically operated and capable of covering the full width of slab in a single pass, at a uniform speed and at a uniform depth. Final approval of the wire comb will be based on satisfactory performance during actual use

502.4.8.3.4.2 Texturing with Wire Comb. Successive passes of the comb shall be overlapped the minimum necessary to attain a continuously textured surface. The surface texture produced shall have an average texture depth of approximately 0.125 inch. Small or irregular areas, or areas not suitable for machine texturing when adjacent surrounding concrete is ready for texturing, may be textured with a hand operated device producing a textured surface equivalent to that required for machine combing.

502.4.8.4 Edging at Forms and Joints. After the final finish, but before the concrete initial set, the edges of the concrete along each form line, and on each side of transverse expansion joints and construction joints shall be worked with an edging tool having a radius of approximately 3/8 inch. A well-defined and continuous radius having a smooth, dense finish shall be produced. The surface of the concrete shall not be unduly disturbed by tilting of the tool during use. Tool marks on the pavement shall be eliminated by brooming or dragging the surface. In doing this, the rounding of the corner of the pavement shall not be disturbed. All concrete on top of the joint filler shall be completely removed. All joints shall be tested with a straightedge before the concrete has set, and corrections made if one side of the joint is higher than the other.

502.4.8.5 Station Numbers. The contractor shall indent station numbers into all pavement immediately following the final finishing operations and before the concrete's final set. The numbers shall be placed at alternating full stations as ascertained by measurements determined by the engineer. Equations in stationing shall also be marked in the pavement. On undivided pavement, the station numbers shall be on the left side of the pavement with respect to the ascending stationing and shall be on the pavement edge unless an integral curb is involved, in which case the numbers shall be placed on the face of the curb. On divided pavement, station numbers shall be placed on the median side of each pavement. The numbers shall be placed facing the centerline of the pavement, or the centerline of each pavement in the case of divided pavements. The numbers shall be placed on a troweled area of the finished surface. No direct payment will be made for marking station numbers.

502.4.8.6 Hand Finishing. Compacting, vibrating and finishing concrete by hand methods will be permitted:

(a) For all curves having a form line radius of less than 200 feet or where wood forms are used.

(b) For all irregularly shaped areas.

(c) For pavement lanes less than 200 feet long.

(d) For pavement lanes less than 10 feet wide.

(e) For bridge approaches and pavement to first expansion joint.

(f) When a breakdown of the mechanical compacting and finishing equipment occurs or in the event of some other emergency. After a breakdown, only material which has already been proportioned and which may be rendered unsatisfactory for use may be finished by hand.

(g) For all Portland cement concrete base.

502.5 Joints. Joints shall be of the specified type and dimensions, and constructed at the locations shown on the plans or as approved by the engineer. Where joints are preformed, the form or joint shall be set and securely fastened to ensure the joint being in the required position when the concrete is finished. The final position of dowels and tie bars shall be parallel to the subgrade and perpendicular to the line of the joint. Dowel supporting assemblies shall conform to one of the types shown on the plans. The concrete shall be placed to avoid displacement or disarrangement of the joint installations.

502.5.1 Expansion Joints. Expansion joints shall extend for the full cross-section of the concrete pavement. Filler placed prior to the placement of the concrete shall be installed with a removable cap or edging bar as a guide for edging the joint and protection of the filler during the concrete's placing and finishing. Joints constructed after the placement of concrete shall be sawed full depth, and the exposed edges shall be ground to a chamfer of 3/8 inch. The filler shall rest snugly on the subgrade from form to form. The joints shall be sealed in accordance with Sec 502.5.4. Upon removal of the forms, any struts or fins of concrete extending across the joint shall be removed to the full width of the joint and the full thickness of the concrete base or pavement.

502.5.2 Construction Joints. Construction joints shall be made at the close of each day's work or when the work is stopped or interrupted for more than 30 minutes. Transverse construction joint shall be located 15 feet from the last contraction joint Construction joints shall be constructed perpendicular to the top surface and the centerline of the concrete base or pavement. Construction joints may be formed with a timber header or may be sawed full depth. The final joint shall conform to the cross-section of the pavement. Before paving operations are resumed, all surplus concrete and other refuse shall be removed from the subgrade.

502.5.3 Sawing Joints. Unless otherwise provided, all transverse contraction joints and all Type L longitudinal joints shall be sawed in a single cutting operation with all joint cuts to the dimensions shown on the plans. For intersections and irregular pavement, joints shall be sawed at locations as approved by the engineer. Sawing of the joints shall begin as soon as the concrete has hardened sufficiently to permit sawing without excessive raveling. All joints shall be established before uncontrolled shrinkage cracking takes place. The sawing of any joint shall be omitted if a crack occurs at or near the joint location prior to the time of sawing. Sawing shall be discontinued when a crack develops ahead of the saw. The engineer reserves the right to have the contractor install preformed type joints on multiple width construction when the use of sawed joints fails to prevent random cracking. Any pavement with random cracking not controlled by dowels or tie bars shall be either removed and replaced using dowels or tie bars as appropriate to the nearest controlled joint or repaired with some other method approved by the engineer at the contractor's expense.

502.5.3.1 Forming Longitudinal Joint. A joint forming device may be used to establish the longitudinal joint between the two driving lanes or between the driving lane and shoulder 6 foot wide or greater. The pavement shall have a plan thickness of 8 inches or greater.

502.5.3.1.1 Notification. The contractor shall indicate in the Quality Control Plan if the longitudinal joint forming device is going to be utilized on the project.

502.5.3.1.2 Joint Forming Device. The joint forming device shall consist of a pair of straight blades mounted under the paver. The first blade shall be placed under the front of the primary pan extending forward between the vibrators, if mechanically possible. The second blade shall be placed on the finishing pan in identical alignment to the first blade. Blade depth shall be equal to one-third of the slab thickness.

502.5.3.1.3 Depth Verification. The engineer shall have access behind the paver to randomly check joint

formation by inserting a thin metal strip equal to one-third of the slab thickness into the formed joint.

502.5.3.1.4 Weak Plane Verification. The contractor shall take four 4-inch diameter cores in the longitudinal joint. Cores shall be taken and tested the following day after the first day of paving. Samples shall be taken from random locations determined by the engineer. The cores shall be centered within ± ½ inch around the joint forming trail. The first one-third of the slab thickness and the second one-third of the slab thickness of each core shall be sawed off from the top and tested in the vertical position for split tensile strength. The average strength ratio of the first and second cores shall be 1/3 or less.

502.5.3.1.5 Testing Frequency. For each successive day after the first day of paving, two 4-inch diameter cores shall be taken in the longitudinal joint. Samples shall be taken from random locations determined by the engineer. Cores shall be taken and tested the following day after placement. Cores shall be tested to determine the indirect tensile strength ratios. If satisfactory results are consistently achieved, the engineer may reduce the number of cores taken.

502.5.3.1.6 Joint Continuity. The contractor shall ensure longitudinal joint continuity between consecutive day's paving.

502.5.3.1.7 Unacceptable Results. If the test results or the quality of the joint forming process are not satisfactory to the engineer, the contractor shall saw the longitudinal joint for the length affected.

502.5.4 Sealing Joints. All sawed contraction joints shall be unsealed, unless otherwise specified. Sawed or formed expansion joints shall be sealed with joint sealing material before the pavement is opened to any traffic, including construction traffic. Immediately prior to sealing, the joints shall be thoroughly cleaned and dried. The sealing material shall be heated to the pouring temperature recommended by the manufacturer. Any material which has been heated above the maximum safe heating temperature will be rejected. Any excess material shall be removed from the pavement surface.

502.5.5 Joint Filler at Railroad Crossings. Bituminous filler for use between railroad crossing approach slabs and the crossing shall be an approved commercial bituminous mixture in accordance with Sec 401. The mixture shall be tamped into a firm and compacted state.

502.6 Curing. Immediately after the finishing operations have been completed and as soon as marring of the concrete will not occur, the entire surface and exposed edges of the newly placed concrete shall be covered and cured in accordance with one of the following methods. The concrete shall not be left exposed for more than 30 minutes between stages of curing or during the curing period.

502.6.1 White Pigmented Membrane. After the free water has left the pavement surface, the entire surface shall be sealed by spraying with a uniform application of white pigmented membrane curing material. The contractor shall provide satisfactory equipment to ensure uniform mixture and coverage of curing material, without loss, on the pavement at the rate of not less than one gallon for each 200 square feet. If rain falls on the newly coated pavement before the film has dried sufficiently to resist damage, or if the film is damaged in any other way, the contractor shall apply additional curing material to the affected portions. All areas cut by finishing tools subsequent to the application of the curing material shall immediately be given new applications at the rate specified above. If hairline cracking develops before the membrane can be applied, the concrete shall be initially cured with wet burlap in accordance with Sec 502.6.2 before the membrane is placed. Membrane curing shall not be used on Portland cement concrete base. Emulsified asphalt may be used to cure the concrete base if the surface course is to be a bituminous type.

502.6.2 Burlap. The top surface of the concrete shall be temporarily covered with thoroughly damp burlap after the concrete has set sufficiently to prevent marring of the surface. Burlap shall be handled in such a manner that contact with earth or other deleterious substances is avoided. All burlap, except burlap previously used for curing concrete, shall be thoroughly washed. The burlap shall be kept thoroughly wet until removed for application of the final curing material. Neither the top nor the edge of the concrete shall be left unprotected for more than 30 minutes. When the burlap is removed, white pigmented membrane curing material shall be continued by one of the approved methods.

502.7 Removing Forms. Forms shall be removed carefully to avoid damage to the concrete base or pavement. Honeycombed areas not rejected shall be immediately repaired. If the forms are removed less than 72 hours after placing concrete, the sides of the concrete shall be cured by one of the methods specified above. Any

trench excavated for the forms shall be entirely backfilled so water will not stand next to the concrete base or pavement.

502.8 Surface Smoothness. The pavement surface shall be thoroughly tested for smoothness by profiling or straightedging as indicated in Sec 610.

502.9 Opening to Traffic. The concrete base and pavement shall not be opened for low volume, light construction traffic until the concrete has attained a minimum compressive strength of 2500 psi. The concrete base and pavement shall not be opened to all types of traffic until the concrete has attained a minimum compressive strength of 3,000 psi and all sawed joints that have opened more than ¼ inch are sealed. Compressive strength will be determined by tests conducted in accordance with MoDOT test methods. Pavement shall be cleaned prior to opening to traffic.

502.10 Material Acceptance. Acceptance will be based on the following criteria being met:

(a) Test results indicating the concrete base or pavement meets the specification requirements

(b) Contractor following the approved Quality Control Plan (QCP)

(c) Favorable comparison between the contractor's quality control tests and the engineer's quality assurance tests. Favorable comparison will be obtained when the engineer's QA tests results are within two standard deviations from the mean of the QC test results for each individual lot of material. For properties not evaluated on a lot by lot basis, favorable comparison will be obtained when both the QC and QA tests results meet the specification requirements. Compressive strength and slab thickness will be evaluated on a lot by lot basis.

502.10.1 Lot Definition. A lot shall be the surface area placed in a single day. Each lot shall be divided into no less than four or more than six sublots of equal surface area. For high daily production rates exceeding 7,500 square yards per day, the contractor may choose to divide the day's production into two equal lots consisting of no less than four or more than six sublots each. The contractor shall notify the engineer of the size of the sublot or of the decision to divide a day's production into two equal lots prior to taking any core samples. When a day's production involves less than 600 square yards, combine the following day's or days' production to reach 600 square yards and treat as a single lot, except while completing a particular mix design or project, in which case combine with the previous day's production and treat as a single lot. If a project has less than 7,500 square yards of a particular mix type, the lot will be defined as the plan quantity shown in the contract documents.

502.10.2 Sampling. One QC sample shall be taken for each sublot and a minimum of one QA sample shall be taken per lot. A sample shall be taken from the finished concrete consisting of a 4-inch diameter core for concrete bases or pavements less than 12 inches thick and a 6-inch diameter core for concrete bases or pavements 12 inches or greater. Sampling locations will be determined by the engineer using random sampling procedures in accordance with ASTM D 3665.

502.10.3 Coring. Cores shall be taken in accordance with AASHTO T 24. Cores shall not be taken until a minimum compressive strength of 3,000 psi has been attained. Cores shall be neatly cut with a core drill. The contractor shall furnish all tools, labor and material for cutting samples and filling the cored hole. The contractor shall fill the core holes with an approved non-shrink grout within one day after sampling.

502.10.3.1 Testing Cores. The core thickness shall be determined by the average caliper measurement in accordance with AASHTO T 148. After the thickness is determined, the cores shall be sawed to an L/D ratio of 2.0 and tested in accordance with AASHTO T 22. Cores shall not be taken until a minimum compressive strength of 3,000 psi has been attained. The contractor shall determine the compressive strength by approved methods. Cores shall be tested for compressive strength 28 days after placement.

502.10.3.2 Pavement Thickness after Diamond Grinding. If the contractor elects to diamond grind to improve smoothness or surface texture, in accordance with Sec 610.5.1.3 and 610.5.1.4, then pavement thickness determination will be made after all smoothness correction has been completed. Cores shall be 4 inch in diameter. Location of coring will be determined by the engineer using random sampling procedures in accordance with ASTM D 3665.

502.10.4 Quality Level Analysis. Compressive strength and thickness shall be evaluated for acceptance on a

lot-by-lot basis using a Quality Level Analysis (QLA). The QLA will consider the variability (standard deviation) of the material and the testing procedures, as well as the average (mean) value of the test results to calculate the percentage of material that is above the lower specification tolerance limit (LSL) for compressive strength and thickness.

502.10.4.1 Determine Quality Index. The Percent Within Limits (PWL) will be based on the mean, standard deviation and quality index of each lot's test results as follows:

Mean

$$x_a = \sum \frac{x_i}{n}$$

where:

x_a = Mean of the individual values being considered
$\sum x_i$ = The summation of all the individual values being considered
n = The number of individual values under consideration

Standard Deviation

$$s = \sqrt{\frac{\sum (x_i - x_a)^2}{n-1}}$$

Where:

s = Standard Deviation

Upper Quality Index

$$Q_U = \frac{USL - x_a}{s}$$

Lower Quality Index

$$Q_L = \frac{x_a - LSL}{s}$$

Where:

Q_U = Upper Quality Index
Q_L = Lower Quality Index
USL = Pay Factor Item Upper Spec Limit
LSL = Pay Factor Item Lower Spec Limit

502.10.4.2 Determine Percent Within limits. The upper (PWL_U) and lower (PWL_L) will be determined from Table I. Total percent within limits is:

$PWL_t = (PWL_U + PWL_L) - 100$. For thickness and compressive strength in this specification, PWL_U shall be 100.

502.10.4.3 Utilizing Quality Control Test Results. The engineer will make the Quality Level Analysis (QLA) within 24 hours after receipt of the contractor's test results, by determining the PWL_t for each designated pay factor item. The contractor's test results will be used when applicable to determine the PWL, provided the contractor's QC tests and the engineer's QA tests compare favorably, and provided the engineer's inspection and monitoring activities indicate the contractor is following the approved QC Plan.

502.10.4.4 Material Rendered Unfit. The engineer may at any time reject and require the contractor to dispose of any batch of concrete mixture which is rendered unfit for use due to contamination, segregation, improper slump or improper entrained air content. Such rejection may be based on only visual inspection. In the event of such rejection, the contractor may take a representative sample of the rejected material in the presence of the engineer, and if demonstrated in the laboratory in the presence of the engineer that such material was erroneously rejected, payment will be made for the material at the contract unit price.

502.10.4.5 Lower Specification Limits. The lower specification limit (LSL) for compressive strength and thickness shall be:

(a) Compressive Strength – 4,000 psi.

(b) Thickness – Plan thickness minus 1/2 inch.

502.10.5 Outliers. Individual compressive strength tests within a lot may be checked for an outlier in accordance with the determination of statistic T in ASTM E 178, at a significance level of 5 percent. Replacement cores shall be obtained at the location designated and in the presence of the engineer. The PWL shall be determined using the replacement values.

502.11 Contractor Quality Control.

502.11.1 Quality Control Plan. Prior to approval of concrete mix designs by the engineer, the contractor shall submit a QCP to Construction and Materials. The QCP shall be approved prior to placing any concrete. The QCP shall include:

(a) Name and contact information should be provided for the contractor's representative in charge of QC and the project level representative if different from the contractor's representative.

(b) Identify the number of sublots each lot will utilize and describe how lots and sublots will be designated.

(c) State the method for determining when concrete cores can be extracted.

(d) State the method for demonstrating the concrete has been protected from freezing.

(e) State the location where control charts will be posted, if utilized by the contractor.

(f) For optimized concrete mix, state the target gradation and allowable gradation ranges for each fraction being used.

(g) A proposed independent third party company name, contact person, address, and phone number for dispute resolution.

502.11.1.1 Third Party. The third party shall be independent of the contractor, MoDOT consultants, and all project subcontractors or suppliers on each specific project. All testing of material for dispute resolution shall be performed by an approved laboratory that is AASHTO Accreditation Program certified in the areas of the material being tested.

502.11.2 Quality Control Testing. The contractor shall perform all quality control tests necessary to control the production and construction processes applicable to this specification and as set forth in the QCP. Quality control testing shall be performed by technicians qualified through MoDOT's technician certification program. Testing shall include, but not necessarily be limited to, deleterious content, coarse aggregate absorption, thin or elongated pieces, entrained air content, slump, pavement thickness and compressive strength. The contractor shall record all test results and furnish a copy to the engineer no later than the beginning of the day following the test.

502.11.2.1 Fine and Coarse Aggregate.

502.11.2.1.1 Aggregate Gradation. A sieve analysis shall be performed once a week. Testing shall be performed in accordance with AASHTO T 27 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt. Sieve analysis shall be performed on the following sieves:

Mix Design Method	Sieves Tested
Absolute Volume	Maximum sieve size[a]
Optimized	Sieves sizes specified by the mix design

[a]Coarse aggregate only

502.11.2.1.2 Deleterious Materials. Deleterious content shall be determined each day at a frequency of one test per 7500 square yards of material placed or fraction thereof. Test shall be performed in accordance with MoDOT Test Method TM 71 from randomly sampled material taken from the discharge gate of the storage bin or from the conveyor belt. Test shall be performed on coarse aggregate fractions.

502.11.2.1.3 Absorption. Samples for coarse aggregate absorption shall be taken from the discharge gate of the storage bins or from the conveyor belt at least once every 2,000 cubic yards with a minimum of once per project. Coarse aggregate absorption shall be in accordance with AASHTO T 85.

502.11.2.1.4 Thin or Elongated Pieces. Thin or elongated pieces shall be determined on samples of coarse aggregate taken from the discharge gate of the storage bins or from the conveyor belt. The aggregate particles retained on the 3/4 in. sieve shall not exceed 5 percent when tested in accordance with ASTM D 4791, based on a 5:1 ratio. Test shall be performed at least once every 10,000 cubic yards with a minimum of once per project.

502.11.2.1.5 Retained Samples. All aggregate samples taken by the contractor for determining the gradation, deleterious content, absorption, and thin or elongated pieces shall be retained for the engineer for a minimum of seven days unless otherwise instructed. The retained sample shall be the remaining half of the final reduction in sample size obtained for QC testing. These samples shall be maintained in clean covered containers, without contamination, readily accessible to the engineer. The retained sample's identification shall consist of, but is not limited to:

(a) Time and date sampled.

(b) Product specification number.

(c) Type of sample, i.e. belt, bin, stockpile.

(d) Lot and sublot designation.

(e) Sampler/Tester.

(f) Project Job Number.

502.11.2.2 Slump. Slump tests shall be performed on a random basis for each 500 cubic yards of material produced. The engineer will designate the random location at the time of sampling. If a day's material production does not exceed 500 cubic yards, one slump test shall be performed. Slump tests shall be in accordance with AASHTO T 119 from randomly sampled material discharged from trucks at the paving site. Material samples shall be in accordance with AASHTO R 60.

502.11.2.3 Entrained Air Content. Tests for entrained air content shall be performed on a random basis for each 500 cubic yards of material produced. The engineer will designate the random location at the time of sampling. The air content shall be in accordance with Sec 501.10.2, except that the minimum air content in front of the paver shall be 4.5 percent plus the air loss through the paver. The air loss through the paver is determined a minimum of once per half-day production by sampling the concrete ahead of the paver and behind the paver and subtracting the value obtained ahead of the paver from the value obtained behind the paver. The engineer shall be given notification prior to determining the air loss in order to witness the air loss determination. On the first day of paving, the target air content shall be determined immediately after placing 200 cubic yards of concrete. The entrained air content of the first 200 cubic yards of concrete placed on the first day of paving, sampled in front of the paver, shall be greater than 6.0 percent. Tests shall be in accordance with AASHTO T 152.

502.11.3 Corrective Action. As a minimum, a process shall be deemed out of control and corrective action taken if any one of the conditions below exists. In addition, each truckload of material en route prior to the process of being deemed out of control shall be tested for specification compliance.

502.11.3.1 Aggregate Gradation. When one test is outside the allowable range, immediate steps shall be taken to correct the gradation.

502.11.3.2 Deleterious Content. When one test is outside the specification limits, immediate steps shall be taken to correct the deleterious content.

502.11.3.3 Slump and Absorption. The contractor shall halt production and make appropriate adjustments whenever either of the following occurs:

(a) One point falls outside the action limit line for individual measurements or range.

(b) Two points in a row fall outside the specification limit but within the action limit line for individual measurements.

Individual Measurements	
Control Parameter	**Action Limit**
Slump	+1 in.
Absorption	Mix Design plus 0.3% to Mix Design plus 0.6%

502.11.4 Pavement. For pavements with a plan thickness below 8 inches, the following shall apply:

(a) QC shall determine compressive strength at a frequency of no less than one per 7,500 square yards. Compressive strength shall be determined from at least two 6- by 12-inch cylinders or from at least three 4- by 8-inch cylinders made in accordance with AASHTO T-23 or by the Maturity Method in accordance with the contract documents. QA will determine the compressive strength at least once per 30,000 square yards. Cylinders shall be tested in accordance with AASHTO T-22. A compressive strength of 3,500 shall be attained by 28-day. Sampling location will be determined by the engineer using random sampling procedures in accordance with ASTM D 3665

(b) QC shall determine pavement thickness of the fresh concrete at a frequency of no less than one per 7,500 square yards. QA will determine the pavement thickness of the fresh concrete at least once per 30,000 square yards. Sampling locations will be determined by the engineer using random sampling procedures in accordance with ASTM D 3665

(c) QC shall determine the slump, air content, gradation, deleterious, thin and elongated and absorption in accordance with Sec 502.11. QA will determine the slump, air content, gradation, deleterious, thin and elongated and absorption in accordance with Sec 502.12.

502.11.5 Shoulders. Shoulders with a plan thickness 8 inches or greater shall be inspected in accordance with requirements applied to concrete placed in the travel way. Shoulders with a plan thickness below 8 inches shall be handled in accordance with Sec 502.11.4.

502.11.6 Dispute Resolution. When there are significant discrepancies between the engineer's and the contractor's test results, dispute resolution procedures will be used.

502.11.6.1 Cease Work. The contractor's operations may be required to cease until the dispute is resolved, if the test results indicate the mixture is unacceptable.

502.11.6.2 Third Party Resolution. The first step in dispute resolution will be to identify differences in procedures and to correct inappropriate procedures before moving to third party resolution. If that does not resolve the dispute, either the contractor or the engineer may request the approved QCP third party involvement. The recommendations of the approved third party will be binding on both the engineer and contractor.

502.11.6.3 Third Party Payment. The contractor shall be responsible for the costs associated with third party testing and resolution if the final result indicates the engineer's test results were correct. Likewise the Commission will be responsible for the cost associated with the third party testing and resolution if the final result indicates the contractor's results were correct.

502.11.6.4 Other Adjustments. The contractor will not be entitled to any additional payment for costs incurred due to use of the dispute resolution procedures such as, but not limited to, those for delay, cessation of operations, costs to subcontractors, etc. The engineer may give consideration to adjustment of working days, if warranted.

502.11.7 Concrete Mix Design Adjustment.

502.11.7.1 Field Adjustment. When test results indicate the concrete produced does not meet the specification requirements or is not performing satisfactory, the contractor may adjust the mix design in the field as noted herein. Field adjustments may consist of changing the constituents listed on the approved mix design by no more than 5.0 percent or changing the water cement ratio by no more than 0.02 from the approved mix design. The engineer shall be notified immediately when any change is made to the mix design. Additional fractions of material or new material will not be permitted as a field adjustment. The field adjusted mix shall meet the requirements specified in Sec 501.

502.11.7.2 Field Redesign. When the constituents listed on the approved mix design are adjusted by more than 5.0 percent or the water cement ratio is changed by more than 0.02, the contractor shall submit a new mix design meeting the requirements specified in Sec 501. The mix design shall be submitted immediately to the District for approval. The contractor will be allowed to continue production while the mix design is reviewed.

502.12 Quality Assurance. Corrective action shall be required in accordance with Sec 502.11.3 for any QA tests outside the action limit. The engineer will at a minimum, independently test at the following frequency:

Test	Frequency
Compressive Strength	1 per lot
Thickness	1 per lot
Surface Texture	1 per lot
Slump	1 per day
Entrained Air Content	1 per day
Aggregate Gradation	1 per project
Coarse Aggregate Deleterious	1 per week
Aggregate Absorption	1 per 10,000 cubic yards
Thin or Elongated Pieces	1 per project

502.12.1 Retained Samples. The QA inspector will test at least ten percent of the retained portion of the QC samples for aggregate gradation and deleterious content. The QA inspector will test at least twenty percent of the QC retained samples for absorption and thin or elongated pieces. Retained samples will be chosen at random. A comparison will be considered favorable when the QA results of a QC retained sample are within the applicable limits specified in Sec 403.18.2

502.12.2 Core Chain of Custody. QA strength and thickness cores that are not in possession of the engineer for the entire time from extraction till testing shall be sealed in tamper proof bags after extraction.

502.12.3 Quality Control Equipment. All QC mixture testing shall be performed using equipment maintained in accordance with Sec 403.17.3, except as follows:

Equipment – Test Method (AASHTO)	Requirement	Interval (Month)
Sieves	Check Physical Condition	6
Mechanical Shakers - T27	Check Sieving Thoroughness	12
Ovens	Verify Temp. Settings	4
Balances	Verify	12[a]
Air Meters - T152	Calibrate	12
Compression Testing Machine - T22	Verify Load Indications	12
Capping Material	Check Strength	3
Slump Cones - T119	Check Critical Dimensions	12

[a]Verify after each move.

502.13 Unacceptable Material. Any material meeting the following criteria shall be considered unacceptable:

(a) If any core measurement of thickness is greater than 10 percent deficient from the plan thickness.

(b) If any core measurement of compressive strength is less than 3,500 psi.

(c) All material with an entrained air content less than 4.0 percent.

502.14 Method of Measurement. Final measurement of the completed pavement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. Where required, measurement of the Portland cement concrete base and pavement complete in place, will be made to the nearest 1/10 square yard. The revision or correction will be computed and added to or deducted from the contract quantity.

502.15 Basis of Payment.

502.15.1 Compensation. The contract unit price for Portland cement concrete base and pavement will be considered as full compensation for all material, including reinforcement, dowels, dowel supports, tie bars and any other items entering into the construction of the traveled way pavement or Portland cement concrete shoulders, and for the cost of QC testing and smoothness testing. No additional compensation will be allowed for any excess thickness.

502.15.2 Payment. The accepted quantities of concrete base will be paid for at the contract unit price with proper allowance made for any deductions for deficiency in thickness and compressive strength. The accepted quantities of Portland cement concrete pavement will be paid for at the contract unit price with proper allowance made for any deductions for deficiency in thickness, compressive strength, smoothness or marred surface.

502.15.3 Width. When paving widths are greater than the travel lane widths, payment for profiling will apply to the traffic lane design driving width only, normally 12 feet. Random lane coring for thickness or required lane replacement will include the full paved lane width to the longitudinal joints or edge of shoulder, whichever is first.

502.15.4 Pay Factors. The total pay factor (PF_t) for each lot is equal to the weighted sum of the pay factors (PF) for each pay factor item for each lot, and is determined as follows:

$PF_t = + (0.5)\ PF_T + (0.5)\ PF_{CS}$

Where: PF_T = Pay Factor for Thickness

PF_{CS} = Pay Factor for Compressive Strength

The PF for each pay factor item for each lot is based on the PWL_t of each pay factor item of each lot and is determined as follows:

When PWL_t is greater than or equal to 70: $PF = 0.5\ PWL_t + 55$

When PWL_t is less than 70: $PF = 2\ PWL_t - 50$

502.15.5 Small Quantities. For each mix type less than 7,500 square yards, the following shall apply:

QLA and PWL will not be required.

Concrete mix shall be within the specified limits for compressive strength, pavement thickness, slump, air content, gradation, deleterious, and thin and elongated.

Payment for each mix type will be made at 100 percent of the contract unit price if compressive strength is equal to or greater than 3,500 psi and the pavement thickness is not deficient by more that 10 percent of the plan thickness.

502.15.6 Pavements. For pavements with a plan thickness below 8 inches, the following shall apply:

(a) QLA and PWL will not be required

(b) Concrete mix shall be within the specified limits for compressive strength, pavement thickness, slump, air content, gradation, deleterious, and thin and elongated.

(c) Payment will be made at 100 percent of the contract unit price if compressive strength is equal to or greater than 3500psi and pavement thickness is not deficient by more than 10 percent of the plan thickness

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502.15.7 Shoulders. Shoulders with a plan thickness below 8 inches shall be handle in accordance with Sec 502.15.6.

502.15.8 PWL Determination Table. Values in Table I are estimates of the PWL corresponding to specific values of the Quality Index (Q). For Q values less than zero, the table shall be subtracted from 100.

TABLE I
Variability-Unknown Procedure
Standard-Deviation Method

Quality Index	PWL For Selected Sample Sizes							
(Q_U or Q_L)	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
0.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
0.01	50.28	50.33	50.36	50.37	50.37	50.38	50.38	50.38
0.02	50.55	50.67	50.71	50.74	50.75	50.76	50.76	50.77
0.03	50.83	51.00	51.07	51.10	51.12	51.13	51.15	51.15
0.04	51.10	51.34	51.42	51.47	51.50	51.51	51.53	51.54
0.05	51.38	51.67	51.78	51.84	51.87	51.89	51.91	51.92
0.06	51.66	52.00	52.14	52.21	52.24	52.27	52.29	52.30
0.07	51.93	52.33	52.49	52.57	52.62	52.65	52.67	52.69
0.08	52.21	52.67	52.85	52.94	52.99	53.02	53.06	53.07
0.09	52.48	53.00	53.20	53.30	53.37	53.40	53.44	53.46
0.10	52.76	53.33	53.56	53.67	53.74	53.78	53.82	53.84
0.11	53.04	53.66	53.91	54.04	54.11	54.16	54.20	54.22
0.12	53.32	54.00	54.27	54.40	54.48	54.54	54.58	54.60
0.13	53.59	54.33	54.62	54.77	54.86	54.91	54.95	54.99
0.14	53.87	54.67	54.98	55.13	55.23	55.29	55.33	55.37
0.15	54.15	55.00	55.33	55.50	55.60	55.67	55.71	55.75
0.16	54.43	55.33	55.68	55.86	55.97	56.04	56.09	56.13
0.17	54.71	55.67	56.04	56.23	56.34	56.42	56.47	56.51
0.18	54.98	56.00	56.39	56.59	56.72	56.79	56.84	56.89
0.19	55.26	56.34	56.75	56.96	57.09	57.17	57.22	57.27
0.20	55.54	56.67	57.10	57.32	57.46	57.54	57.60	57.65
0.21	55.82	57.00	57.45	57.68	57.83	57.91	57.98	58.03
0.22	56.10	57.33	57.81	58.05	58.20	58.29	58.35	58.40
0.23	56.39	57.67	58.16	58.41	58.56	58.66	58.73	58.78
0.24	56.67	58.00	58.52	58.78	58.93	59.04	59.10	59.15
0.25	56.95	58.33	58.87	59.14	59.30	59.41	59.48	59.53
0.26	57.23	58.66	59.22	59.50	59.67	59.78	59.85	59.90
0.27	57.52	59.00	59.57	59.86	60.03	60.15	60.22	60.28
0.28	57.80	59.33	59.93	60.22	60.40	60.51	60.60	60.65
0.29	58.09	59.67	60.28	60.58	60.76	60.88	60.97	61.03
0.30	58.37	60.00	60.63	60.94	61.13	61.25	61.34	61.40
0.31	58.66	60.33	60.98	61.30	61.49	61.62	61.71	61.77
0.32	58.94	60.67	61.33	61.66	61.85	61.98	62.08	62.14
0.33	59.23	61.00	61.68	62.01	62.22	62.35	62.44	62.51
0.34	59.51	61.34	62.03	62.37	62.58	62.71	62.81	62.88
0.35	59.80	61.67	62.38	62.73	62.94	63.08	63.18	63.25
0.36	60.09	62.00	62.73	63.09	63.30	63.44	63.54	63.61
0.37	60.38	62.33	63.08	63.44	63.66	63.80	63.91	63.98
0.38	60.68	62.67	63.42	63.80	64.02	64.17	64.27	64.34
0.39	60.97	63.00	63.77	64.15	64.38	64.53	64.64	64.71
0.40	61.26	63.33	64.12	64.51	64.74	64.89	65.00	65.07
0.41	61.56	63.66	64.46	64.86	65.09	65.25	65.36	65.43
0.42	61.85	64.00	64.81	65.21	65.45	65.60	65.72	65.79
0.43	62.15	64.33	65.15	65.57	65.80	65.96	66.07	66.15
0.44	62.44	64.67	65.50	65.92	66.16	66.31	66.43	66.51
0.45	62.74	65.00	65.84	66.27	66.51	66.67	66.79	66.87
0.46	63.04	65.33	66.18	66.62	66.86	67.02	67.14	67.22
0.47	63.34	65.67	66.53	66.96	67.21	67.37	67.49	67.57

0.48	63.65	66.00	66.87	67.31	67.56	67.73	67.85	67.93
0.49	63.95	66.34	67.22	67.65	67.91	68.08	68.20	68.28
0.50	64.25	66.67	67.56	68.00	68.26	68.43	68.55	68.63
0.51	64.56	67.00	67.90	68.34	68.61	68.78	68.90	68.98
0.52	64.87	67.33	68.24	68.69	68.95	69.12	69.24	69.32
0.53	65.18	67.67	68.58	69.03	69.30	69.47	69.59	69.67
0.54	65.49	68.00	68.92	69.38	69.64	69.81	69.93	70.01
0.55	65.80	68.33	69.26	69.72	69.99	70.16	70.28	70.36
0.56	66.12	68.66	69.60	70.06	70.33	70.50	70.62	70.70
0.57	66.44	69.00	69.94	70.40	70.67	70.84	70.96	71.04
0.58	66.75	69.33	70.27	70.73	71.00	71.17	71.29	71.38
0.59	67.07	69.67	70.61	71.07	71.34	71.51	71.63	71.72
0.60	67.39	70.00	70.95	71.41	71.68	71.85	71.97	72.06
0.61	67.72	70.33	71.28	71.74	72.01	72.11	72.30	72.39
0.62	68.05	70.67	71.61	72.08	72.34	72.37	72.63	72.72
0.63	68.37	71.00	71.95	72.41	72.68	72.63	72.97	73.06
0.64	68.70	71.34	72.28	72.75	73.01	72.89	73.30	73.39
0.65	69.03	71.67	72.61	73.08	73.34	73.15	73.63	73.72
0.66	69.37	72.00	72.94	73.41	73.67	73.55	73.95	74.04
0.67	69.71	72.33	73.27	73.73	73.99	73.95	74.28	74.36
0.68	70.05	72.67	73.60	74.06	74.32	74.35	74.60	74.69
0.69	70.39	73.00	73.93	74.38	74.64	74.75	74.93	75.01
0.70	70.73	73.33	74.26	74.71	74.97	75.15	75.25	75.33
0.71	71.08	73.66	74.59	75.03	75.29	75.46	75.57	75.64
0.72	71.44	74.00	74.91	75.35	75.61	75.78	75.88	75.96
0.73	71.79	74.33	75.24	75.68	75.92	76.09	76.20	76.27
0.74	72.15	74.67	75.56	76.00	76.24	76.41	76.51	76.59
0.75	72.50	75.00	75.89	76.32	76.56	76.72	76.83	76.90
0.76	72.87	75.33	76.21	76.63	76.87	77.03	77.14	77.21
0.77	73.24	75.67	76.53	76.95	77.18	77.34	77.44	77.51
0.78	73.62	76.00	76.85	77.26	77.50	77.64	77.75	77.82
0.79	73.99	76.34	77.17	77.58	77.81	77.95	78.05	78.12
0.80	74.36	76.67	77.49	77.89	78.12	78.26	78.36	78.43
0.81	74.75	77.00	77.81	78.20	78.42	78.56	78.66	78.72
0.82	75.15	77.33	78.12	78.51	78.72	78.86	78.95	79.02
0.83	75.54	77.67	78.44	78.81	79.03	79.16	79.25	79.31
0.84	75.94	78.00	78.75	79.12	79.33	79.46	79.54	79.61
0.85	76.33	78.33	79.07	79.43	79.63	79.76	79.84	79.90
0.86	76.75	78.66	79.38	79.73	79.92	80.05	80.13	80.19
0.87	77.18	79.00	79.69	80.03	80.22	80.34	80.42	80.47
0.88	77.60	79.33	80.00	80.33	80.51	80.63	80.70	80.76
0.89	78.03	79.67	80.31	80.63	80.81	80.92	80.99	81.04
0.90	78.45	80.00	80.62	80.93	81.10	81.21	81.28	81.33
0.91	78.91	80.33	80.92	81.22	81.38	81.49	81.56	81.61
0.92	79.37	80.67	81.23	81.51	81.67	81.77	81.84	81.88
0.93	79.83	81.00	81.53	81.81	81.95	82.05	82.11	82.16
0.94	80.29	81.34	81.84	82.10	82.24	82.33	82.39	82.43
0.95	80.75	81.67	82.14	82.39	82.52	82.61	82.67	82.71
0.96	81.27	82.00	82.44	82.67	82.80	82.88	82.94	82.97
0.97	81.78	82.33	82.74	82.95	83.07	83.15	83.20	83.24
0.98	82.30	82.67	83.04	83.24	83.35	83.42	83.47	83.50
0.99	82.81	83.00	83.34	83.52	83.62	83.69	83.73	83.77
1.00	83.33	83.33	83.64	83.80	83.90	83.96	84.00	84.03
1.01	83.93	83.66	83.93	84.08	84.17	84.22	84.26	84.28
1.02	84.53	84.00	84.22	84.35	84.43	84.48	84.51	84.53
1.03	85.14	84.33	84.51	84.63	84.70	84.74	84.77	84.79
1.04	85.74	84.67	84.80	84.90	84.96	85.00	85.02	85.04
1.05	86.34	85.00	85.09	85.18	85.23	85.26	85.28	85.29
1.06	87.10	85.33	85.38	85.44	85.49	85.51	85.53	85.53
1.07	87.87	85.67	85.66	85.71	85.74	85.76	85.77	85.77

1.08	88.63	86.00	85.95	85.97	86.00	86.01	86.02	86.02
1.09	89.40	86.34	86.23	86.24	86.25	86.26	86.26	86.26
1.10	90.16	86.67	86.52	86.50	86.51	86.51	86.51	86.50
1.11	91.55	87.00	86.80	86.76	86.75	86.75	86.74	86.73
1.12	92.95	87.33	87.07	87.01	87.00	86.99	86.98	86.96
1.13	94.34	87.67	87.35	87.27	87.24	87.22	87.21	87.20
1.14	95.74	88.00	87.62	87.52	87.49	87.46	87.45	87.43
1.15	97.13	88.33	87.90	87.78	87.73	87.70	87.68	87.66
1.16	100.00	88.66	88.17	88.03	87.96	87.93	87.90	87.88
1.17	100.00	89.00	88.44	88.27	88.20	88.15	88.12	88.10
1.18	100.00	89.33	88.70	88.52	88.43	88.38	88.35	88.32
1.19	100.00	89.67	88.97	88.76	88.67	88.60	88.57	88.54
1.20	100.00	90.00	89.24	89.01	88.90	88.83	88.79	88.76
1.21	100.00	90.33	89.50	89.25	89.12	89.05	89.00	88.97
1.22	100.00	90.67	89.76	89.48	89.35	89.26	89.21	89.17
1.23	100.00	91.00	90.02	89.72	89.57	89.48	89.43	89.38
1.24	100.00	91.34	90.28	89.95	89.80	89.69	89.64	89.58
1.25	100.00	91.67	90.54	90.19	90.02	89.91	89.85	89.79
1.26	100.00	92.00	90.79	90.41	90.23	90.12	90.05	89.99
1.27	100.00	92.33	91.04	90.64	90.44	90.32	90.25	90.19
1.28	100.00	92.67	91.29	90.86	90.65	90.53	90.44	90.38
1.29	100.00	93.00	91.54	91.09	90.86	90.73	90.64	90.58
1.30	100.00	93.33	91.79	91.31	91.07	90.94	90.84	90.78
1.31	100.00	93.66	92.03	91.52	91.27	91.13	91.03	90.96
1.32	100.00	94.00	92.27	91.73	91.47	91.32	91.22	91.15
1.33	100.00	94.33	92.50	91.95	91.68	91.52	91.40	91.33
1.34	100.00	94.67	92.74	92.16	91.88	91.71	91.59	91.52
1.35	100.00	95.00	92.98	92.37	92.08	91.90	91.78	91.70
1.36	100.00	95.33	93.21	92.57	92.27	92.08	91.96	91.87
1.37	100.00	95.67	93.44	92.77	92.46	92.26	92.14	92.04
1.38	100.00	96.00	93.66	92.97	92.64	92.45	92.31	92.22
1.39	100.00	96.34	93.89	93.17	92.83	92.63	92.49	92.39
1.40	100.00	96.67	94.12	93.37	93.02	92.81	92.67	92.56
1.41	100.00	97.00	94.33	93.56	93.20	92.98	92.83	92.72
1.42	100.00	97.33	94.55	93.75	93.37	93.15	93.00	92.88
1.43	100.00	97.67	94.76	93.94	93.55	93.31	93.16	93.05
1.44	100.00	98.00	94.98	94.13	93.72	93.48	93.33	93.21
1.45	100.00	98.33	95.19	94.32	93.90	93.65	93.49	93.37
1.46	100.00	98.66	95.39	94.49	94.06	93.81	93.64	93.52
1.47	100.00	99.00	95.59	94.67	94.23	93.97	93.80	93.67
1.48	100.00	99.33	95.80	94.84	94.39	94.12	93.95	93.83
1.49	100.00	99.67	96.00	95.02	94.56	94.28	94.11	93.98
1.50	100.00	100.00	96.20	95.19	94.72	94.44	94.26	94.13
1.51	100.00	100.00	96.39	95.35	94.87	94.59	94.40	94.27
1.52	100.00	100.00	96.57	95.51	95.02	94.73	94.54	94.41
1.53	100.00	100.00	96.76	95.68	95.18	94.88	94.69	94.54
1.54	100.00	100.00	96.94	95.84	95.33	95.02	94.83	94.68
1.55	100.00	100.00	97.13	96.00	95.48	95.17	94.97	94.82
1.56	100.00	100.00	97.30	96.15	95.62	95.30	95.10	94.95
1.57	100.00	100.00	97.47	96.30	95.76	95.44	95.23	95.08
1.58	100.00	100.00	97.63	96.45	95.89	95.57	95.36	95.20
1.59	100.00	100.00	97.80	96.60	96.03	95.71	95.49	95.33
1.60	100.00	100.00	97.97	96.75	96.17	95.84	95.62	95.46
1.61	100.00	100.00	98.12	96.88	96.30	95.96	95.74	95.58
1.62	100.00	100.00	98.27	97.02	96.43	96.08	95.86	95.70
1.63	100.00	100.00	98.42	97.15	96.55	96.21	95.98	95.81
1.64	100.00	100.00	98.57	97.29	96.68	96.33	96.10	95.93
1.65	100.00	100.00	98.72	97.42	96.81	96.45	96.22	96.05
1.66	100.00	100.00	98.84	97.54	96.92	96.56	96.33	96.16
1.67	100.00	100.00	98.97	97.66	97.04	96.67	96.44	96.27

1.68	100.00	100.00	99.09	97.78	97.15	96.79	96.54	96.37
1.69	100.00	100.00	99.22	97.90	97.27	96.90	96.65	96.48
1.70	100.00	100.00	99.34	98.02	97.38	97.01	96.76	96.59
1.71	100.00	100.00	99.43	98.13	97.48	97.11	96.86	96.69
1.72	100.00	100.00	99.53	98.23	97.58	97.21	96.96	96.78
1.73	100.00	100.00	99.62	98.34	97.69	97.31	97.05	96.88
1.74	100.00	100.00	99.72	98.44	97.79	97.41	97.15	96.97
1.75	100.00	100.00	99.81	98.55	97.89	97.51	97.25	97.07
1.76	100.00	100.00	99.86	98.64	97.98	97.60	97.34	97.16
1.77	100.00	100.00	99.91	98.73	98.07	97.69	97.43	97.25
1.78	100.00	100.00	99.95	98.81	98.17	97.78	97.52	97.33
1.79	100.00	100.00	100.00	98.90	98.26	97.87	97.61	97.42
1.80	100.00	100.00	100.00	98.99	98.35	97.96	97.70	97.51
1.81	100.00	100.00	100.00	99.06	98.43	98.04	97.78	97.59
1.82	100.00	100.00	100.00	99.14	98.51	98.12	97.86	97.67
1.83	100.00	100.00	100.00	99.21	98.58	98.19	97.93	97.75
1.84	100.00	100.00	100.00	99.29	98.66	98.27	98.01	97.83
1.85	100.00	100.00	100.00	99.36	98.74	98.35	98.09	97.91
1.86	100.00	100.00	100.00	99.42	98.81	98.42	98.16	97.98
1.87	100.00	100.00	100.00	99.48	98.87	98.49	98.23	98.05
1.88	100.00	100.00	100.00	99.53	98.94	98.55	98.30	98.11
1.89	100.00	100.00	100.00	99.59	99.00	98.62	98.37	98.18
1.90	100.00	100.00	100.00	99.65	99.07	98.69	98.44	98.25
1.91	100.00	100.00	100.00	99.69	99.13	98.75	98.50	98.31
1.92	100.00	100.00	100.00	99.73	99.18	98.81	98.56	98.37
1.93	100.00	100.00	100.00	99.77	99.24	98.87	98.62	98.44
1.94	100.00	100.00	100.00	99.81	99.29	98.93	98.68	98.50
1.95	100.00	100.00	100.00	99.85	99.35	98.99	98.74	98.56
1.96	100.00	100.00	100.00	99.87	99.39	99.04	98.79	98.61
1.97	100.00	100.00	100.00	99.90	99.44	99.09	98.84	98.67
1.98	100.00	100.00	100.00	99.92	99.48	99.14	98.90	98.72
1.99	100.00	100.00	100.00	99.95	99.53	99.19	98.95	98.78
2.00	100.00	100.00	100.00	99.97	99.57	99.24	99.00	98.83
2.01	100.00	100.00	100.00	99.98	99.60	99.28	99.05	98.88
2.02	100.00	100.00	100.00	99.98	99.64	99.32	99.09	98.92
2.03	100.00	100.00	100.00	99.99	99.67	99.37	99.14	98.97
2.04	100.00	100.00	100.00	99.99	99.71	99.41	99.18	99.01
2.05	100.00	100.00	100.00	100.00	99.74	99.45	99.23	99.06
2.06	100.00	100.00	100.00	100.00	99.76	99.48	99.27	99.10
2.07	100.00	100.00	100.00	100.00	99.79	99.51	99.30	99.14
2.08	100.00	100.00	100.00	100.00	99.81	99.55	99.34	99.18
2.09	100.00	100.00	100.00	100.00	99.84	99.58	99.37	99.22
2.10	100.00	100.00	100.00	100.00	99.86	99.61	99.41	99.26
2.11	100.00	100.00	100.00	100.00	99.88	99.64	99.44	99.29
2.12	100.00	100.00	100.00	100.00	99.89	99.66	99.47	99.32
2.13	100.00	100.00	100.00	100.00	99.91	99.69	99.51	99.36
2.14	100.00	100.00	100.00	100.00	99.92	99.71	99.54	99.39
2.15	100.00	100.00	100.00	100.00	99.94	99.74	99.57	99.42
2.16	100.00	100.00	100.00	100.00	99.95	99.76	99.59	99.45
2.17	100.00	100.00	100.00	100.00	99.96	99.78	99.62	99.48
2.18	100.00	100.00	100.00	100.00	99.97	99.80	99.64	99.50
2.19	100.00	100.00	100.00	100.00	99.98	99.82	99.67	99.53
2.20	100.00	100.00	100.00	100.00	99.99	99.84	99.69	99.56
2.21	100.00	100.00	100.00	100.00	99.99	99.85	99.71	99.58
2.22	100.00	100.00	100.00	100.00	99.99	99.87	99.73	99.61
2.23	100.00	100.00	100.00	100.00	100.00	99.88	99.75	99.63
2.24	100.00	100.00	100.00	100.00	100.00	99.90	99.77	99.66
2.25	100.00	100.00	100.00	100.00	100.00	99.91	99.79	99.68
2.26	100.00	100.00	100.00	100.00	100.00	99.92	99.80	99.70
2.27	100.00	100.00	100.00	100.00	100.00	99.93	99.82	99.72

2.28	100.00	100.00	100.00	100.00	100.00	99.94	99.83	99.73
2.29	100.00	100.00	100.00	100.00	100.00	99.95	99.85	99.75
2.30	100.00	100.00	100.00	100.00	100.00	99.96	99.86	99.77
2.31	100.00	100.00	100.00	100.00	100.00	99.96	99.87	99.78
2.32	100.00	100.00	100.00	100.00	100.00	99.97	99.88	99.80
2.33	100.00	100.00	100.00	100.00	100.00	99.97	99.90	99.81
2.34	100.00	100.00	100.00	100.00	100.00	99.98	99.91	99.83
2.35	100.00	100.00	100.00	100.00	100.00	99.98	99.92	99.84
2.36	100.00	100.00	100.00	100.00	100.00	99.98	99.93	99.85
2.37	100.00	100.00	100.00	100.00	100.00	99.99	99.93	99.86
2.38	100.00	100.00	100.00	100.00	100.00	99.99	99.94	99.87
2.39	100.00	100.00	100.00	100.00	100.00	100.00	99.94	99.88
2.40	100.00	100.00	100.00	100.00	100.00	100.00	99.95	99.89
2.41	100.00	100.00	100.00	100.00	100.00	100.00	99.96	99.90
2.42	100.00	100.00	100.00	100.00	100.00	100.00	99.96	99.91
2.43	100.00	100.00	100.00	100.00	100.00	100.00	99.97	99.91
2.44	100.00	100.00	100.00	100.00	100.00	100.00	99.97	99.92
2.45	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.93
2.46	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.94
2.47	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.94
2.48	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.95
2.49	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.95
2.50	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.96
2.51	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.96
2.52	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.97
2.53	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.97
2.54	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98
2.55	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98
2.56	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98
2.57	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98
2.58	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.59	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.60	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.61	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.62	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.63	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2.64	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2.65	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

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SECTION 503
BRIDGE APPROACH SLAB

503.1 Description. This work shall consist of constructing a reinforced concrete or asphaltic concrete bridge approach slab on a prepared subgrade in accordance with these specifications and as shown on the plans or as directed by the engineer.

503.2 Material. All material, proportioning, air-entraining, mixing, slump and transporting of Portland cement concrete shall be in accordance with Sec 501. All material for asphalt shall meet the specification requirements for the mix type specified. Approach slabs shall be constructed of pavement concrete or an approved Class B-1 concrete mixture, or asphaltic concrete. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Aggregate for Base	1007.3
Reinforcing Steel for Concrete Structures	1036
Concrete Sealer	1053
Concrete Curing Material	1055
Material for Joints	1057
Polyethylene Sheeting	1058

503.3 Construction Requirements. Concrete bridge approach slabs shall be constructed in accordance with Secs 703 and 706, and shall attain a compressive strength of 4,000 psi prior to opening to traffic. Concrete bridge approach slabs shall be textured in accordance with Sec 703. Curing shall be in accordance with Sec 502, except the liquid membrane-curing compounds shall be in accordance with Sec 1055 for bridge curing compounds. Bridge approach slabs shall require sealing with a concrete sealer.

Asphalt bridge approach slabs shall be constructed in accordance with the specifications for the mix type specified.

503.3.1 Voids Under Completed Concrete Approach Slabs. Prior to acceptance of the work, underseal access holes may be required to be drilled by the contractor to permit investigation by the engineer of any suspected voids or cavities, which if found shall be filled by the contractor using an approved method. Care shall be taken during pumping operations to avoid raising the approach slab.

503.3.1.1 Filling Holes. At the completion of the investigation or underseal pumping, the holes shall be filled with sand to within one inch of the top and the remainder filled with joint sealing material.

503.3.2 Aggregate Base. Testing of aggregate base will be completed by the engineer.

503.4 Method of Measurement. Final measurement of the completed bridge approach slab will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, measurement of the approach slab will be made to the nearest square yard. This area will be measured transversely from out to out and longitudinally from end to end of bridge approach slab. The revision or correction will be computed and added to or deducted from the contract quantity.

503.5 Basis of Payment. The amount of completed and accepted work as shown on the plans, measured as provided above, will be paid for at the contract unit price. Any access holes required for investigation where no voids or cavities are detected will be paid at the fixed unit price for concrete coring specified in Section 109.15 Fixed Cost Items. No direct payment will be made for the reinforcing steel for concrete bridge approach slabs. No direct payment will be made for investigating void conditions under the completed slab or for filling any voids found for concrete bridge approach slabs.

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SECTION 504
CONCRETE APPROACH PAVEMENT

504.1 Description. This work shall consist of placement and preparation of base material and the construction of concrete approach pavement in accordance with these specifications, as shown on the plans or as directed by the engineer.

504.2 Material. All material, proportioning, air-entraining, mixing, slump and transporting of Portland cement concrete shall be in accordance with Sec 501. Approach pavement shall be constructed of pavement concrete or an approved Class B-1 concrete mixture. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Aggregate for Base	1007.3
Concrete Curing Material	1055
Material for Joints	1057

504.3 Construction Requirements.

504.3.1 Base placement shall be in accordance with Sec 304. Concrete approach pavement and shoulders shall be constructed in accordance with Sec 503. Concrete approach pavement will not require sealing with a concrete sealer. Type A Curb, where required, shall be constructed in accordance with Sec 609.

504.3.2 Aggregate Base Testing of aggregate base will be completed by the engineer.

504.4 Method of Measurement. Final measurement of the completed concrete approach pavement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, concrete approach pavement areas, including shoulders, will be measured to the nearest 1/10 square yard. The revision or correction will be computed and added to or deducted from the contract quantity.

504.5 Basis of Payment. The accepted quantity of concrete approach pavement will be paid for at the contract unit price and will be considered full compensation for Type A Curb, all labor, equipment and material to complete the described work.

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SECTION 505
BRIDGE DECK CONCRETE WEARING SURFACE

SECTION 505.10 LOW SLUMP CONCRETE.

505.10.1 Description. This work shall consist of constructing a wearing surface of low slump, dense concrete on a prepared surface in accordance with these specifications, as shown on the plans or as directed by the engineer.

505.10.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Type I or II Cement	1019
Air-Entraining Admixture	1054
Water Reducing Admixture	1054
Burlap	1055
Polyethylene Sheeting	1058
Water	1070

505.10.2.1 Coarse aggregate shall be an approved crushed limestone, crushed quartzite, flint chat from the Joplin area or porphyry in accordance with Sec 1005.2, Gradation E, except that the sum of percentages of all deleterious substances shall not exceed one percent and the percentage of deleterious substances shall not exceed the following values:

Item	Percent by Weight
Deleterious Rock	1.0
Shale and Pyrite	0.2
Chert in Limestone	0.5
Other Foreign Material	0.1

505.10.2.2 Gradation D may be used when the plan thickness of the bridge deck overlay is 3 inches or greater.

505.10.2.3 Fine aggregate shall be in accordance with Sec 1005.3 and shall be Class A sand in accordance with Sec 501.

505.10.2.4 Pozzolanic material or Portland pozzolan cements shall not be used.

505.10.3 Concrete Mixture.

505.10.3.1 The contractor shall submit a mix design to Construction and Materials meeting the following properties:

Property	Requirement
Air Content, percent (minimum)	5.0
Slump, inches	1/2 ± 1/2
Percent Fine Aggregate as Percent of Total Aggregate by Absolute Volume	50
Cement Content, lbs./cubic yard	818 to 827

505.10.3.2 The cement content and percent fine aggregate shall not be changed. If total mixing water, including free water in aggregate and liquid admixtures, varies from design mixing water to cause a change in batch volume of more than two percent, a new mix design will be required.

505.10.3.3 A Type A water-reducing admixture will be required.

505.10.3.4 During placement, the mixture shall be compacted to no less than 98 percent of the standard density.

505.10.4 Testing.

505.10.4.1 Slump will be determined in accordance with AASHTO T 119. The sample for slump testing will be taken at the point of placement in the structure.

505.10.4.2 Air content will be determined by the pressure method in accordance with AASHTO T 152.

505.10.4.3 When required, standard density, unit weight, will be determined in accordance with AASHTO T 121. Standard density will be determined for at least each two hours of concrete production or any time significant fluctuations occur within the range of air content or slump.

505.10.4.4 Compressive strength will be determined from at least two 6- by 12- inch cylinders or from at least three 4- by 8- inch cylinders prepared in accordance with AASHTO T 23 and tested in accordance with AASHTO T 22. One set consisting of two cylinders will be made for 28-day compressive strength from each day's production. Cylinders made for determining when to permit traffic will be made at a frequency determined by the engineer, and will be cured in the near vicinity and in the same manner as the bridge deck.

505.10.4.5 Concrete taken as a sample for testing slump and air content shall be wasted and shall not be placed in the deck. If air content or slump test results are not in accordance with specifications, any concrete represented by those tests and any concrete in the mixer chute shall be wasted, and the necessary adjustments shall be made in the mix design or proportioning devices.

505.10.4.6 When concrete density is specified, in-place density of plastic concrete will be determined in accordance with MoDOT Test Method TM 36. In-place density will be determined at a minimum passing test rate of one per 100 square yards or three per continuous pour, whichever is greater. A nuclear gauge correction factor will be determined at least once for each day of concrete production. Work bridges spanning the plastic concrete shall be provided by the contractor to permit performing nuclear density tests.

505.10.5 Mixing.

505.10.5.1 Concrete shall be mixed in accordance with Sec 501.

505.10.5.2 Mixing time for rotating paddle type mixers shall be a minimum of 60 seconds after all ingredients have been added. All batches shall be mixed approximately the same length of time. Material for a batch of concrete shall not be placed in the mixing drum until the material for the previous batch has been discharged.

505.10.6 Surface Preparation.

505.10.6.1 On new concrete decks, the surface shall be given a very rough texture while still plastic by use of a wire comb or other approved texturing device which will produce a bondable surface acceptable to the engineer.

505.10.6.2 On old existing concrete decks with existing wearing surfaces, the wearing surface shall be removed in accordance with Sec 216. On existing concrete decks without existing wearing surfaces, the surface shall be scarified in accordance with Sec 216.

505.10.6.3 The textured or scarified deck shall be sandblasted followed by an air blast. The sandblast shall remove all dirt, oil and other foreign material, as well as any unsound concrete or laitance from the surface and edges against which new concrete is to be placed. The compressor shall be equipped to prevent oil in the air supply. That portion of the curb and previously placed overlays against which new concrete is to be placed shall be sandblasted. Any loose or foreign material detected on the concrete surface prior to placement of the overlay shall be removed by sand or air blasting. Containment and disposal of material shall be in accordance with Sec 202.2. The concrete surface may require retexturing where penetration of foreign material is evident. No contamination of the retextured or scarified concrete surface will be permitted.

505.10.6.4 To assure that the thickness of the concrete overlay above the prepared surface will be as specified on the plans, the clearance shall be checked in the following manner before concrete is placed. A filler block having a thickness 1/8 inch less than the overlay thickness shall be attached to the bottom of the screed. With screed guides in place, the screed shall be passed over the area to be concreted. Where the intended clearance does not allow use of this method, a stringline or other means shall be used, subject to approval from the engineer. All old concrete that does not have sufficient clearance shall be removed.

505.10.7 Finishing Equipment.

505.10.7.1 The finishing machine shall be designed for striking off and finishing low slump concrete overlay. The machine shall be mechanically powered to operate forward and reverse in a smooth manner, under positive control of the operator. The basic machine shall be of a width to finish a basic 12-foot width of overlay and shall be adjustable for wider placements. The finishing machine shall be designed to allow the screeds to be extended with bolted units to match the extension of the basic unit. The drive wheels shall be of the type that may be replaced with solid rubber wheels to permit travel upon previously completed lanes of overlay when striking off the abutting lanes.

505.10.7.2 The finishing machine shall be equipped with two oscillating transverse screeds. The screeds shall oscillate in a straight line. A swinging pendulum stoke shall not be used. The front screed shall vibrate uniformly for the full length of the screed. The vibrators shall be placed such that the screed vibrates efficiently and the frequency of the vibrators shall be controlled by the operator from the console to achieve the required density.

505.10.7.2.1 Screeds shall be held positive to the machine with rollers and, unless otherwise approved by the engineer, shall be equipped with screed guides such as to control the profile grade of the finished overlay. The screed stroke shall be synchronized to speeds not exceeding 50 strokes per minute, with infinite variable control from the console. The screeds shall be capable of vertical lift when the machine is reversed for travel, and controlled for downward direction to the finishing position to permit feathering of the screeds to any previously finished surface.

505.10.7.2.2 The bottom face of the screeds shall be at least 5 inches wide, with an effective pressure to produce no less than 75 psf. The bottom face of the screeds shall have a turned up leading edge to prevent tearing of the screeded surface and shall be adjustable for tilt and crown. The screed lengths shall be such to produce positive strike off and density of the concrete for at least 6 inches beyond the line where the saw cut for the longitudinal joint is to be made and to within one inch of the curb reinforcing steel or face of any curb barrier already in place.

505.10.7.3 The machine shall be equipped with a mechanically-powered adjustable auger positioned in front of the lead screed. The strike-off shall travel back and forth for the full width to be screeded and shall be properly designed to meter the concrete to the screeds.

505.10.7.4 Heavy duty support rails shall be used to support the finishing machine. Support rails shall be adjustable and the rail shall not deflect more than 1/32 inch between adjustable supports. Support rails shall be placed outside the area and parallel to axis of the area to be concreted. Support rails shall extend a sufficient distance beyond the end of the deck to allow the finishing machine to be completely removed from the deck surface such that hand finishing may proceed without interruption. The support rails shall be set to produce the final profile grade of the surface of the overlay. A hold-down device shot into the concrete will not be permitted unless the concrete is to be subsequently resurfaced. The proposed method of anchoring the support rails shall be submitted to the engineer for approval.

505.10.8 Placing and Finishing Concrete.

505.10.8.1 A lateral support for the concrete such as 2 x 4-inch lumber attached to the deck will be required at least 6 inches beyond the line where the saw cut for the longitudinal joint is to be made.

505.10.8.2 In order to avoid locating the longitudinal construction joints in a wheelpath, the joints shall be placed between the designated traffic lanes. The location of the longitudinal joints shall be subject to the approval from the engineer.

505.10.8.3 At transverse and longitudinal joints, the surface course previously placed shall be sawn to a straight vertical edge before the adjacent course is placed.

505.10.8.4 Transverse joints in the overlay will be permitted if approved by the engineer. These joints shall be located a minimum of 10 feet from the centerline of bent.

505.10.8.5 The contractor shall take every reasonable precaution to secure a smooth riding bridge deck. Prior to placement operations, the contractor shall review with the engineer, equipment, procedures, personnel and previous results as well as inspection procedures to assure coordination. The contractor shall take every

reasonable precaution to ensure that concrete can be produced and placed within the specified limits, continuously and with uniformity.

505.10.8.6 The areas of half-sole and full-depth repair shall have individual concrete placement up to bottom of the low slump concrete wearing surface. These individual placements shall remain rough and shall be completed before the overlay course is started. Areas of half-sole, full-depth repair and all other patched areas shall be surface dried, sandblasted and cleaned prior to the placement of low slump concrete wearing surface.

505.10.8.7 Prior to placement of low slump concrete, the cleaned surface shall be thoroughly wetted for a minimum of three hours, then covered with polyethylene sheeting until the time of concrete placement. The surface shall be damp at the time the overlay is placed. Any standing water in depressions, holes or areas of concrete removal shall be blown out with compressed air. No free water or puddles of standing water shall exist at the time of placement.

505.10.8.8 The wheels of rubber wheeled vehicles or transport containers for the concrete shall not be permitted to contact any portion of the existing concrete surface prior to placement of the concrete. Protection shall be provided for the concrete surface by means of plywood, mats or other suitable material placed on the surface. Any loose or foreign material or rubber marks accidentally deposited on the surface shall be removed by the contractor prior to low slump concrete placement.

505.10.8.9 Placement of the concrete shall be a continuous operation throughout the pour. Only the minimum amount of concrete necessary for proper placement shall be placed in front of the screeds. If the concrete paver is stopped for any reason, all plastic concrete in front of the paver shall be covered with wet burlap. Concrete shall be poured and finished at a minimum of 2.5 cubic yards per hour for a 12-foot wide pour, except when the contractor elects to pour a wider section, the rate of pour shall be increased proportionately. When concrete is being mixed and placed at the specified minimum rate under normal operations, the finishing machine shall be designed such that the elapsed time between depositing the concrete on the deck and final screeding shall not exceed 10 minutes.

505.10.8.10 If concrete is added to the overlay behind the finishing machine, the area shall be mechanically consolidated again by the finishing machine.

505.10.8.11 After finishing, the contractor shall check the surface with a lightweight 10-foot straightedge. Causes for irregularities exceeding 1/8 inch shall be eliminated and corrections shall be made.

505.10.8.12 The roadway surface finish shall be in accordance with Sec 703.3.5.5. The texture shall not extend into the areas within approximately 12 inches of curbs.

505.10.8.13 After texturing the concrete surface, but before applying the wet cure, all vertical joints with the adjacent concrete shall be sealed by painting with thinned grout consisting of equal parts cement, sand and sufficient water for the mixture to be the consistency of paint.

505.10.8.14 After the joint painting is completed, the freshly placed lane and joint shall be promptly covered with a single layer of clean, wet burlap. Care shall be exercised to ensure that the wet burlap is well drained and that the burlap is placed as soon as the surface will support the burlap without deformation.

505.10.8.15 The wet cure shall be applied within 30 minutes after the concrete has been placed on the deck, except when the surface will be excessively marred by doing so, as determined by the engineer. If the concrete requires refinishing because of failure to meet density requirements, the time will be extended 15 minutes. Failure to apply wet cure within the required time will be cause for rejecting the work affected. Surface concrete in the rejected area shall be removed and replaced by the contractor at the contractor's expense.

505.10.8.16 The surface shall receive a wet cure of at least 72 hours.

505.10.8.17 After placement and cure of the low slump concrete, the finished deck will be tested to detect unbonded areas.

505.10.8.18 As soon as curing has been completed, the riding surface will be thoroughly straightedged by the engineer and all variations exceeding 1/8 inch in 10 feet will be plainly marked. Areas more than 1/8 inch high shall be removed by an approved device consisting of multiple cutting edges leaving a grooved surface finish

comparable to that produced by the texturing device. A bush hammer or other impact device shall not be used.

505.10.8.19 The surface of low slump concrete shall be sealed in accordance with Sec 703.3.8 and payment for furnishing and placing shall be included in the contract unit price for other items.

505.10.9 Limitations of Operations.

505.10.9.1 Vehicle traffic shall not be permitted on the low slump concrete surface for 72 hours and until 3,000 psi compressive strength is attained.

505.10.9.2 No low slump concrete shall be placed at ambient temperatures below 45 F or above 85 F. Concrete placement may begin when the air temperature and deck temperature is 45 F and rising. Concrete shall not be exposed to freezing temperatures until a strength of 3,000 psi has been attained. Any concrete damaged by freezing shall be removed and replaced at the contractor's expense.

505.10.9.3 When the weather forecast predicts temperatures of 85 F or higher, the contractor shall schedule placing and finishing low slump concrete during hours in which the ambient temperature will be lower than 85 F. The mixed concrete when placed shall have a maximum temperature of 90 F.

505.10.9.4 Concrete shall not be placed adjacent to a parallel surface course that is less than 72 hours old. This restriction will not apply to a continuation of placement in a lane or strip beyond a joint in the same lane or strip.

505.10.9.5 Preparation of the area may be started in a lane or strip adjacent to a newly placed surface the day following placement of the new surface. If this work is started before the end of the 72-hour curing period, the work shall be restricted as follows:

(a) Sawing or other operations shall interfere with the curing process for the minimum practical time only, in the immediate work area only, and the curing shall be resumed promptly.
(b) No power-driven tools heavier than 15 pounds shall be used.
(c) Air compressors shall be operated on the deck only directly over the piers.
(d) No loads other than construction equipment shall be permitted on any portion of the bridge floor that has undergone preparation prior to placement and curing of new concrete.

505.10.10 Removal. All material removed shall be disposed of by the contractor at the contractor's expense in a location meeting the approval of the engineer.

505.10.11 Repair.

505.10.11.1 Unbonded areas will be marked by the engineer. The contractor shall saw cut and remove the affected area. All saw cuts shall be straight vertical lines and form square corners at all changes in direction. After removal of the concrete, the surface of the area to be repaired and vertical saw cuts shall be cleaned of all loose or foreign material by sandblasting and then air blasting. The surface shall be comparable to the original concrete surface prior to the original overlay being placed.

505.10.11.2 The concrete used for repair shall meet the same requirements as the original mixture. The concrete shall be vibrated with a surface or pan-type vibrator to obtain compaction. Spud type vibrators shall not penetrate to contact with the original concrete. Surface finish and curing shall be in accordance with the specifications for the mixture used.

505.10.12 Method of Measurement. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The area of concrete wearing surface will be measured and computed to the nearest square yard. This area will be measured longitudinally from end to end of bridge deck and transversely between roadway face of curbs, excluding from measurement the area of drains and expansion devices. The revision or correction will be computed and added to or deducted from the contract quantity.

505.10.13 Basis of Payment. Payment for the above described work shall be considered completely covered by the contract unit price per square yard of concrete wearing surface.

SECTION 505.20 LATEX MODIFIED CONCRETE.

505.20.1 Description. This work shall consist of constructing a wearing surface of latex modified concrete on a prepared surface in accordance with these specifications as shown on the plans or as directed by the engineer.

505.20.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Type I or II Cement	1019
Latex Emulsion Admixture	1054
Polyethylene Sheeting	1058
Water	1070

505.20.2.1 Aggregate shall be in accordance with Sec 505.10.2.

505.20.2.2 Pozzolanic material or Portland pozzolan cements shall not be used.

505.20.2.3 Latex admixture shall be kept in a suitable enclosure that will protect the admixture from freezing and from exposure to temperatures in excess of 85 F. Drums of latex admixture to be stored at the work site in direct sunlight shall be completely covered with a suitable insulating blanket material to maintain an enclosed temperature below 85 F.

505.20.3 Concrete Mixture.

505.20.3.1 The contractor shall submit a mix design to Construction and Materials meeting the following requirements:

Property	Requirement
Air Content, percent	0 to 6.5
Slump, inches	9 (max.)
Percent Fine Aggregate as percent of Total Aggregate by Absolute Volume	50 to 55
Cement Content, lbs./cubic yard min.	658
Latex Emulsion Admixture, gallons/cubic yard. min.	24.5
Net Water/Cement Ratio, max., lbs.[a] water/lbs. cement	0.40

[a] Net water shall be considered the quantity of mixing water added, plus the non-solid portion of the latex emulsion.

505.20.3.2 Any change in mix design or proportions shall be approved by the engineer.

505.20.3.3 Anti-foam additives, as recommended by the latex emulsion manufacturer, may be required if the concrete mixture entrains air above the specified amount.

505.20.3.4 Air-entraining admixtures shall not be added.

505.20.4 Testing. Testing will be done in accordance with Sec 505.10.4, except the slump test will be conducted 4 to 5 minutes after discharge from the mixer. During the waiting period, concrete shall be deposited on the deck and shall not be disturbed.

505.20.5 Mixing.

505.20.5.1 The concrete shall be volumetrically mixed at the bridge site by a continuous mixer in accordance with Sec 501. In addition to other requirements, the mixer shall provide positive control of the latex emulsion into the mixing chamber and the latex emulsion shall calibrate to within ± 2 percent of that required. The mixer shall be capable of continuously circulating the latex emulsion and shall have a flow-through screen between the storage tank and the discharge.

505.20.5.2 The concrete discharged from the mixer shall be uniform in composition and consistency. Mixing capability shall be such that initial and final finishing operations can proceed at a steady pace. Final finishing shall be completed before the formation of a plastic surface film.

505.20.5.3 The moisture content of aggregate at the time of proportioning shall be such that water will not drain or drip from a sample. Coarse and fine aggregate shall be furnished and handled to avoid variations in the moisture content affecting the uniform consistency of the concrete.

505.20.5.4 Each drum of latex admixture shall be mechanically agitated or hand rolled until thoroughly mixed prior to being introduced into the mixer storage compartment. Latex admixture that is stored in the mixer storage compartment overnight or during delays in mixing of four hours or more shall be agitated by at least two complete cycles in a continuous circulating pump or by mechanical means in the storage compartment. The flow through screen shall be cleaned immediately prior to beginning proportioning and as often as necessary thereafter. Latex admixtures of different brands shall not be combined together in any manner.

505.20.6 Surface Preparation. Surface preparation shall be in accordance with Sec 505.10.6 except as specified herein.

505.20.6.1 Prior to scarifying or chipping on concrete adjacent to latex modified concrete, 96 hours of curing shall elapse. If practical, all scarifying by mechanical units shall be completed prior to placing any latex modified concrete, unless otherwise shown on the plans. Areas from which unsound concrete and patches have been removed shall be kept free of slurry produced by wet sawing or wet scarifying by planning the work such that this slurry will drain away from the completed areas of preparation.

505.20.6.2 On both old and new decks, within 24 hours prior to placing latex modified concrete, the entire surface shall be thoroughly cleaned by sandblasting followed by an air blast. Containment and disposal of material shall be in accordance with Sec 202.2.

505.20.7 Finishing Equipment.

505.20.7.1 The finishing machine shall be self-propelled and shall be capable of forward and reverse movement under positive control, with a provision for raising all screeds to clear the screeded surface for traveling in reverse. A self-propelled finishing machine with one or more rollers, augers and 1,500 to 2,500 vpm vibratory pans shall be used. A drag float may be necessary. Any modifications will be subject to approval from the engineer.

505.20.7.2 Support rails shall be in accordance with Sec 505.10.7.4.

505.20.8 Placing and Finishing Concrete. Placing and finishing shall be in accordance with Sec 505.10.8 except as specified herein.

505.20.8.1 Prior to placement of latex modified concrete, the cleaned surface shall be thoroughly wetted for a minimum of three hours, then covered with polyethylene sheeting until time of concrete placement. The surface shall be damp at the time the overlay is placed. Any standing water in depressions, holes or areas of concrete removal shall be blown out with compressed air. No free water or puddles of standing water shall exist at the time of placement.

505.20.8.2 Expansion joints and dams shall be formed in the concrete overlay. Formation of the joint by sawing through the overlay will not be permitted.

505.20.8.3 Texturing shall occur immediately after finishing and before the plastic film forms on the surface. Texturing shall be performed in a manner to prevent pulling the concrete away from an existing vertical face. Care shall be taken not to texture too deep and not to tear the surface.

505.20.8.4 Screed rails and headers shall be separated from the newly placed material by passing a pointing trowel along the inside face. Metal expansion dams shall not be separated from the overlayment. The trowel cut shall be made for the entire depth and length of rails or headers after the mixture has stiffened sufficiently and shall prevent the concrete from flowing back into the cut.

505.20.8.5 During placement of the overlay, all joints with adjacent concrete shall be sealed with a mortar paste of equal parts cement and fine aggregate, using latex emulsion in lieu of mixing water.

505.20.8.6 The wet cure shall be applied promptly after the concrete has been placed on the deck without deforming the finished surface.

505.20.8.7 The surface shall receive a wet cure for at least 48 hours.

505.20.8.8 After placement and cure of the latex modified concrete, the finished deck will be tested to detect unbonded areas.

505.20.8.9 No surface sealing shall be applied to the latex modified concrete wearing surface.

505.20.9 Limitations of Operations.

505.20.9.1 No latex modified concrete shall be placed when the ambient or deck surface temperature is above 85 F. Deck temperature shall be determined in accordance with MoDOT Test Method TM 20.

505.20.9.2 No latex modified concrete shall be placed at ambient or deck surface temperatures below 45 F. Latex modified concrete shall be protected to maintain a minimum specified curing temperature of 45 F. Any concrete damaged by freezing or that is exposed to a temperature of less than 45 during the first 8 hours after placement shall be removed and replaced at the contractor's expense.

505.20.9.3 The temperature of the latex modified concrete at time of placement shall be between 45 F and 90 F. If either the aggregate or water is heated, the maximum temperature for each shall be 100 F at the time of addition to the mix. Any method of heating during the mixing of concrete may be used provided the heating apparatus will heat the mass uniformly and avoid hot spots that will burn the material. Cement or aggregate containing lumps or crusts of hardened material or frost shall not be used.

505.20.9.4 No vehicular traffic shall be permitted on the latex modified concrete surface until the concrete is at least 72 hours old and has attained a minimum compressive strength of 3,000 psi.

505.20.9.5 Concrete shall not be placed adjacent to a parallel surface course that is less than 96 hours old; however, this restriction will not apply to a continuation of placement in a lane or strip beyond a joint in the same lane or strip.

505.20.9.6 Preparation of the area, except scarifying, may be started in a lane or strip adjacent to a newly placed surface the day following the surface placement. If this work is started before the end of the 48-hour wet curing period, the work will be restricted such that any interference with the curing process is held to the minimum practical time.

505.20.9.7 Longitudinal construction joints shall be placed between designated traffic lanes. The location of the longitudinal joints will be subject to the approval from the engineer.

505.20.9.8 Transverse joints in the overlay may be permitted if approved by the engineer. These joints shall be located a minimum of 10 feet from the centerline of bent.

505.20.9.9 A header shall be installed in case of delay in the placement operations exceeding one-half hour in duration. During minor delays of one-half hour or less, the end of the placement shall be protected from drying with several layers of wet burlap.

505.20.9.10 Adequate precautions shall be taken to protect freshly placed concrete from rain. All placing operations shall cease when rain begins. The engineer may order removal of any material damaged by rainfall and such material shall be replaced in accordance with these specifications at the contractor's expense.

505.20.10 Removal. Material removal and disposal shall be in accordance with Sec 505.10.10.

505.20.11 Repair. Repair shall be in accordance with Sec 505.10.11.

505.20.12 Method of Measurement. Measurement of latex modified concrete will be in accordance with Sec

505.10.12.

505.20.13 Basis of Payment. Payment for latex modified concrete will be made in accordance with Sec 505.10.13.

SECTION 505.30 SILICA FUME CONCRETE.

505.30.1 Description. This work shall consist of constructing a wearing surface of silica fume concrete on a prepared surface in accordance with these specifications as shown on the plans or as directed by the engineer.

505.30.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Type I Cement	1019
Air Entraining Admixture	1054
Retarding Admixture	1054
Water-Reducing Admixture	1054
Burlap	1055
Polyethylene Sheeting	1058
Water	1070

505.30.2.1 Silica fume shall be in accordance with Sec 501.

505.30.2.2 Aggregate shall be in accordance with Sec 505.10.2.

505.30.2.3 Pozzolanic material, other than silica fume or Portland pozzolan cements shall not be used.

505.30.2.4 A retarding admixture may be permitted, if recommended by the manufacturer of the silica fume admixture.

505.30.2.5 Approved Type F or G high range water-reducing admixtures will be permitted if specified or recommended by the supplier of the silica fume admixture.

505.30.3 Concrete Mixture.

505.30.3.1 The contractor shall submit a mix design to Construction and Materials with the following properties:

Property	Requirement
Air Content, percent, minimum	5.0
Slump, inches,	3 – 7 1/2
Cement Content, pounds/cubic yard, min	640
Water/Cement Ratio lbs. water/lbs. cementitous materials, max.	0.37
Silica Fume, % replacement of cement	6-8
Percent Fine Aggregate (as percent of total fine and coarse aggregate by absolute volume)	50 – 55
High Range Water Reducer	As required

505.30.3.2 The water content shall include all free moisture in the fine and coarse aggregate, water content of the silica fume admixture and water content of the high range water reducer.

505.30.3.3 The contractor shall designate in the mix design letter what target the slump will be in the field.

505.30.4 Testing. Testing will be done in accordance with Sec 505.10.4.

505.30.5 Mixing.

505.30.5.1 Silica fume concrete shall be batched and mixed in accordance with Sec 501, except as herein

specified.

505.30.5.2 High range water-reducing admixtures shall be incorporated and mixed into the silica fume concrete in accordance with the silica fume admixture manufacturer's recommendations and as approved by the engineer. Water-reducing admixtures may be added by hand methods. The water-reducing admixture shall not be mixed with the air-entraining admixture nor shall the water reducer be added to the same portion of the mixing water as the air-entraining admixture. Either the air-entraining admixture or the water-reducing admixture shall be mixed into the concrete before the other is added.

505.30.5.3 Truck mixed silica fume concrete shall be initially mixed for at least 70 revolutions at a rate of no less than 12 revolutions per minute or more than 18 revolutions per minute. Truck mixed silica fume concrete shall be transported to the work site at agitating speeds of 2 to 6 revolutions per minute. After arriving at the work site and before use, the silica fume concrete shall be mixed for at least 30 revolutions at 12 to 18 revolutions per minute.

505.30.5.4 If on-site rotating paddle-type mixers or on-site rotating drum mixers are used, the length of mixing time and the revolution rate shall be as recommended by the silica fume admixture manufacturer.

505.30.5.5 The silica fume admixture manufacturer's technical representative shall advise the engineer in writing of the proper batching sequence, mixing time, mixing speed and other handling procedures necessary to produce a uniform, homogeneous mixture in accordance with this specification prior to preparation of silica fume concrete trial batches or placement of any silica fume concrete.

505.30.5.6 Prior to placement of concrete in the work, the contractor may be required to prepare trial batches of concrete for tests. Trial batches shall comply with and be paid for in accordance with Sec 501.

505.30.6 Surface Preparation. Surface preparation shall be in accordance with Sec 505.10.6.

505.30.7 Finishing Equipment. The finishing machine shall be designed for striking off and finishing silica fume concrete overlay. The finishing machine, screeds, traveling strike off and support rails shall be in accordance with Sec 505.10.7.

505.30.8 Placing and Finishing Concrete. Placing and finishing shall be in accordance with Sec 505.10.8 except as noted herein.

505.30.8.1 The cleaned areas to receive the overlay shall be thoroughly and continuously wetted with water at least three hours before placement of the overlay is started, then covered with polyethylene sheeting until the time of placement. Any accumulations of water shall be dispersed or removed prior to applying the overlay.

505.30.8.2 Since silica fume concrete produces very little bleed water, the engineer may require one or both of the following procedures to maintain a surface film until the burlap is placed.

505.30.8.2.1 A commercially available evaporative retarder may be used judiciously with a misting device during the finishing process until the wet burlap is applied only to prevent the surface of the concrete from drying out. The evaporative retarder shall not be used to increase surface workability.

505.30.8.2.2 Fogging may be done to increase humidity in the area of placement. Any fogging shall be done with nozzles specifically designed for fogging, with a maximum rate of one gallon per minute per nozzle.

505.30.8.3 The surface shall receive a wet cure for at least 7 days. Time when the ambient temperature is below 45 F will not be counted as cure time. Cure shall be continued until 3,000 psi compressive strength has been attained.

505.30.8.4 The finished deck will be examined for cracking. If cracking is found, the engineer will determine whether cracking is detrimental, whether remedial surface repairs are needed or whether the overlay in the cracked area should be removed and replaced. All remedial surface repairs, removal or replacement shall be done by the contractor at the contractor's expense.

505.30.8.5 After placement and cure of the silica fume concrete, the finished deck will be tested to detect unbonded areas.

505.30.8.6 No surface sealing shall be applied to the silica fume concrete wearing surface.

505.30.9 Limitations of Operations. Operations shall be limited in accordance with Sec 505.10.9, except as noted herein.

505.30.9.1 Vehicular traffic shall not be permitted on the silica fume concrete surface for seven days, and in no case until 3,000 psi compressive strength is attained.

505.30.9.2 Silica fume concrete shall not be placed when the air temperature or deck temperature is below 45 F or above 85 F. Concrete placement may begin when the air temperature and deck temperature are 45 F and rising. Concrete shall not be exposed to freezing temperatures until a strength of 3,000 psi has been attained. Any concrete damaged by freezing shall be removed and replaced at the contractor's expense.

505.30.9.3 When the weather forecast predicts temperatures of 85 F or higher, the contractor shall schedule placing and finishing silica fume concrete during hours in which the ambient temperature will be lower than 85 F. The mixed concrete shall not have a temperature higher than 85 F when placed.

505.30.9.4 Since silica fume concrete may not exhibit bleed water, the probability of plastic shrinkage cracking is increased. At surface evaporation rates above 0.1 pound per square foot per hour, plastic shrinkage cracking is probable and the contractor shall take precautions such as erecting windbreaks, lowering the mix temperature or delaying operations until ambient temperatures are lower. Fogging the concrete surface will only be permitted as provided for in this specification. Surface evaporation rates may be predicted from mix temperature, air temperature, relative humidity and wind velocity, using Figure 1 of the 1986 revised edition of ACI 308-81, Standard Practice for Curing Concrete.

505.30.10 Removal. Material removal and disposal shall be in accordance with Sec 505.10.10.

505.30.11 Repair. Repairs shall be in accordance with Sec 505.10.11.

505.30.12 Method of Measurement. Measurement of silica fume concrete will be in accordance with Sec 505.10.12.

505.30.13 Basis of Payment. Payment for silica fume concrete will be made in accordance with Sec 505.10.13.

SECTION 505.40 LATEX MODIFIED VERY EARLY STRENGTH CONCRETE.

505.40.1 Description. This work shall consist of a wearing surface of latex modified very early strength concrete constructed on a prepared surface in accordance with this specification and in accordance with lines, grades, thickness and typical cross sections shown on the plans or as directed by the engineer.

505.40.2 Material. All material shall be in accordance with Sec 505.10, Division 1000, Materials Details and specifically as follows:

Item	Section
Latex Emulsion Admixture	1054
Polyethylene Sheeting	1058
Water	1070

505.40.2.1 Hydraulic cement shall be in accordance with ASTM C 1600, Type VRH. Type HE (ASTM C 1157) or Type III cement will not be permitted.

505.40.2.2 Coarse aggregate shall be an approved crushed limestone, crushed quartzite, flint chat from the Joplin area, or porphyry in accordance with Sec 1005, Gradation E or Gradation F, except the percentage of deleterious substances shall not exceed the following values, and the sum of percentages of all deleterious substances shall not exceed one percent.

Item	Percent by Weight (Mass)
Deleterious Rock	1.0

Shale and Pyrite	0.2
Chert in Limestone	0.5
Other Foreign Material	0.1

505.40.2.3 Fine aggregate shall be in accordance with Sec 1005 and shall be Class A sand in accordance with Sec 501.

505.40.2.4 With approval of the engineer, other gradations of coarse or fine aggregate may be used, however all quality requirements, including a maximum of 2.0 percent passing the No. 200 for fine and coarse aggregate, shall apply and the maximum aggregate size shall not exceed that of Sec 1005, Grade E aggregate.

505.40.2.5 Pozzoloanic material or Portland pozzolan cements shall not be used.

505.40.2.6 Latex admixture shall be kept in suitable enclosures which will protect it from freezing and from exposure to temperatures in excess of 85 F.

505.40.3 Concrete Mixture.

505.40.3.1 The concrete mixture shall meet the following requirements:

Property	Specific Value
Air Content percent	0 to 6.5
Slump, inches	9 (max.)
Percent Fine Aggregate as percent of total aggregate by weight	50 to 55
Cement Content, lb/cu yd min.	658
Latex Emulsion Admixture, gal/cu yd	24.5
Net Water-Cement Ratio, max. Lbs.[a] of water/lbs. of cement	0.42

[a]Net water shall be considered the quantity of mixing water added plus the non-solid portion of the latex emulsion.

505.40.3.2 Chloride permeability shall not be greater than 1000 coulombs when tested in accordance with AASHTO T 277. Tests shall be performed on specimens at 28-days. This test shall be performed on each mixture submitted for approval. The tests are to be performed by a qualified commercial laboratory.

505.40.3.3 The mixture shall be designed to develop a minimum 28-day compressive strength of 4,500 psi.

505.40.3.4 Anti-foam additives as recommended by the latex emulsion manufacturer may be required if the concrete mixture entrained air is above the specified amount.

505.40.3.5 Air-entraining admixtures shall not be added.

505.40.3.6 A set control in accordance with the cement manufacturer's recommendation may be considered.

505.40.3.7 Admixtures containing calcium chloride shall not be used.

505.40.4 Mix Design. The contractor shall submit the mix design to Construction and Materials for approval. The mix design shall be within the limits specified in this provision. The mix design shall also include actual test results for the following information:

(a) Air.

(b) Slump.

(c) Compressive strengths at 4-hours, 8-hours, 12-hours, 24-hours, 7-days and 28-days. Compressive strengths determined using 6 x 12 inch cylinders.

(d) Results of chloride permeability testing.

505.40.4.1 If other aggregate gradations than standard specifications are utilized, the contractor shall designate the intended target gradation and allowable gradation range for each fraction. The target gradations and allowable gradation ranges will be used for inspection and quality control of the aggregates.

505.40.4.2 Any change in mix design or proportions shall be approved by the engineer.

505.40.5 Testing. Testing will be done in accordance with Sec 505.10, except that the slump test will be conducted 4 to 5 minutes after discharge from the mixer. During the waiting period, concrete shall be deposited on the deck and shall not be disturbed.

505.40.6 Mixing.

505.40.6.1 The concrete shall be volumetrically mixed at the bridge site by a continuous mixer in accordance with Sec 501. In addition to other requirements, the mixer shall provide positive control of the latex emulsion into the mixing chamber, and the latex emulsion shall calibrate to within ±2 percent of that required. The mixer shall be capable of continuously circulating the latex emulsion and have a flow-through screen between the storage tank and the discharge.

505.40.6.2 The concrete discharged from the mixer shall be uniform in composition and consistency. Mixing capability shall be such that initial and final finishing operations can proceed at a steady pace. Final finishing shall be completed before the formation of a plastic surface film on the surface.

505.40.6.3 The moisture content of aggregates at the time of proportioning shall be such that water will not drain or drip from a sample. Coarse and fine aggregate shall be furnished and handled to avoid variations in the moisture content affecting the uniform consistency of the concrete.

505.40.6.4 Each drum of latex admixture shall be mechanically agitated or hand rolled until thoroughly mixed prior to being introduced into the mixer storage compartment. Latex admixture that is stored in the mixer storage compartment overnight or during delays in mixing of four hours or more shall be agitated by at least two complete cycles in a continuous circulating pump or by mechanical means in the storage compartment. The flow through screen shall be cleaned immediately prior to beginning proportioning and as often as necessary thereafter. Latex admixtures of different brands shall not be combined together in any manner.

505.40.6.5 The water/cement ratio shall be within 0.02 of that specified in the approved mix design. If adjustments for water content beyond that are necessary, a previously tested and approved mixture shall be used.

505.40.6.6 Prior to placement of concrete in the work, the contractor shall be required to prepare trial batches of concrete for testing. Trial batches shall comply with the limits specified in this provision.

505.40.7 Surface Preparation. Surface preparation shall be in accordance with Sec 505.10 except as specified herein.

505.40.7.1 Prior to scarifying or chipping on concrete adjacent to latex modified very early strength concrete, 24 hours of curing shall elapse. If practical, or unless otherwise shown on the plans, all scarifying by mechanical units shall be completed prior to placing any latex modified very early strength concrete. Areas from which unsound concrete and patches have been removed shall be kept free of slurry produced by wet sawing or wet scarifying by planning the work such that this slurry will drain away from the completed areas of preparation.

505.40.7.2 On both old and new decks within 24 hours before latex modified very early strength concrete placement begins, the entire surface shall be thoroughly cleaned by hydro blasting followed by an air blast in accordance with Sec 505.10.

505.40.7.3 Containment and disposal of material shall be in accordance with Sec 202.2.

505.40.8.0 Finishing Equipment.

505.40.8.1 The finishing machine shall be self-propelled with one or more rollers, augers and vibratory pans capable of 1,500 to 2,500 vpm. It shall also be capable of forward and reverse movement under positive control, with a provision for raising all screeds to clear the screeded surface for traveling in reverse. A drag float may be

necessary. Any modifications shall be subject to approval from the engineer.

505.40.8.2 Support rails shall be in accordance with Sec 505.10.

505.40.9 Placing and Finishing Concrete. Placing and finishing shall be in accordance with Sec 505.10 except as specified herein.

505.40.9.1 Prior to placement of latex modified very early strength concrete, the cleaned surface shall be thoroughly wetted for a minimum of one hour, then covered with polyethylene sheeting until time of concrete placement. The surface shall be damp at the time the overlay is placed. Any standing water in depressions, holes or areas of concrete removal shall be blown out with compressed air. No free water or puddles of standing water shall exist at the time of placement.

505.40.9.2 Expansion joints and dams shall be formed in the concrete overlay. Formation of the joint by sawing through the overlay will not be allowed.

505.40.9.3 Water shall not be added to the surface of the concrete during finishing. A commercially available evaporation retardant may be used judiciously with a misting device during the finishing process until the wet burlap is applied only to prevent the surface of the concrete from drying out. The evaporation retardant shall not be used to increase surface workability.

505.40.9.4 Texturing shall occur immediately after finishing and before the plastic film forms on the surface. Texturing shall be performed in a manner to prevent pulling the concrete away from an existing vertical face Care shall be taken not to texture too deep and not to tear the surface.

505.40.9.5 Screed rails and headers shall be separated from the newly placed material by passing a pointing trowel along their inside face. Metal expansion dams shall not be separated from the new overlay. The trowel cut shall be made for the entire depth and length of rails or headers after the mixture has stiffened sufficiently and shall prevent the concrete from flowing back into the cut.

505.40.9.6 During placement of the overlay, all joints with adjacent concrete shall be sealed with a mortar paste of equal parts cement and fine aggregate, using latex emulsion in lieu of mixing water.

505.40.9.7 The overlay concrete shall be moist cured from the time placed until opened to traffic.

505.40.9.8 The wet cure shall be applied promptly after the concrete has been placed on the deck without deforming the finished surface.

505.40.9.9 Within one hour of covering with wet burlap, a layer of white polyethylene sheeting shall be placed on the wet burlap. The surface shall receive a wet cure until the latex modified very early strength concrete has attained a compressive strength of at least 3,200 psi.

505.40.9.10 The thickness of the overlay shall not exceed 3 inches, unless otherwise approved by the engineer.

505.40.9.11 The finished deck will be examined for cracking. If cracking is found, the engineer will determine whether cracking is detrimental, whether remedial surface repairs are needed or whether the overlay in the cracked area should be removed and replaced. All remedial surface repairs, removal or replacement shall be done by the contractor at the contractor's expense.

505.40.9.12 After placement and curing of the latex modified very early strength concrete, the finished deck will be tested to detect unbonded areas.

505.40.9.13 No surface sealing shall be applied to the latex modified very early strength concrete wearing surface.

505.40.10 Limitations of Operations.

505.40.10.1 No latex modified very early strength concrete shall be placed when the ambient or deck surface temperature is above 85 F. Deck temperature shall be determined in accordance with MoDOT Test Method T20.

505.40.10.2 Since latex modified very early strength concrete may not exhibit bleed water, the probability of plastic shrinkage cracking is increased. At surface evaporation rates above 0.1 pounds per square foot per hour plastic shrinkage cracking is probable and the contractor should take precautions such as erecting windbreaks, lowering the mix temperature or delaying operations until ambient temperatures are lower. Fogging the concrete surface will only be allowed, as provided for in this specification. Surface evaporation rates can be predicted from mix temperature, air temperature, relative humidity and wind velocity using Figure 1 of ACI 308-81 (revised 1986) "Standard Practice for Curing Concrete".

505.40.10.3 A fogging system shall be in-place prior to concrete placement. The fogging system shall consist of pressurized equipment that distributes water at minimum rate of 0.10 gallon per hour per square foot. The fogging system shall apply the fog uniformly over the entire surface of the bridge deck. The fogging system shall produce atomized water that has a droplet with a maximum diameter of 0.003 inches and which keeps the finished deck surface saturated without producing standing water. The contractor shall submit a letter certifying that their fogging system is in accordance with this provision.

505.40.10.4 The fogging system shall be started progressively along the length of the deck, during or immediately after floating.

505.40.10.5 No latex modified very early strength concrete shall be placed at ambient or deck surface temperatures below 45 F. Latex modified very early strength concrete shall be protected to maintain a minimum specified curing temperature of 45 F. The contractor shall provide a method, meeting the approval of the engineer, of monitoring the concrete that demonstrates that the concrete has been maintained above the minimum curing temperature and has been protected from freezing. Any concrete damaged by freezing or which is exposed to a temperature of less than 45 F during the first 8 hours after placement shall be removed and replaced at the contractor's expense.

505.40.10.6 The temperature of the latex modified very early strength concrete at time of placement shall be between 45 F and 90 F. If either the aggregate or water is heated, the maximum temperature for each shall be 100 F at the time of addition to the mix. Any method of heating during the mixing of concrete may be used provided the heating apparatus will heat the mass uniformly and avoid hot spots which will burn the material. Cement or aggregate containing lumps or crusts of hardened material or frost shall not be used.

505.40.10.7 No vehicle traffic shall be permitted on the latex modified very early strength concrete surface until the latex modified very early strength concrete has attained a minimum compressive strength of 3,200 psi. Compressive strength will be determined by tests conducted in accordance with MoDOT test methods.

505.40.10.8 Concrete shall not be placed adjacent to a parallel surface course which is less than 24 hours old; however, this restriction will not apply to a continuation of placement in a lane or strip beyond a joint in the same lane or strip.

505.40.10.9 Preparation of the area, except scarifying, may be started in a lane or strip adjacent to newly placed surface the day following the surface placement. If this work is started before the end of the curing period, the work will be restricted such that any interference with the curing process is held to the minimum practical time only.

505.40.10.10 Longitudinal construction joints shall be placed between designated traffic lanes. The location of the longitudinal joints shall be subject to the approval from the engineer.

505.40.10.11 Transverse joints in the overlay may be permitted if approval by the engineer. Transverse joints shall be located a minimum of 10 feet from the centerline of bent.

505.40.10.12 A header shall be installed in case of delay in the placement operations exceeding one-half hour in duration. During minor delays of one-half hour or less, the end of the placement shall be protected from drying with several layers of wet burlap.

505.40.10.13 Adequate precautions shall be taken to protect freshly placed concrete from rain. All placing operations shall stop when rain begins. The engineer may order removal of any material damaged by rainfall and such material shall be replaced in accordance with this specification at the contractor's expense.

505.40.11 Removal. Material removal and disposal shall be in accordance with Sec 505.10.

505.40.12 Repair. Repair shall be in accordance with Sec 505.10.

505.40.13 Method of Measurement. Measurement will be in accordance with Sec 505.10.

505.40.14 Basis of Payment. The basis for payment will be in accordance with Sec 505.10.

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SECTION 506
CONCRETE OVERLAYS FOR PAVEMENTS

SECTION 506.10 BONDED CONCRETE OVERLAYS OF ASPHALT PAVEMENTS.

506.10.1 Description. This work shall consist of producing and placing a bonded concrete overlay on asphalt(BCOA) as shown on the plans or as directed by the engineer. The BCOA pavement shall be in accordance with Sec 502, except as modified herein. The BCOA pavement shall consist of a fiber reinforced concrete pavement placed over a prepared asphalt surface. Unless otherwise specified on the plans, the minimum BCOA pavement thickness shall be 4 inches. The prepared base asphalt shall have a minimum thickness of
3 inches.

506.10.2 Material. All material shall be in accordance with Division 1000, Material Details, unless otherwise noted.

506.10.2.1 Fibers. Fibrillated polypropylene fibers shall be added at a rate of 3.0 pounds per cubic yard. All fibers shall be measurable by weight. Fibers may be measured in bags, boxes or like containers with approval from the engineer. The containers shall be sealed by the fiber manufacturer, and shall have the weight contained therein clearly marked by the manufacturer. No fraction of container delivered unsealed or left over from previous work shall be used unless weighed. Fibers shall be added to the concrete mix and mixed according to the fiber manufacturer's recommendations.

506.10.2.2 Water-Reducers. An approved high range water-reducer admixture may be used. No re-dosing of high range water-reducing admixture will be permitted.

506.10.3 Mix Design.

506.10.3.1 Mix Approval. The contractor shall submit a mix design to Construction and Materials for approval in accordance with Sec 501. The mixture shall be designed to develop a minimum 28-day compressive strength of 4,600 psi. The maximum aggregate size shall be no more than one-third the thickness of the BCOA pavement.

506.10.3.2 Admixtures. Any admixtures used shall be certified by the fiber manufacturer for compatibility with the fibers used in the concrete.

506.10.3.3 Mix Adjustments. The contractor shall not make any mix design changes during placement of the BCOA pavement without prior approval from the engineer.

506.10.4 Construction Requirements. The QC/QA provisions of Sec 502 will not apply.

506.10.4.1 Surface Preparation. The existing bituminous surface shall be coldmilled in accordance with Sec 622.10 and as indicated elsewhere in the contract.

506.10.4.1.1 Prior to placing the BCOA pavement, the surface shall be thoroughly cleaned of all vegetation, dirt, mud and other objectionable material. All dust and loose particles shall be completely removed.

506.10.4.1.2 The asphalt surface temperature shall not exceed 90 F at the time of BCOA pavement placement. This may require night placement, water fogging or other suitable means of obtaining a cooler surface. At the time of placement of the BCOA pavement, there shall be no puddled water or other contamination to prevent bonding of the BCOA to the asphalt surface.

506.10.4.2 Placement.

506.10.4.2.1 Provided no loose, foreign material is tracked onto the surface, trucks used for transporting concrete may drive on the pavement being overlaid and concrete may be deposited directly in front of the concrete spreader.

506.10.4.2.2 The BCOA pavement shall be free of fiber balls when placed.

506.10.4.2.3 The concrete temperature shall not exceed 90 F when delivered to the site.

506.10.4.2.4 The BCOA pavement shall be placed in a uniform thickness on a final grade that has been established by other means, such as cold milling.

506.10.4.3 Surface Finish. The surface finish of the BCOA pavement shall be in accordance with Sec 502.

506.10.4.4 Joints. Sawing of the joints shall not cause excessive raveling. The joints shall be spaced equidistant longitudinally and transversely and at a distance approximately equal to twelve times the specified BCOA pavement thickness, with the following exceptions. Slight adjustments may be made in the joint spacing to equalize the longitudinal joints between pavement cast edges. All sawed BCOA pavement units shall be square, except as necessary in pavement width transitions. In such cases, slight field adjustments may be made to maintain relatively square units. Joint spacing for any adjustments shall not exceed one foot more than 12 times the specified BCOA pavement thickness. Transverse joints on adjoining lanes shall match. The minimum depth of the joints shall be one-third the BCOA and the width of the joint shall be 1/8 inch maximum. The joints shall not be sealed but shall be cleaned of all deleterious material after sawing. The engineer may require the contractor to replace BCOA pavement where cracking occurs due to late sawing at the contractor's expense.

506.10.4.5 Curing. Curing compound shall be applied at 1.5 times the normal application rate. If blankets are used for fast tracking, the blankets shall be light in color and shall not take the place of a curing compound. The temperature under the blanket shall not exceed 160 F. Blankets shall not be removed until the temperature under the blanket is within 40 F of the ambient temperature.

506.10.4.6 Opening to Traffic. BCOA pavement shall not be opened to all types of traffic until the concrete has attained a minimum compressive strength of 3,500 psi. Compressive strength will be determined by tests conducted in accordance with MoDOT Test Methods.

506.10.5 Method of Measurement.

506.10.5.1 Material Furnished. Measurement for furnishing BCOA concrete will be made to the nearest 0.1 cubic yard for material incorporated into the BCOA pavement.

506.10.5.2 Material Placed. Measurement for placing BCOA pavement will be computed to the nearest 0.1 square yard.

506.10.5.3 Pavement Thickness Determination. The thickness of the BCOA pavement will be determined by the average caliper measurement of cores in accordance with AASHTO T 148.

506.10.5.3.1 For the purpose of determining the constructed thickness of the pavement, cores will be taken at random intervals in each traffic lane at the rate of one core per 1,000 feet, or increment thereof. In addition, cores will be taken at all locations where thickness measurements taken during construction indicate a thickness deficiency sufficient to justify a deduction from the contract unit price or at any other locations as may be determined by the engineer. If the measurement of any core is deficient in excess of 3/10 inch from the plan thickness, additional cores will be taken at 30-foot intervals parallel to the centerline ahead and behind the affected location until the extent of the deficiency has been determined.

506.10.5.3.2 Each core will represent the pavement thickness for a distance extending one-half the distance to the next core, measured along the centerline. In the case of a beginning or ending core, the distance shall extend to the end of the pavement section.

506.10.5.4 Pavement Strength Determination. The strength of the BCOA concrete will be determined by testing cylinders in accordance with AASHTO T 22. Cylinders will be tested at the rate of one per 500 cubic yards, or increment thereof. Any 28-day cylinder strength below 4,000 psi is unacceptable.

506.10.5. 5 Final Measurement. Final measurement of the complete UTW pavement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

506.10.5. 6 Quantity of Cold milling. Measurement for cold milling bituminous pavement for removal of surface will be made in accordance with Sec 622.10.4.

506.10.6 Basis of Payment.

506.10.6.1 Material Furnished. The plan quantity for the furnishing of BCOA concrete will be paid for at the contract unit price for BCOA concrete, per cubic yard. Reimbursement for any additional concrete incorporated into the BCOA pavement will be in accordance with Sec 109.5.3 and shall not exceed the unit contract price.

506.10.6.2 Material Placed. The plan quantity for the placement of BCOA pavement will be paid for at the contract unit price for BCOA pavement, per square yard. No direct payment will be made for surface preparation following cold milling of the bituminous surface, or furnishing labor, equipment, reinforcement and other materials to place, finish, texture cure, and saw the joints in the BCOA pavement.

506.10.6.3 Pavement Thickness. Pavement thickness determination will be made after all smoothness correction has been completed. If any core measurement of thickness is deficient, the contractor may remove and replace the pavement at the contractor's expense or leave the pavement in place, and receive the following deductions in payment:

Deficiency in Thickness	Deductions, Percent of Contract Unit Price
0 to 3/10 inch	None
Over 3/10 inch	100

506.10.6.3.1 The above deductions will be applied to a section of pavement 30 feet long and will include the entire paved width for a specific pass. Deductions for deficient thickness or damaged pavement may be entered on any estimate after the information becomes available.

506.10.6.3.2 Any pavement that is replaced shall be of a satisfactory quality and thickness that, when accepted by the engineer, will be included in the pay quantity. No payment will be made for any costs incurred in the removal of the deficient pavement.

506.10.6.3.3 Removal of pavement shall be from the edge to a longitudinal joint or between longitudinal joints and on each side of the deficient measurement until no portion of the exposed cross sections is more than 3/10 inch deficient, except that there shall be no less than 15 linear feet of pavement removed. If there remains less than 15 feet of acceptable pavement between the section that has been removed and a transverse contraction, expansion or construction joint, the contractor shall remove the pavement to the joint, at the contractor's expense.

506.10.6.4 Adjustments. Any adjustments in payment as a result of the profilograph index or pavement thickness deficiency of the BCOA pavement will be made to the unit contract prices for furnishing BCOA concrete, per cubic yard and placing BCOA pavement, per square yard. For this purpose, the volume of BCOA pavement placed per cubic yard price will be adjusted to a square yard price based on the plan BCOA pavement thickness.

506.10.6.5 Cold Milling. Payment for cold milling bituminous pavement for removal of surface will be made in accordance with Sec 622.10.5.

SECTION 506.20 UNBONDED CONCRETE OVERLAYS OF CONCRETE PAVEMENTS.

506.20.1 Description. This work shall consist of placing an interlayer material on an existing concrete pavement and constructing an unbonded concrete overlay in accordance with the details and locations shown on the plans. The standard unbounded concrete overlay design thickness is either 8 or 5 inches. The eight-inch overlays are constructed similarly to new concrete pavement in terms of joint spacing and use of dowel bars and tie bars. The five-inch overlays are sawed into smaller panels and require no steel. The overlay shall be placed in accordance with Sec 502, except as herein stated.

506.20.2 Material. All material shall be in accordance with Division 1000, Material Details, unless specified otherwise.

506.20.2.1 Patching Material. Patching material for use in repair of surface defects prior to the overlay shall consist of bituminous material, cementitious material, or other equivalent material meeting the approval of the

engineer.

506.20.2.2 Interlayer. The interlayer material shall be a minimum one-inch thick new bituminous or a geotextile fabric in accordance with Section 1011.3.7.

506.20.2.3 Concrete. All procedures and material for the unbonded overlay shall be in accordance with Sec 502, including QC/QA and PWL provisions for non-reinforced concrete pavement, except the strength pay factor will account for 100 percent of the total pay factor. The pay factor for thickness will not apply.

506.20.2.4 Dowel Bars. Dowel bars shall be in accordance with Sec 1057.1 and of the size shown on the plans.

506.20.3 Construction Requirements.

506.20.3.1 Handling Traffic. Preliminary work, including joint sealing and patching, may be done under traffic as permitted elsewhere in the contract. Prior to placement of the debonding material, the traffic shall be diverted as shown on the plans, and the remaining operations shall commence.

506.20.3.2 Surface Preparation. All holes greater than 2 inches wide and one inch deep in the surface of the traffic lanes, excluding shoulders, shall be filled with patching material and shall be compacted to a flat, tight surface.

506.20.3.3 Expansion Joints. Any transverse expansion joints in the existing pavement shall be specifically marked and identified as such.

506.20.3.4 Interlayer Placement.

506.20.3.4.1 Bituminous Interlayer. The surface temperature of a bituminous interlayer shall not exceed 90 degrees F prior to the overlay placement. The temperature may be controlled with any means approved by the Engineer, including, but not limited to white curing compound and water misting.

506.20.3.4.2 Geotextile Interlayer. Geotextile interlayer placement shall comply with the following requirements:

506.20.3.4.2.1 Fabric shall be tight without excess wrinkles and folds.

506.20.3.4.2.2 Fabric shall be pinned to underlying layer with bolts/nails punched through galvanized washers/discs every 6 ft.

506.20.3.4.2.3 Where it occurs, fabric shall overlap by 8 ± 2 in.

506.20.3.4.2.4 Fabric shall be damp, but not saturated, prior to concrete placement.

506.20.3.4.2.5 The surface temperature of the fabric shall not exceed 90 degrees F prior to the overlay placement.

506.20.3.4.2.6 Fabric shall extend throughout the travelway and overlap onto the shoulder by at least 18 inches.

506.20.3.5 Surace Cleaning. Before the unbonded concrete overlay is placed, the interlayer surface shall be free of loose material.

506.20.3.6 Dowel Bars. Dowel bars for eight-inch unbounded overlays shall be installed the full width of the unbonded overlay and the baskets, if used, shall be firmly anchored to the interlayer surface.

506.20.3.7 Tie Bars. Tie bars shall be installed between lanes in an eight-inch unbounded concrete overlay.

506.20.3.8 Concrete Temperature. The concrete temperature shall not exceed 90 F when delivered to the site.

506.20.3.9 Placing Concrete. Provided no loose foreign material is tracked onto the surface, trucks used for transporting concrete may drive on the pavement being overlaid and concrete may be deposited directly in front of the concrete spreader.

506.20.3.10 Joints.

506.20.3.10.1 Any expansion joints shall be precut in the plastic concrete to allow for slab movement prior to sawing. As soon as sawing is possible, the contractor shall saw two full-depth cuts on each side of the precut joint following the edges of the underlying expansion joint, as marked out, and the concrete between the saw joints shall be removed.

506.20.3.10.2 Sawing of the contraction joints shall not cause excessive raveling. Standard joint spacing for a five-inch unbounded concrete overlay is 6 feet transversely and longitudinally. Standard joint spacing for an eight-inch unbounded overlay is 15 ft transversely and 12 ft across the full lane width. New transverse joints will not be required to match existing transverse joints. The minimum depth of the sawed joints shall be one-third the pavement thicknesss and the width of the joint shall be 1/8-inch maximum. The joints shall not be sealed, unless open more than ¼ inch, but shall be cleaned of all deleterious material after sawing. Concrete panels with cracking outside of the sawed joints shall be considered unacceptable.

506.20.3.11 Opening Strength. The unbounded concrete overlay may be opened for light-weight traffic when the concrete has attained a minimum compressive strength of 2,500 psi. The concrete pavement shall not be opened to all types of traffic until the concrete has attained a minimum compressive strength of 3,000 psi. Compressive strength for opening to traffic shall be determined either by compressive strength tests in accordance with AASHTO T 22 or the maturity method in accordance with Sec 507.

506.20.3.12 Acceptance Testing Procedures and Reporting. All testing and reporting procedures for the unbonded concrete overlay shall be in accordance with Sec 502.10, including QC/QA and PWL provisions for concrete pavement, except the following shall apply:

506.20.3.12.1 Minimum Thickness. Pavement thickness determination will be made after all smoothness correction has been completed. The minimum concrete overlay thickness shall be the design thickness less 10 percent. Any core less than the minimum thickness is unacceptable. Additional cores will be taken at 30-foot intervals parallel to the centerline ahead and behind the affected locations until the extent of the deficiency has been determined.

506. 20.3.12.2 Compressive Strength. After the thickness is determined, the cores shall be tested for compressive strength in accordance with AASHTO T 22. The length-to-diameter (L/D) ratio of the core shall be measured and recorded to the nearest 0.01 inch, and the L/D ratio shall be between 1.00 and 2.00. If the L/D ratio of the drilled core is 1.75 or less, the compressive strength shall be corrected by multiplying the appropriate correction factor shown in the following table:

L/D	1.75	1.5	1.25	1.00
Correction Factor	0.98	0.96	0.93	0.87

Use interpolation to determine correction for L/D values between those given in the table.

506.20.3.12.3 Pay Factor. The Pay Factor for Compressive Strength (PF_{CS}) will account for 100 percent of the total pay factor. The total pay factor (PF_t) for each lot shall be determined as follows:

$(PF_t) = (1.0)\ PF_{CS}$; where the pay factor for thickness does not apply.

The PF for each pay factor item for each lot is based on the PWL_t of each pay factor item of each lot and is determined as follows:

When PWL_t is greater than or equal to 70: $PF = 0.5\ PWL_t + 55.0$
When PWL_t is less than 70: $PF = 2\ PWL_t - 50$.

506.20.4 Method of Measurement.

506.20.4.1 Furnishing Concrete. Measurement for furnishing unbonded overlay concrete will be to the nearest 0.1 cubic yard. The cubic yard quantity will be calculated in one of the two ways explained in Secs 506.20.4.1.1

and 506.20.4.1.2. Thickness, profile, and smoothness requirements shall not be waived for either method of measurement, unless stated so in the plans or agreed to by the engineer.

506.20.4.1.1 Field Established Profile. The contractor shall establish the roadway profile prior to the overlay. The profile shall be submitted to the engineer and include edge of pavement and centerline elevations at 50-foot intervals in tangent sections and 25-foot intervals in curve sections. The engineer will determine the final profile within 7 calendar days of receipt. The engineer will determine the required number of cubic yards of concrete from this profile. This quantity will be the field established plan quantity.

506.20.4.1.2 Existing Profile. The contractor shall use the plan quantity shown in the contract documents. The contractor shall construct the overlay to match the profile of the existing roadway. The contractor may utilize traveling grade control to place the overlay.

506.20.4.2 Placing Unbonded Concrete Overlay. Measurement for placing unbonded overlay concrete will be computed to the nearest 0.1 square yard. Final measurement of the completed pavement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

506.20.4.3 Interlayer. Measurement for the interlayer will be made to the nearest square yard.

506.20.5 Basis of Payment.

506.20.5.1 Furnishing Concrete. The accepted volume of concrete for the unbonded concrete overlay will be paid for at the contract unit price for furnishing concrete, per cubic yard.

506.20.5.2 Placing Unbonded Concrete Overlay. Placement of the unbonded concrete overlay will be paid for at the contract unit price for placing unbonded concrete overlay per square yard. No direct payment will be made for furnishing labor, equipment, dowels, tie bars and other materials to place, finish, texture and cure the overlay including sawing and sealing, if necessary, the joints, in accordance with the plans and specifications.

506.20.5.3 Payment Adjustments. Any adjustments in payment as a result of the profilograph index or pavement thickness deficiency of the unbonded concrete overlay will be made to the contract unit price for furnishing concrete and placing unbonded concrete overlay each, for the segments involved. Adjustment in payment for QC/QA concrete strength pay factors will be made to the contract unit price for furnishing concrete and placing unbonded concrete overlay, each, for the segments involved. For all adjustments, the furnishing concrete per cubic yard price will be adjusted to a square yard price based on the plan overlay thickness.

506.20.5.4 Interlayer. Payment for the interlayer will be paid for at the contract unit price per square yard.

506.20.5.5 Repairs. Payment for full depth and partial depth repairs shall be in accordance with Sec 613.

506.20.5.6 Surveying and Staking. Payment for contractor surveying and staking will be in accordance with Sec 105.

SECTION 506.30 UNBONDED CONCRETE OVERLAYS ON ASPHALT PAVEMENTS.

506.30.1 Description. This work shall consist of constructing an unbonded concrete overlay on an existing asphalt surface in accordance with the details and locations shown on the plans. All work shall be performed in accordance with Section 506.20, except that an interlayer shall not be used.

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SECTION 507
STRENGTH OF CONCRETE USING THE MATURITY METHOD

507.1 Description. This specification covers the maturity method as a non-destructive means of determining in-place concrete strength for pavement or structural applications. The concept of the maturity method is based on the combined effects of concrete age and temperature, during hydration, on the rate of strength gain for a specific concrete mix. This method requires the establishment of a relationship between compressive strength and calculated maturity indices for a specific concrete mixture prior to placement of the mixture in the field. The contractor may use the maturity method in accordance with this specification to estimate the compressive strength of the in-place concrete.

507.2 Procedure. In-place concrete strength determined by the maturity method shall be in accordance with ASTM C 1074, except as noted herein.

507.2.1 Maturity Meter. The maturity meter shall have a secure means of collecting data that is unalterable.

507.2.2 Maturity Function Values. In lieu of determining values for datum temperature, To, or activation energy divided by the gas constant, Q, values of 14° F or 5,000 Kelvin may be used, respectively.

507.2.3 Standardization. The calibration of systems used for monitoring the maturity of concrete shall be verified every seven working days in accordance with AASHTO T 325, Sec 9.1 and ASTM C 1074, Sec 7.1.

507.2.4 Development of the Strength-Maturity Relationship. The contractor shall develop the strength-maturity relationship prior to placing any concrete on the project, and shall notify the engineer prior to development of the maturity curve. The development of the
strength-maturity relationship shall be done in the field using project equipment and materials.

507.2.4.1 Preparing Test Specimens. When the strength-maturity relationship is developed, compressive strength specimens shall be fabricated, cured and tested at the plant site and fabricated from a minimum 3 cubic yard batch of concrete. Temperature of the fresh concrete shall be measured and recorded. All field specimens shall be fabricated and cured in accordance with AASHTO T 23, with the following exceptions. Specimens shall be cured for the first 24 hours under similar or like temperature conditions anticipated during construction, and specimens, including the cylinder used to monitor temperature, shall be de-molded at approximately 24 hours and cured in accordance with AASHTO T 23. The concrete mixture shall meet the specification requirements in order to determine the strength-maturity relationship. The concrete mixture shall be at or above the target air content established by the contractor.

507.2.4.2 Required Documentation. The contractor shall provide the engineer with the following information prior to placing any concrete on the project:

(a) The project number, route, county, concrete job mix number and date of testing.

(b) The air, slump and water content from the batch of concrete tested.

(c) The amount and type of admixture(s) used in the concrete mix.

(d) The strength of each test specimen, and the average strength of test specimens at each test age.

(e) Maturity index for each instrumented test specimen, and the average maturity index for the instrumented specimens at each test age.

(f) A graph of the average compressive strength versus the average value of the maturity index, as described in the strength-maturity relationship section of ASTM C 1074.

507.2.5 Compressive Strength Testing. At a minimum, compressive strength tests shall be performed on three specimens, and the average strength computed at 1, 3, 7, 14 and 28 days. Production may start after the seven-day compressive strengths have been determined with approval from the engineer.

507.2.6 Placement of Temperature Sensors. For pavement and pavement repairs, temperature sensors shall be embedded at approximately mid-depth and 18 inches from the edge of pavement. For other applications,

temperature sensors shall be embedded in locations considered critical in terms of exposure conditions and structural requirements. Temperature sensors shall be placed at the following frequency:

Structure Component	Frequency
Pavement	1 sensor per 3750 sq. yd., with a minimum of one in the last 50 feet of pavement
Pavement Repairs	1 sensor per 10 patches, with a minimum of one sensor in the last patch
Structural	A minimum of one sensor at the end of the pour, with three others sensors available to be placed as directed by the engineer

507.3 Proportioning, Mixing, Placing and Curing Field Placed Concrete. The maturity method does not account for variations in strength due to proportioning, mixing, placing and curing of concrete. Proper methods shall be followed at all times during proportioning, mixing, placing and curing the field placed concrete.

507.3.1 Field Placed Concrete Mix Requirements. Mix constituents of the field placed concrete shall not change, and mix proportions of the field placed concrete shall not vary more than 5.0 percent from the concrete mix used to develop the strength-maturity relationship. The water cement ratio shall not vary by more than 0.02.

507.3.2 Requiring Immediate Validation of Strength-Maturity Relationship. If the mix constituents a change more than 5.0 percent, the water cement ratio changes more than 0.02, the material sources change or the mixing operation changes, an immediate validation of the strength-maturity curve shall be done in accordance with Sec 507.4.

507.4 Validation of Strength-Maturity Relationship. At a minimum, every seventh day of concrete placement a validation test shall be conducted to verify that in-place concrete strength is accurately represented by the strength maturity relationship. The engineer shall be notified at least one business day in advance of when and where the validation test will be done.

507.4.1 Documentation for Validation. The contractor shall document the air, slump, and water content from the batch of concrete tested and any deviations from the original job mix.

507.4.2 Specimens for Validation. During placement of the field placed concrete, a minimum of four compressive strength cylinders shall be fabricated and cured as specified in Sec 507.2.4.1.

507.4.3 Sensor Location for Validation. A temperature sensor shall be embedded to within 1/2 inch of the center of one cylinder for computing the maturity index from the measured temperature history as specified in Sec 507.2.

507.4.4 Test Specimens for Validation. Once the maturity index, according to the temperature monitored cylinder, is achieved which corresponds to the maturity index desired for the first critical action such as opening pavement to traffic or removing formwork, three cylinders shall be tested for compressive strength.

507.4.5 Strength-Maturity Relationship Validated. The average compressive strength of the three cylinders shall be compared to the compressive strength as determined by the strength-maturity relationship. If the predicted strength is within 10 percent or 200 psi, whichever is less, of the actual compressive strength, then the strength-maturity relationship will be considered validated.

507.4.6 Strength-Maturity Relationship Acceptable. If the actual compressive strength is more than 10 percent or 200 psi above the compressive strength as determined by the strength-maturity relationship, then a new strength-maturity relationship may be developed.

507.4.7 Strength-Maturity Relationship Not Validated. If the actual compressive strength is more than 10 percent or 200 psi, whichever is less, below the compressive strength as determined by the strength-maturity relationship, the contractor shall make cylinders to determine compressive strengths until a new strength-maturity relationship has been developed.

507.5 Field Documentation. The contractor shall provide the engineer with the following information prior to taking any field action based on the strength-maturity strengths:

(a) Project number, route, county, and date tested.

(b) A list of each concrete lot evaluated.

(c) Station numbers.

(d) Quantity of concrete.

(e) Maturity index determined for each sensor location.

(f) Estimated strength determined for each sensor location.

507.5.1 Calibration and Verification Records. The contractor shall record all test results for equipment calibration and verification, and shall maintain all results in an organized format.

507.5.2 Availability of Test Results. Test results shall be available to the engineer at all times.

507.6 Basis of Payment. No additional payment will be made for compliance with this specification.

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SECTION 601
FIELD LABORATORIES

601.1 Description. This work shall consist of providing one or more laboratories at the site of work and at locations designated by the engineer.

601.2 Laboratory Requirements. A laboratory shall be furnished for each item of work that is specified in the contract as requiring such a unit. Separate laboratories will not be required for successive items of work when any preceding item has been completed, provided that the laboratory complies with the requirements for specific work. Additional laboratories may be required for the proper control of the work when simultaneous operations on the same item of work are being carried on at more than one location separated by a distance of one mile or more and separate testing operations are necessary. The engineer will specify the number of laboratories required based on the operations of the contractor.

601.2.1 The laboratory shall be located and maintained at the site of current operations by the contractor. Work that requires the use of a field laboratory will not be permitted until a laboratory is provided. The laboratory shall remain the property of the contractor, and shall be disposed of by the contractor upon completion of the work requiring the laboratory.

601.2.2 Laboratory Approval. Laboratory verification and approval shall be required for laboratories performing acceptance tests for related work and shall be performed by the engineer annually; not to exceed 18 months.

601.2.2.1 Equipment Verification Samples. Equipment Verification Samples are required to verify equipment where QC and QA are performing acceptance test(s) on the same equipment Frequency of Equipment Verification Samples for permanent laboratories shall be required once per laboratory per quarter. Frequency of Equipment Verification Samples for mobile labs shall be required after setup and continued at once per quarter. Testing of samples shall be on independent equipment meeting the requirements as outlined in Sec 403.17.3.1. Test equipment that requires a correction factor is exempt.

601.2.3 Regardless of the number of field laboratories specified on the plans, the number may be increased, decreased or completely underrun at the discretion of the engineer.

601.3 Type 1 Field Laboratory. The Type 1 field laboratory shall be substantially constructed and weatherproof with wood or concrete floors, windows on at least two sides and at least one outside door. Windows and doors shall be equipped with screens and locks, and the necessary keys shall be furnished to the engineer. The laboratory shall have a minimum of 120 square feet of floor space. The ceiling shall be no less than 7 feet high. The laboratory shall have at least one worktable 30 inches high, with a smooth one-piece top, no less than 8 feet long and 30 inches wide. The laboratory shall be equipped with a storage shelf, a fire extinguisher, a desk and a chair. An operational electric hot plate or gas burner, having no less than two burners with adjustable temperature controls and capability of accommodating two 14 x 20-inch sample pans, shall be provided. A faucet-equipped sink capable of accommodating a 14 x 20-inch sample pan and connected to an operating water source of at least a 50-gallon capacity shall be provided. The contractor shall keep an adequate supply of potable water available at all times. Lighting facilities shall be located to adequately illuminate all work in the interior of the laboratory. When required by the engineer, grounded electrical outlets with 110 to 120 volts, 60-Hertz continuous current and a climate control capable of maintaining an ambient temperature range of 72 to 80 F shall be provided. Laboratories shall be relocated on the project as directed by the engineer.

601.4 Type 2 Field Laboratory. The laboratory shall be in accordance with Sec 601.3, except as follows. The laboratory shall have a minimum of 200 square feet of floor space. The laboratory shall be constructed with a dividing wall and doorway to allow for a separate testing work area and an office area suitable for computer operation meeting the engineer's approval. Telephone service shall be provided. The laboratory shall be provided with an exhaust fan capable of moving a volume of air equal to at least ten times the volume of the laboratory each hour. Grounded electrical outlets with 110 to 120 volts, 60-Hertz continuous current and a climate control capable of maintaining an ambient temperature range of 72 to 80 F shall be provided. When a field laboratory is provided in accordance with Sec 502, at least one window shall provide a direct view of plant operations.

601.5 Type 3 Field Laboratory. The laboratory shall be in accordance with Sec 601.4, except as follows. At least one window shall provide a direct view of plant operations. A locked storage area for nuclear equipment

shall be provided that is at least 15 feet from the normal work areas. A steel box shall be provided in the storage area with locks for the purpose of storing nuclear equipment in accordance with Nuclear Regulatory Commission specifications.

601.5.1 In accordance with Sec 401 or 402, a thermostatically controlled operating oven, capable of maintaining a minimum temperature of 375 F and having a capacity to accommodate at least one standard gallon can, shall be furnished. The laboratory shall have a minimum of 300 square feet of floor space. The laboratory shall contain a sieve shaker in accordance with AASHTO T 27, including time controls, a minimum sieve stacking height of 28 inches, platform adapters to accommodate 8 or 10-inch sieves, and a sample splitter meeting AASHTO T 248 requirements, having a minimum length of 20 inches with a 2-inch maximum opening size, complete with a minimum of three pans.

601.5.2 When a field laboratory is provided in accordance with Sec 403, the laboratory shall have a minimum of two outside doors and four windows. The outside doors shall be located such that ingress and egress is permitted from opposite ends of the building. Each window shall provide at least 4 square feet of glazed area. The laboratory shall have a minimum of 320 square feet of floor space, with a minimum width of 8 feet. An exhaust fan shall be provided that is capable of moving a volume of air each hour equal to at least ten times the volume of the laboratory. Anchored tables of adequate dimensions shall be furnished. All tables shall have smooth, one-piece tops. The laboratory shall be equipped with storage shelves, a minimum of four chairs, a two-drawer filing cabinet and the bituminous mixture equipment described in Sec 403.6. Circuitry shall be such that all indicated equipment can be used without disruption. The contractor may provide a facsimile machine with a private line, at the contractor's expense, to provide faster communications when mix adjustments are needed.

601.6 Basis of Payment. Unless otherwise specified, no direct payment will be made for Type 1 or Type 3 Field Laboratories. When provided in accordance with Sec 203, authorized Type 2 Field Laboratories, complete in place, will be paid for at the contract unit price. No direct payment will be made for relocation of Type 2 Field Laboratories. No direct payment will be made for furnishings, maintenance, utilities, heating and cooling facilities, including operation and fuel, and final removal of the laboratory.

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SECTION 602
MARKERS

602.1 Description. This work shall consist of constructing drain markers or steel right of way markers as specified in the contract documents, at the locations shown on the plans or as directed by the engineer.

602.2 Material.

602.2.1 All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Steel Post for Markers	1044

602.2.2 Right of way and drain marker plaques and fasteners will be furnished at the job site at no cost to the contractor.

602.3 Construction Requirements. Steel markers shall be set with the legend facing the centerline of the highway. Posts shall be set vertically and the plaques firmly attached. Posts shall be driven in accordance with Sec 903. Posts having battered or mushroomed tops will not be accepted.

602.4 Method of Measurement. Measurement of drain markers and right of way markers will be made per each.

602.5 Basis of Payment. The accepted quantity of markers will be paid for at the contract unit price.

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SECTION 603
WATER LINE INSTALLATION

603.1 Description. This work shall consist of furnishing material for, and installing water lines and appurtenances as shown on the plans or as directed by the engineer.

603.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section/Specification
Concrete	501
Reinforcing Steel for Concrete	1036
Ductile Iron Pipe, 3 to 48 inch diameters	AWWA C151
Polyethylene (PE) Pipe and Tubing, 1.2 to 3 inch diameter	AWWA C901
Polyethylene (PE) Pipe and Fittings, 4 to 63 inch diameter	AWWA C906
Polyvinyl Chloride (PVC) Pipe and Fabricated Fittings, 4 to 12 inch diameter	AWWA C900
Polyvinyl Chloride (PVC) Pipe and Fabricated Fittings, 14 to 48 inch diameter	AWWA C905
Ductile Iron and Gray-Iron Fittings	AWWA C110
Rubber Gasket Joints	AWWA C111
Cement Mortar Lining	AWWA C104
Gate Valves	AWWA C500
Rubber-Seated Butterfly Valves	AWWA C504
Dry-Barrel Fire Hydrants	AWWA C502
Seamless Copper Water Tube	ASTM B 88, Type K (ASTM B 88 M, Type A)

603.2.1 Service Connections. Service connections shall be completed in accordance with AWWA, ANSI, ASTM or the local utility code, as applicable.

603.2.2 Material Acceptance. The contractor shall furnish one copy of each manufacturers' certification that all specified tests have been conducted and that the material and fittings are in accordance with these specifications.

603.3 Construction Requirements. Service shall not be interrupted without approval from the engineer and the proper utility official. The contractor shall arrange the work to minimize service interruptions. Prior notice of at least 24 hours shall be given to the proper utility official and the engineer before any main is shut off. In no case shall a valve or hydrant be opened or shut without proper authorization.

603.3.1 Construction and Installation. Construction and installation shall be in accordance with AWWA, ANSI, ASTM, or local utility code, as applicable.

603.3.2 Inspection and Acceptance. Inspection and acceptance of the completed installation, prior to backfilling, shall be the responsibility of the utility owner.

603.3.3 Appurtenance Installation. Appurtenances shall be located as shown on the plans or as directed by the engineer.

603.3.4 Abandoned Water Mains. Abandoned water mains shall be plugged and sealed watertight by means of a ductile iron plug or cap, or by covering the end of the pipe with concrete of any mixture specified in Sec 501. The concrete cover shall provide a minimum of 6 inches cover around the outside of the pipe and shall extend a minimum of 6 inches in each direction from the end of the pipe. All existing valves that will have pressure on one side and an abandoned main on the other side shall be closed with a ductile iron plug and blocked with reaction backing on the side where the main has been abandoned. A portion of the abandoned pipe shall be removed to allow clearance for plugging and backing.

603.3.5 Encasement. Encasement, if required, shall be as specified in the contract.

603.3.6 Backfilling. Material placed around and 12 inches above the top of the pipe shall be free of cinders,

ashes, refuse, boulders, rocks or other unsuitable material. The remainder of the trench shall be backfilled in accordance with Sec 726.

603.3.7 Disinfection. The completed water line installation shall be disinfected in accordance with the provisions of MDNR.

603.4 Method of Measurement.

603.4.1 Pipe. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, measurement of pipe, complete in place, including joint accessories, fittings and service connections greater than 2 inches inside diameter, will be made to the nearest linear foot along the geometrical center of the pipe with no exceptions for valves or fittings. The revision or correction will be computed and added to or deducted from the contract quantity.

603.4.2 Rock. Rock encountered in trenching and classified as Class 3 Excavation in Rock in accordance with Sec 203 will be measured to the nearest cubic yard. Measurement of yardage to be paid for as Class 3 Excavation in Rock will be a width 18 inches greater than the inside diameter of the pipe and a depth from the surface of the rock as determined by the engineer to a plane 6 inches below the outside bottom of the pipe or to the bottom of the rock, whichever is higher. Any Class 3 Excavation in Rock performed prior to the establishment of the lines of demarcation and notification to the engineer will not be measured or paid for.

603.4.3 Service Connections. Measurement of relocating service connections, 2 inches inside diameter or less, will be made per each.

603.4.4 Encasement. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, measurement of encasement conduit will be made to the nearest linear foot along the geometrical center of the conduit. Contract quantities will be used for final payment except as hereinafter provided. Measurement of reinforced concrete encasement, including reinforcing steel, will be made to the nearest 1/10 cubic yard. The revision or correction will be computed and added to or deducted from the contract quantity.

603.5 Basis of Payment. Accepted water line will be paid for at the contract unit price for each of the pay items included in the contract. No direct payment will be made for excavation or backfill except in accordance with Secs 206.6.3.3 and 603.4.2. No direct payment will be made for fittings regardless of the type of fittings used. Accessories required for fittings will be considered part of the fitting. In relocating service connections 2 inches inside diameter or less, no direct payment will be made for the pipe or fittings. No direct payment will be made for incidental construction items including, but not limited to, reaction backing, plugging and sealing of abandoned water mains, and for disinfecting of water lines.

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SECTION 604
MISCELLANEOUS DRAINAGE

SECTION 604.10 CONCRETE HEADWALLS, DROP INLETS AND MANHOLES.

604.10.1 Description. This work shall consist of constructing concrete headwalls, drop inlets and manholes in accordance with these specifications, as shown on the plans or as directed by the engineer.

604.10.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Precast Drainage Units	1033
Reinforcing Steel for Concrete	1036

604.10.2.1 All concrete, except that portion placed monolithic with paved surfaces, shall be Class B. Concrete for inverts shall be either Class B or concrete of a commercial mixture in accordance with Sec 501. Material, proportioning, mixing, slump and transporting shall be in accordance with Sec 501. Concrete shall be placed, finished and cured in accordance with Sec 703.

604.10.2.2 Steps for concrete manholes and drop inlets may be cast iron, aluminum alloy or polypropylene plastic coated reinforcing steel. The portion of the step to be embedded in the concrete shall have a configuration that will prevent any pullout. These steps shall withstand a single concentrated load of 300 pounds without distortion on that portion protruding from the wall. The minimum width of rungs or cleats shall be 10 inches and shall be shaped to prevent the foot from slipping off the side. The step shall project a minimum distance of 4 inches from the wall of the riser or cone section measured from the point of embedment. The steps shall be embedded a minimum distance of 3 inches and shall be spaced vertically at a maximum distance of 16 inches.

604.10.2.3 Steps for drop inlets may be steel step bars as shown on the plans or steps meeting the above requirements.

604.10.3 Construction Requirements.

604.10.3.1 All pipe built into the walls of the structure shall fit flush with the inside face of the wall. A joint, consisting of one layer of commercially available 55 pound smooth roll roofing, a heavy coat of bituminous material or other appropriate bond breaker, shall be placed around that portion of the pipe extending into the walls of the structure. Steps shall clear all pipes and shall be built in the wall as designated by the engineer. Reinforcement of these structures shall be in accordance with Sec 706, and the excavation shall be in accordance with Sec 206.

604.10.3.2 Steps for concrete manholes and drop inlets shall be embedded by casting in place, mortaring or by friction fit. Steps cast in place shall be set through the forms and secured against displacement before concrete is placed. The cavity receptacle for steps placed by friction fit shall be formed by casting in place a removable mold recommended for use by the manufacturer of the step.

604.10.3.3 New manholes for existing sewers shall be constructed as shown on the plans. Cutting the existing sewer will be required to provide inlet and outlet connections to the new structure, and a bypass line shall be provided around construction at all locations where continuous sewer service will be required. Any portion of an existing sewer that is damaged in constructing the new manhole shall be repaired or replaced at the contractor's expense with new material of a type matching the old.

604.10.4 Basis of Payment.

604.10.4.1 The accepted quantity of concrete headwalls, drop inlets and manholes will be paid for in the following manner:

(a) Class B concrete will be measured and paid for in accordance with Sec 703 for miscellaneous concrete.

(b) Reinforcing steel will be measured and paid for in accordance with Sec 706.

(c) Excavation will be measured and paid for in accordance with Sec 206.

604.10.4.2 No direct payment will be made for:

(a) Maintaining service or for cutting the existing sewer.

(b) Weep holes, including excavation, permeable granular backfill, 4-inch drain tile, screen for inlet or any other work incidental thereto.

(c) Manhole steps.

SECTION 604.20 ADJUSTING DRAINAGE FACILITIES.

604.20.1 Description. This work shall consist of adjusting manholes, catch basins, inlets and similar items as shown on the plans. Existing frames and covers shall be salvaged and reused if specified in the contract. New manhole steps shall be provided as necessary. New manhole adjusting rings (adapters) shall be provided if specified in the contract.

604.20.2 Basis of Payment. The accepted adjustments of manholes, catch basins and inlets will be paid for at the contract unit price for each of the pay items included in the contract. No direct payment will be made for steps or adjusting rings.

SECTION 604.30 ADJUSTING HOUSE SEWER CONNECTIONS.

604.30.1 Description. This work shall consist of laying or relaying sanitary sewer house connections that are to be relocated or that are to be reconnected to new sewers or temporarily removed to permit the installation of other items in the contract.

604.30.2 Material. The size and class of pipe to be used shall be in accordance with the local authority having jurisdiction over the installation of sewer connections. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Vitrified Clay Sewer and Culvert Pipe	1030
Plastic Joint Compound for Pipe	1057.8
Mortar for Pipe Joints	1066

604.30.3 Construction Requirements. Excavation for the laying of pipe and for backfilling the trench shall be in accordance with Sec 726. The adjustment shall be made to the line and grade shown on the plans or as directed by the engineer. Where a house sewer connection is relocated or relaid above a water main, Class B concrete or concrete of a commercial mixture in accordance with Sec 501 shall be used to encase the sewer line a minimum thickness of 6 inches. The encasement shall extend to a point where the normal distance from the sewer to the water main is a minimum of 10 feet.

604.30.4 Method of Measurement. Measurement of adjusting house sewer connections will be made to the nearest linear foot along the geometrical center of the adjusted pipe.

604.30.5 Basis of Payment.

604.30.5.1 The accepted quantity of adjusted house sewer connections, complete in place, will be paid for at the contract unit price. Payment will be considered full compensation for all necessary pipe, tees, bends, wyes, the cutting of and joining new pipe to old pipe or structure, excavation, backfill, traps, fittings and items incidental thereto.

604.30.5.2 Payment for encasement, complete in place, will be paid for at the contract unit price.

SECTION 604.40 PIPE COLLARS.

604.40.1 Description. This work shall consist of metal or concrete collars constructed around a pipe joint as shown on the plans or as directed by the engineer.

604.40.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Corrugated Metallic-Coated Steel Culvert Pipe, Pipe-Arches and End Sections	1020
Reinforcing Steel for Concrete	1036

604.40.2.1 Metal pipe for pipe collars shall be of the same thickness and shall have the same corrugation dimensions as the corrugated metal pipe to be connected.

604.40.2.2 Concrete used for collars shall be Class B or concrete of a commercial mixture in accordance with Sec 501.

604.40.3 Construction Requirements.

604.40.3.1 Pipe collars shall be provided for the following purposes:

(a) Extending existing pipes where the pipe required for the extension will not form a normal joint with the pipe in place.

(b) Connecting two different sizes of pipe

(c) Connecting two pipes of different material.

604.40.3.2 If the pipe collar design is not applicable to the type of pipe being extended, the pipe collar shall be modified to ensure a joint connection that will fit the pipe.

604.40.4 Basis of Payment. The accepted quantity of pipe collars will be paid for at the contract unit price.

SECTION 604.50 CONNECTING PIPE TO EXISTING STRUCTURES.

604.50.1 Description. This work shall consist of joining new pipe to existing manholes, box culverts, drop inlet boxes or sewer pipes as shown on the plans or as directed by the engineer.

604.50.2 Construction Requirements. An opening for the new pipe shall be made through the walls or barrel of the existing structure or pipe at the proper location and grade. The new pipe shall be properly fitted into place, flush with the inner face of the existing masonry, or as nearly so as the engineer determines is practical. After the pipe is in place, the opening around the pipe shall be sealed watertight in a manner approved by the engineer. Any portion of an existing structure that is damaged in joining the new pipe shall be repaired or replaced, at the contractor's expense, with new material of a type matching the old. These requirements will be applicable in joining new pipe to another new pipe if the engineer determines the use of a manufactured connection joint is unnecessary.

604.50.3 Basis of Payment. No direct payment will be made for connecting pipe to existing structures.

SECTION 604.60 SLOTTED DRAINS.

604.60.1 Description. This work shall consist of furnishing and installing slotted drains in accordance with these specifications, as shown on the plans or as directed by the engineer.

604.60.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Slotted Drain	1051

604.60.3 Construction Requirements.

604.60.3.1 The slotted drain shall be Type A, B or C as shown on the plans.

604.60.3.2 If Type C slotted drain is specified, the drain shall be installed such that the slanted spacer bars are facing upstream, sloped against the direction of the surface flow.

604.60.3.3 Unless otherwise shown on the plans, the slotted drain shall be placed on Class A Bedding in accordance with Sec 726 and backfilled to the top of the grate assembly with concrete meeting the requirements of Sec 609.10. The upper portion of the backfill may be placed in conjunction with the concrete curb or paving operations.

604.60.4 Method of Measurement. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, measurement of slotted drain, complete in place, will be made to the nearest linear foot along the geometric center of the drain. The revision or correction will be computed and added to or deducted from the contract quantity.

604.60.5 Basis of Payment. The accepted quantity of slotted drain, complete in place, including coupling devices and any other necessary fittings, will be paid for at the contract unit price. No direct payment will be made for concrete required for installation of the slotted drain.

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SECTION 605
UNDERDRAINAGE

605.1 Description. This work shall consist of furnishing and installing underdrains and edge drains as shown on the plans or as directed by the engineer, and shall include excavating the trench, installing all required drainage media, and backfilling with material as specified or as directed by the engineer.

605.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Aggregate for Drainage	1009
Geotextile	1011
Geocomposite Edge Drain	1012
Outlet Pipes	1013
Pipe Aggregate Pavement Edge Drain	1013
Corrugated Metallic-Coated Steel Cross Drain and Structural Drain Pipe	1022
Corrugated Aluminum Alloy Cross Drain and Structural Drain Pipe	1025

605.2.1 All underdrain and edge drain pipes shall be perforated, except as specified otherwise.

605.2.2 All special fittings, such as caps, wyes, tees and couplings, shall be of standard design and manufacture, and shall be compatible with the type of pipe or geocomposite drain to be used.

605.2.3 All steel fittings shall be zinc or aluminum coated.

605.2.4 All welds and cuts of steel pipe or fittings shall be repaired after welding, in accordance with Sec 1020.

605.3 Construction Requirements.

605.3.1 Although probable locations of underdrains are shown on the plans, modifications may be necessary due to conditions found on the project. The contractor shall perform work only as shown on the plans or as specified or approved in writing by the engineer.

605.3.2 Any underdrain trenching that results in an uneven trench bottom or exposes soft, yielding or unstable ground in the trench bottom shall be undergraded and backfilled with drainage aggregate material of sufficient thickness to ensure maintenance of proper alignment and gradient for all subsequent operations.

605.3.3 Any required drain pipe shall be firmly bedded and carefully aligned. The pipe shall be laid with perforations down if the perforations are not uniformly distributed around the circumference of the pipe, unless otherwise shown on the plans. All longitudinal pipe shall slope toward an outlet pipe at a minimum rate of one inch per 10 feet. Sections shall be jointed with approved fittings. Dead ends of pipe shall be completely closed by means of caps or plugs. Outlet openings shall be a minimum of 6 inches above the ditch bottom, and shall be protected with rodent screens in accordance with Sec 1013. Outlet pipe openings that are not exposed shall be connected to drain as shown on the plans or directed by the engineer.

605.3.4 Geotextile shall be used to completely envelope any drainage aggregate in trenches, except a geotextile will not be required when Grade 1 drainage aggregate is used, and only partial envelopment may be required when the underdrain abuts or is overlain by an approved open-graded base course or other drainage medium. A drainage geotextile wrap or sock shall envelope perforated drainage pipe when Grade 1 or Grade 2 drainage aggregate is used, or whenever any portion of a perforated pipe used as a discharge pipe is backfilled with soil.

605.3.5 Porous backfill shall be ponded with water immediately before covering to effect maximum settlement of backfill.

SECTION 605.10 PIPE-AGGREGATE PAVEMENT EDGE DRAIN.

605.10.1 Description. This work shall consist of placing a continuous pipe-aggregate edge drain under the edge of new pavement as shown on the plans or as directed by the engineer.

605.10.2 Construction Requirements. Aggregate shall be Grade 3, Grade 4 or Grade 5 drainage aggregate. Edge drain pipe shall have a nominal internal diameter of 4 inches unless otherwise shown on the plans.

605.10.2.1 The contractor shall select plastic pipe meeting these specifications, except that geocomposite drains shall not be used. Pavement edge drains shall be provided with outlet pipe and splash pads in accordance with Sec 605.60.

605.10.2.2 Trenching, placement, and backfill of underdrains shall be performed only after Type 1 or Type 5 base is placed and compacted. Backfill material shall be compacted by three passes of a vibrating pad or drum-type compactor approved by the engineer.

605.10.2.3 If a pipe-aggregate pavement edge drain is used on a pavement rehabilitation project, the contractor shall not install the drain until all pavement repair and required undersealing have been completed in the area where the edge drain is to be placed.

605.10.2.4 Under new pavement, pipe-aggregate pavement edge drains shall be lined with geotextile and wrapped. Edge drains underneath stabilized permeable base shall have the geotextile wrapped around the outside edge and over the top of the permeable base. The trench for pipe-aggregate pavement edge drains shall be lined and wrapped with a geotextile as shown on the plans.

605.10.2.5 All longitudinal edge drains and outlet pipes installed on the project will be subject to video camera inspection as directed by the engineer.

605.10.2.5.1 Video inspection shall be conducted after all paving is complete. The engineer may randomly select no less than ten percent of the lateral outlet pipes for inspection and extend inspection to 500 feet of the mainline pipe. Inspection areas shall not overlap each other, if possible. If deficiencies are found, a more extensive video inspection with expanded video coverage shall be conducted, which may inspect any or all of the edge drains on the project, as directed by the engineer.

605.10.2.5.2 The video camera head shall remain centered in the pipe during the inspection. The camera shall be capable of negotiating a 90˚ angle from the 4-inch outlet pipe to the 4-inch longitudinal pipe. Camera progress shall be clearly visible on an 8-inch or greater monitor screen. The unit shall be able to record and play back the inspection. The unit shall allow audio dubbing during the inspection. The contractor shall provide a copy of the video inspection tapes to the engineer within three working days of inspection.

605.10.2.5.3 If the inspection reveals crushed or compressed pipe, separated joints, obstructions within the pipe that prohibit the passage of the camera head, rips or cracks in the pipe wall, or longitudinal sags which allow silt to collect or water to stand in more than half the pipe depth, repair or replacement of the deficient portions of outlet or longitudinal pipe and the repair of the pavement, which is damaged by improper installation of the drain or the repair of deficient portions of the drain, shall be performed at the contractor's expense.

605.10.3 Method of Measurement. Measurement of pipe-aggregate edge drain will be made to the nearest linear foot along the centerline of the drain, center to center of fittings and junctions.

605.10.4 Basis of Payment.

605.10.4.1 Accepted quantities of pipe-aggregate edge drain will be paid for at the contract unit price per linear foot, or at an adjusted contract unit price per linear foot as described herein. No overrun or underrun of contract quantity will constitute the basis for contract adjustment, other than as provided in Sec 605.10.4.2. No direct payment will be made for excavating the trench, backfilling and backfill material, or for video inspection of the outlet and longitudinal pipes. Outlet pipes will not be separately paid for, except in combination with any required splash pad.

605.10.4.2 Adjustments in the contract unit price per linear foot of pipe-aggregate edge drain will be made in accordance with the following schedule where the engineer directs an increased depth of excavation from that shown on the plans. For purposes of determining the adjusted price, the excess depth of excavation will be averaged for the entire length of the drain if less than 100 feet and, if more than 100 feet, will be subdivided into 100-foot increments plus any remaining fraction. Any required undergrading to provide a 3-inch bedding of drainage aggregate where geotextile trench lining is omitted will not be included in any calculation of excess depth of excavation for pay purposes.

Average Excess Depth of Excavation	Adjusted Price
0 to 6 inches	Contract Price
> 6 inches	In accordance with Sec 104.3

SECTION 605.20 GEOCOMPOSITE PAVEMENT EDGE DRAIN.

605.20.1 Description. This work shall consist of furnishing and installing geocomposite pavement edge drain at the locations shown on the plans or as directed by the engineer.

605.20.2 Construction Requirements.

605.20.2.1 The contractor shall furnish to the engineer a copy of the drain manufacturer's printed instructions for installing the edge drain at least two weeks prior to installation. Except as noted herein, the installation of the drain shall be in accordance with the manufacturer's recommendations.

605.20.2.2 The contractor shall not install the drain until after all pavement repairs and required undersealing have been completed in the area where the edge drain is to be placed.

605.20.2.3 Each length of drain shall be joined to the adjacent length prior to installation. Splices shall keep adjoining lengths in proper alignment and shall not separate during installation. Splices shall have the same or greater compressive strength than the geocomposite edge drain, and shall be sealed against infiltration of the backfill material.

605.20.2.4 The drain shall be placed against the pavement side of the trench and shall be held in place while backfill is placed to a compacted height of 6 inches ± one inch, using a vibratory wheel or plate compactor with a rated impact force of approximately 5000 pounds. The placement of the edge drain and the first lift of backfill shall be accomplished in a single continuous operation. After the first lift of backfill has been placed, the remainder of the backfill shall be placed and compacted by a vibratory compactor to the satisfaction of the engineer. Material excavated from the trench may be used for backfill, except that all backfill shall pass a 2-inch sieve. At the contractor's option, Grade 1 drainage aggregate may be used in two lifts and flooded with clean water to compact each lift. If this method is chosen, the drain shall be placed against the shoulder side of the trench.

605.20.3 Method of Measurement. Measurement of geocomposite pavement edge drain will be made to the nearest linear foot along the centerline of the drain, center to center of fittings and junctions.

605.20.4 Basis of Payment. Accepted quantities of geocomposite pavement edge drain will be paid for at the contract unit price per linear foot. No overrun or underrun of contract quantity will constitute the basis for contract adjustment. No direct payment will be made for excavating the trench or backfilling and backfill material. Outlet pipes will not be separately paid for, except in combination with any required splash pad.

SECTION 605.30 PIPE-AGGREGATE PAVEMENT CROSS DRAIN.

605.30.1 Description. This work shall consist of placing metal pipe for sub drainage purposes as shown on the plans or as directed by the engineer, and shall include excavating the trench and backfilling with material as specified or directed. Pipe-aggregate pavement cross drains shall be non-continuous and will typically be installed laterally beneath the pavement to improve localized drainage problems. Except as otherwise specified, all cross drains shall have a nominal internal diameter of 6 inches and shall be perforated.

605.30.2 Construction Requirements.

605.30.2.1 Porous backfill shall extend a minimum distance of shoulder line to shoulder line of flexible pavements and a minimum of 18 inches outside of each edge of rigid pavement.

605.30.2.2 The pipe shall be firmly bedded in the trench. Dead ends of pipe shall be completely closed by means of caps securely affixed to the pipe. Outlet ends shall be connected to a drain as shown on the plans or as directed by the engineer.

605.30.2.3 Trenching, placement and backfill of cross drains shall be performed only after Type 1 or Type 5

base is placed and compacted.

605.30.3 Method of Measurement. Measurement of pipe-aggregate cross drain will be made to the nearest linear foot along the centerline of the drain, center to center of fittings and junctions.

605.30.4 Basis of Payment. Adjustments in the contract unit price per linear foot of pipe-aggregate cross drain will be made in accordance with the following schedule where the engineer directs increased depth of excavation from that shown on the plans. For purposes of determining the adjusted price, the excess depth of excavation will be averaged for the entire length of the drain if less than 100 feet and, if more than 100 feet, will be subdivided into 100-foot increments plus any remaining fraction. Any required undergrading to provide a 3-inch bedding of drainage aggregate where geotextile trench lining is omitted will not be included in any calculation of excess depth of excavation for pay purposes.

Average Excess Depth of Excavation	Adjusted Price
0 to 6 inches	Contract Price
> 6 inches	In accordance with Sec 104.3

SECTION 605.40 STRUCTURAL UNDERDRAIN.

605.40.1 Description. This work shall consist of installing pipe, generally for draining porous or other backfill adjacent to concrete masonry construction, as shown on the plans or as directed by the engineer. The contractor shall select either plastic or metal pipe meeting these specifications, except that geocomposite drains shall not be used and where plastic pipe is used, a concrete splash pad will be required.

605.40.2 Construction Requirements.

605.40.2.1 The pipe shall be laid to the grade and alignment shown. Where a section of pipe is cast into concrete, the remaining pipe shall be joined to these sections with connecting bands. The porous backfill material shall be placed such that the pipe will not become displaced and shall be firmly tamped under and around the entire pipe. Discharge ends shall be protected by approved methods to prevent obstruction until connections to outlets are installed.

605.40.2.2 When the fill above the drainage system is coarse aggregate or rock fill, Grade 3, 4 or 5, drainage aggregate shall be used with no geotextile. When the remaining backfill is sand or soil, any drainage aggregate may be used with the following exceptions. For sand backfill and Grades 3, 4 and 5, drainage aggregate or for earth backfill and Grades 2, 3, 4 and 5 drainage aggregate, the backfill material shall be separated from the drainage aggregate with geotextile.

605.40.2.3 After placement of the drain pipe, the initial lift of backfill material shall be placed around and over the pipe to a compacted depth not to exceed 6 inches above the pipe. This initial lift shall be compacted by two passes of a vibrating pad or drum-type compactor approved by the engineer. Any remaining porous backfill shall be placed in loose lift thicknesses not exceeding 6 inches and each lift compacted by two passes of the same equipment.

605.40.3 Method of Measurement. Measurement of structural underdrain will be made to the nearest linear foot along the centerline of the drain, center to center of fittings and junctions.

605.40.4 Basis of Payment. Accepted quantities of structural underdrain will be paid for at the contract unit price per linear foot. No direct payment will be made for excavating the trench or backfilling and backfill material. Outlet pipes will not be separately paid for, except in combination with any required splash pad.

SECTION 605.50 FRENCH UNDERDRAIN.

605.50.1 Description. This work shall consist of installing a drain, laterally across a pavement, using a trench, geotextile lining, and Grade 3 or Grade 4 drainage aggregate.

605.50.2 Construction Requirements.

605.50.2.1 French underdrains shall be constructed in the subgrade and through the shoulders to provide drainage at locations shown on the plans. French underdrains shall have a trench of the dimensions shown on the

plans, filled with porous backfill material. For that part of the trench in shoulders, the trench above the porous backfill shall be filled with suitable earth, well compacted.

605.50.2.2 Unless otherwise specified, both the trench width and depth of drainage aggregate shall be no less than 18 inches. Where directed, the trench above the drainage aggregate shall be backfilled with well compacted suitable earth.

605.50.2.3 Drainage aggregate shall be placed in lifts not to exceed 18 inches in thickness and compacted in a manner meeting the approval of the engineer.

605.50.2.4 All french underdrains shall be daylighted at discharge ends with minimum 10-foot lengths of perforated 6-inch diameter metal pipe placed at or within 3 inches of the flow line.

605.50.3 Method of Measurement. Measurement of french underdrain will be made to the nearest linear foot along the centerline of the drain.

605.50.4 Basis of Payment. Accepted quantities of french underdrain will be paid for at the contract unit price per linear foot.

SECTION 605.60 OUTLET PIPES AND SPLASH PADS.

605.60.1 Description. This work shall consist of furnishing and installing outlet pipes and splash pads for pipe-aggregate pavement edge drain, geocomposite pavement edge drain, and structural underdrain, when four-inch plastic pipe is used, at the locations shown on the plans or as directed by the engineer.

605.60.2 Construction Requirements.

605.60.2.1 Unless otherwise shown, outlet pipes shall be installed perpendicular to the drain, with a two percent gradient.

605.60.2.2 Concrete for splash pads shall be air-entrained and Class B, B-1 or concrete of a commercial mixture in accordance with Sec 501.

605.60.2.3 Construction requirements for the splash pads shall be in accordance with Sec 609. If the excavation is done to neat lines, forming will not be required. Pre-cast splash pads may be substituted for cast-in-place splash pads where approved by the engineer.

605.60.2.4 Outlet pipes shall be 4-inch diameter, non-perforated, schedule 40 or SDR 23.5 PVC pipe. Outlet connections to pipe-aggregate pavement edge drains shall be with wye connectors or 90-degree elbows as shown on the plans.

605.60.2.5 Outlet pipe trenches shall not be cut prior to installation of the edge drain. Outlet installation shall be completed promptly and, in all cases, within 72 hours of edge drain installation except with written approval from the engineer. The trench shall not be backfilled until the installation is inspected and approved by the engineer.

605.60.2.6 Backfilling of excavations for outlet pipe and splash pads shall be performed in accordance with Sec 203. If additional material is needed to complete the backfill, suitable material meeting the approval of the engineer shall be provided by the contractor at the contractor's expense.

605.60.3 Method of Measurement. Measurement of outlet pipes and splash pads will be made per each.

605.60.4 Basis of Payment. Payment for plan quantity of outlet pipes and splash pads, in combination, will be made at the contract unit price for each of the items included in the contract.

SECTION 605.70 AGGREGATE DRAINS.

605.70.1 Description. This work shall consist of trenching and placing granular filler material wrapped with geotextile as shown on the standard plans or as directed by the engineer. Construction of aggregate drains shall be after completion of granular base courses on new pavement or at least two weeks prior to shoulder work or

pavement repair during pavement rehabilitation.

605.70.2 Construction Requirements.

605.70.2.1 The trench shall be constructed to the width and depth as shown on the standard plans. The bottom of the trench shall be no higher than the bottom of pavement or granular base. The trench shall be smooth, firm and furnish a clean exposure to the pavement bottom or granular base course.

605.70.2.2 Any remaining trench shall be backfilled and compacted with suitable material in accordance with Sec 203. When erodible aggregate material such as recycled glass, tire chips or fine aggregate, are used, the in slope or exposed area shall be covered with a minimum of 6 inches Grade 3, Grade 4, or Grade 5 aggregate, in accordance with Sec 1009.

605.70.3 Method of Measurement. Final measurement of aggregate drains will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, measurement of aggregate drains will be made to the nearest linear foot along the centerline of the drain from the edge of pavement to the end of the trench top.

605.70.4 Basis of Payment. Accepted quantities of aggregate drain, complete in place, will be paid for at the contract unit price per linear foot. Payment will be considered full compensation for all labor, equipment, materials, and incidentals to complete this work, including excavation and geotextile wrap.

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SECTION 606
GUARDRAIL, CRASHWORTHY END TERMINALS, ONE-STRAND ACCESS RESTRAINT CABLE AND THREE-STRAND GUARD CABLE

606.1 Description. This work shall consist of furnishing and installing guardrail, crashworthy end terminals, one-strand access restraint cable or three-strand guard cable as shown on the plans or as directed by the engineer.

606.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Concrete	501
Guardrail, End Terminals, Crash Cushions, One-Strand Access Restraint Cable and Three-Strand Guard Cable	1040

606.2.1 Concrete. Concrete shall be placed, finished and cured in accordance with Sec 703.

606.2.2 Cold Weather. During cold weather, the weather limitations of Sec 502 will apply to concrete work.

606.2.3 Aesthetic Guardrail. When specified, aesthetic guardrail shall be in accordance with NCHRP 350, Test Level 3 criteria and shall be of new stock. End terminals and crash cushions for aesthetic guardrail shall be fabricated and installed in accordance with Sec 606.30.3.

606.3 Construction Requirements.

606.3.1 General. Work on guardrail or guard cable removal and replacement when the adjacent travel or auxiliary lane is open to traffic during non-working hours shall adhere to the following requirements:

(a) The contractor shall provide a schedule of work prior to the beginning of work.

(b) Remove no more guardrail or guard cable than can be replaced in the same day.

(c) Schedule guardrail and guard cable installation to ensure guardrail beam or guard cable is properly attached to all installed posts at the end of each work day.

(d) Ensure end sections or terminals exposed to traffic meet current standards.

(e) Notify the engineer prior to delivery of the material to the project.

606.3.1.1 If guardrail or three-strand guard cable cannot be replaced the same day as removal, traffic control measures meeting the approval of the engineer shall be provided. The contractor will not be compensated for any additional traffic control items required to perform this work. In all cases, the contractor shall ensure that the guardrail or guard cable installation is fully anchored before opening the adjacent lane to traffic.

606.3.1.2 The shoulders and slopes shall be in accordance with all standards shown on the plans or shall be as directed by the engineer before the installation of any guardrail, guard cable or end treatments.

606.3.2 Field Repair of Galvanizing. Galvanized material shall be handled in a manner to avoid damage to the surface. No punching, drilling, cutting or welding will be permitted after galvanizing, except as approved by the engineer to provide for lapped beams, or for changes in location of splices necessitated by field clearances. Any galvanized material on which the galvanizing has been damaged will be rejected or may, with the engineer's approval, be repaired in accordance with Sec 1080.

606.3.3 Posts for Guardrail and One-Strand Access Restraint Cable.

606.3.3.1 Posts may be wood or steel as shown on the plans. The same material shall be used for all new installations within a single project, except for end treatments. If the project requires an extension of existing guardrail, the new post material for the extension shall match the existing material.

606.3.3.2 Wood posts for end anchors shall be installed as shown on the plans.

606.3.3.3 Posts may be installed by either drilling or driving.

606.3.3.3.1 Posts installed by drilling shall have sufficiently sized holes to permit thorough compaction of backfill material around the posts. The backfill material shall be compacted in layers not exceeding 12 inches high.

606.3.3.3.2 Posts installed by driving may be driven by a power hammer or any other method approved by the engineer. Any mushrooming on the top of the post shall be removed. Damaged zinc coating on galvanized posts shall be field repaired in accordance with Sec 1081. If, in the judgment of the engineer, the exposed portion of a wood post is split or the driving process noticeably worsens the check cracking, the post shall be replaced by the contractor at the contractor's expense.

606.4 Basis of Payment. The accepted quantities of grading and drainage at barrier locations will be paid for at the contract unit price for each of the pay items included in the contract.

SECTION 606.10 GUARDRAIL.

606.10.1 Description. This work shall consist of furnishing and installing guardrail as shown on the plans or as directed by the engineer.

606.10.2 Construction Requirements.

606.10.2.1 Beams. Beams shall be spliced by lapping in the direction of traffic. The use of 12'-6" or 25-foot sections of beam rails and channels, if required, will be permitted where true line and grade can be maintained.

606.10.2.2 End Anchors. End anchors shall be installed on ends of guardrail runs where crashworthy end terminals are not required.

606.10.2.3 Delineators. Delineators shall be placed on all guardrail located 2 feet or less from the edge of the shoulder. Delineators shall be spaced at 50-foot intervals.

606.10.2.3.1 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Delineators	1065

606.10.2.3.2 Construction Requirements.

606.10.2.3.2.1 Delineator reflector colors shall correspond with pavement marking. Delineators shall be sheeted on one side, facing oncoming traffic, unless otherwise specified. Where guardrail divides opposing lanes of travel, the delineators shall have retro-reflective sheeting on both sides corresponding to adjacent pavement markings. Guardrail located on off ramps shall have red reflective sheeting placed on the reverse side of the reflector. The use of the red sheeting on the back side of guardrail delineators may be used wherever there is a need to discourage wrong way driving. Guardrail located on two lane roads shall have retro-reflective sheeting on both sides corresponding to the adjacent pavement markings. If there are not edgelines present, white retro-reflective sheeting shall be used.

606.10.2.3.2.2 Delineators shall be installed according to manufacturer's recommendations or as shown on the plans.

606.10.2.3.2.3 Any damaged or missing delineators shall be replaced by the contractor at the contractor's expense.

606.10.3 Method of Measurement.

606.10.3.1 Measurement of guardrail will be made to the nearest 1/2 linear foot for each increment along a line

passing through the centerline of each post, and totaled to the nearest linear foot for the sum of the increments in the contract. The length will be measured separately for each guardrail type, as shown on the plans, excluding bridge anchor sections, end anchors, transition sections and bullnose guardrail systems. Bridge anchor sections, end anchors, transition sections and bullnose guardrail systems will be measured per each item furnished and installed.

606.10.3.2 Measurement for MGS Guardrail will be made to the nearest ½ linear foot for each segment measured along the center of the W-beam rail from the centerline of the mid-span lap splice to the centerline of the mid-span lap splice totaled to the nearest linear foot for the sum of the increments in the contract. The length will be measured for each type of guardrail, as shown on the plans, excluding vertical barrier transitions, end terminals, MGS height and block transitions, MGS long span, and embedded anchor transitions. Vertical barrier transitions, end terminals, MGS height and block transitions, MGS long span, and embedded anchor transitions will be measured per each item furnished and installed.

606.10.4 Basis of Payment. The accepted quantities of guardrail, bridge approach transitions, end anchors, MGS height and block transitions, MGS Long Span Guardrail, and bullnose guardrail systems, complete in place, will be paid for at the contract unit price for each of the pay items included in the contract. No direct payment will be made for end sections or terminal connectors. No direct payment will be made for setting posts in rock. No direct payment will be made for guardrail delineators provided on new guardrail. Delineators specified for installation on existing guardrail will be measured and paid for per each.

SECTION 606.20 BLANK.

SECTION 606.30 CRASHWORTHY END TERMINALS.

606.30.1 Description. This work shall consist of furnishing and installing crashworthy end terminals as shown on the plans or as directed by the engineer.

606.30.2 Material.

606.30.2.1 Equipment and material shall be of new stock and in accordance with Sec 1040.

606.30.2.2 All Type A end terminal installations shall be a minimum of 50 feet long. Additional Type A or MGS guardrail shall be provided by the contractor, at the contractor's expense, to increase the Type A end terminal to a length of 50 feet. If the end terminal is to be installed on MGS rail, the additional guardrail supplied shall be MGS rail.

606.30.3 Construction Requirements. End terminals and crash cushions shall be fabricated and installed in accordance with the manufacturer's approved shop drawings, recommendations and as shown on the plans. Any units damaged during the term of the contract shall be replaced immediately at the contractor's expense.

606.30.3.1 Where a specific end terminal or crash cushion is shown by product name, that unit shall be used as shown on the plans. No substitutions will be permitted without prior approval from the engineer.

606.30.3.2 The contractor shall not install flared Type A end terminals in medians or on curbs.

606.30.3.3 The contractor shall not install Type B end terminals on paved surface locations, unless the location is temporary and the paved area is to be resurfaced after removal of the system.

606.30.3.4 The contractor may use Type C, D, and E end terminals where Type B units are specified or shown on the plans.

606.30.3.5 Crashworthy end terminals located 12 feet or less from the edge of the traveled way shall be furnished with a modified Type 3 object marker. The marker size, shape, method of attachment and placement shall be approved by the engineer prior to installation.

606.30.4 Method of Measurement. Measurement for crashworthy end terminals will be made for each unit assembled, installed and complete in place. Grading for crashworthy end terminals will be measured in accordance with Sec 203 when roadway and drainage excavation is included in the contract, otherwise grading will be measured in accordance with Shaping Slopes, Class III or as directed on plans.

606.30.5 Basis of Payment. The accepted quantities of Type A, B, C, D and E crashworthy end terminals, complete in place, will be paid for at the contract unit price. Payment will be considered full compensation for complete installation including any backup assemblies or other items necessary for proper installation of the end terminal or crash cushion as required. Grading for end terminals will be paid for at the contract unit price for roadway and drainage excavation if included in the contract; otherwise it will be paid for as Shaping Slopes, Class III. If the contractor elects to use a flared Type A crashworthy end terminal, additional embankment as shown on the plans shall be provided at the contractor's expense.

SECTION 606.40 ONE-STRAND ACCESS RESTRAINT CABLE.

606.40.1 Description. This work shall consist of furnishing and installing one-strand access restraint cable as shown on the plans or as directed by the engineer.

606.40.2 Construction Requirements. The cable shall be strung directly from the reel and pulled tight after the initial anchoring. The cable shall then be attached to the second anchor assembly with all turnbuckles fully opened. The cable shall be completely anchored before attaching to the line posts. Only one splice will be permitted between anchors, located between the line posts. Splices will not be permitted in spans adjacent to the anchor and cable end assemblies.

606.40.3 Method of Measurement. Measurement of one-strand access restraint cable will be made to the nearest 1/2 linear foot for each increment, from center of end post to center of end post, and totaled to the nearest linear foot for the sum of the increments on the project.

606.40.4 Basis of Payment. The accepted quantities of one-strand access restraint cable, end anchors, posts and hardware, complete in place, will be paid for at the contract unit price for each of the pay items included in the contract.

SECTION 606.50 THREE-STRAND GUARD CABLE.

606.50.1 Description. This work shall consist of furnishing and installing three-strand guard cable, including all hardware, appurtenances and aggregate bedding, as shown on the plans or as directed by the engineer.

606.50.2 Construction Requirements.

606.50.2.1 Line Posts. All posts shall be driven unless otherwise directed by the engineer. Driving shall be accomplished with approved equipment and methods that will leave the posts in the final position, free from any distortion, burring or other damage. All posts shall be aligned to a tolerance of 1/4 inch for plumb and grade line. If rock is encountered when setting line posts, the contractor may set line posts with or without a soil plate. Line posts set with a soil plate shall be installed by digging or boring a hole into the rock to the required depth and of sufficient size for the post to be set with the soil plate attached. Line posts set without the soil plate shall be installed by drilling a hole to the required depth not to exceed 5 inches in diameter. Following placement of the post, the hole shall be backfilled with a cohesive soil or sand in accordance with Sec 1005.3, and thoroughly tamped.

606.50.2.2 Anchor Assemblies. The specified type of anchor assembly shall be constructed at each end of a run of guard cable. If intermediate end anchors are required, the cable assembly shall be overlapped as shown on the plans. The location of all intermediate anchor assemblies shall be determined by the contractor and approved by the engineer. The concrete anchor shall be cast in place with the centerline normal to the line of the guard cable. The top 12 inches of the anchor below finished ground line shall be formed, unless the engineer determines soil conditions permit excavation to be made to the neat lines of the anchor and the anchor cast against the undisturbed vertical soil face. Anchors shall be constructed on firm, stable, undisturbed soil to the minimum dimensions shown on the plans. Anchor bolts and anchor post slip bases shall be firmly held in the proper position supported at the top by a template during concrete placement. Backfill shall be thoroughly compacted with mechanical tampers with care taken to prevent damage to the finished concrete. Backfill shall be brought up level with the finished grade line. The anchor may be cast in place or precast as either one or two units.

606.50.2.3 Cables. Cables shall be attached to the line posts, anchor posts, cable transition brackets and anchor brackets as shown on the plans. Where compensating devices or turnbuckles are required, the cables shall be attached to the end anchor with turnbuckles fully opened. Compensating devices and turnbuckles shall be

installed such that no interference with the functions of any other part of the system occurs. Individual cables may be spliced with a device approved by the engineer. Each cable shall be stretched taught by mechanical means to eliminate sag between the posts. The contractor may tighten cable hook bolts after final cable tensioning is complete to allow cable slack to be adequately taken up. Prior to final acceptance, the cables shall be tensioned in accordance with the temperature and spring compression table shown on the plans and all cable hook bolts tightened.

606.50.2.4 Aggregate Bedding. Material for aggregate bedding shall consist of a durable crushed stone, shot rock or broken concrete with approximately 20 percent of the pieces being between 1 inch and 3 inches in diameter but none greater than 3 inches. The remainder of the material shall be such that provides a uniform, angular appearance. Acceptance by the engineer will be made by visual inspection.

606.50.2.5 Delineators. Delineator spacing and reflector colors shall be in accordance with Sec 606.10.

606.50.3 Method of Measurement.

606.50.3.1 Three-Strand Guardrail. Measurement of three-strand guard cable will be made from center of line post to center of line post, totaled to the nearest linear foot.

606.50.3.2 Anchor Assemblies. Measurement of anchor assemblies will be made per each.

606.50.3.3 Aggregate Bedding. Aggregate bedding material will be measured to the nearest cubic yard of material.

606.50.4 Basis of Payment. The accepted quantities of three-strand guard cable, end anchors, posts, hardware and aggregate bedding will be paid for at the contract unit price for each of the pay items included in the contract. No direct payment will be made for setting posts in rock. No direct payment will be made for guard cable delineators provided on new guard cable. Delineators specified for installation on existing guard cable will be measured and paid for per each.

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SECTION 607
FENCING

SECTION 607.10 CHAIN-LINK FENCE.

607.10.1 Description. This work shall consist of furnishing and erecting chain-link fence and gates as shown on the plans or as directed by the engineer.

607.10.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Chain-Link Fence	1043

607.10.2.1 The contractor may select either zinc-coated steel, aluminum-coated steel, aluminum alloy or vinyl-coated steel fencing material, except that the same kind of material shall be used throughout the project.

607.10.2.2 Walk gates and drive gates, if required, shall be of the same material as that selected for the fence. If the project requires an extension of an existing fence, the new fence material for the extension shall match the existing material.

607.10.3 Construction Requirements.

607.10.3.1 The contractor shall fill, cut or trench where necessary to produce a smooth and uniform ground surface so the bottom of the fabric is no more than 3 inches above the finished ground line. All posts shall be set plumb, true to line and grade. Terminal posts, defined as end, gate, corner and pull posts, shall be set in concrete. Concrete for the footings shall be Class B concrete or a commercial mixture in accordance with Sec 501. The concrete footing shall be a uniform thickness around the post and shall have a cone or dome shaped top. At the option of the contractor, line posts may be driven or placed in dug or drilled holes and set in concrete or quick-setting polyurethane foam in accordance with Sec 903.3.1.2. If the contractor elects to drive line posts, the posts shall be of the length and driven to the depth shown on the plans. If posts cannot be driven to the correct depth, the posts shall be removed and placed in dug or drilled holes and set in foam or concrete footings. Posts damaged during installation shall be removed and replaced at the contractor's expense.

607.10.3.2 Fabric shall not be attached to posts until the concrete footings have cured for at least five days. Fabric shall be securely attached to end, corner, gate and pull posts in accordance with manufacturer's recommendations. The fabric shall be attached to the tension wire with hog rings, spaced as shown on the plans. The fabric shall be attached to line posts with wire ties or bands spaced in accordance with manufacturer's recommendations. All fabric shall be taut before attaching to line posts and tension wire.

607.10.3.3 Drive gates shall have an approximate full circle opening swing. Walk gates shall have positive stops to prevent the gates from swinging into the right of way.

607.10.3.4 If the chain link fence is required to be topped with barbed wire, the barbed wire support arm shall be at a 45-degree angle, ± 5 degrees, from the vertical plane of the fence line extended above the fence, and shall be fitted with clips, slots or other device for attaching three strands of barbed wire to the arm. The top strand shall be located 12 inches horizontally from the fence line, ± 3 inches, with the other wires spaced uniformly between the top of the fence fabric and the top outside strand of barbed wire. The barbed wire arm shall be of sufficient strength to withstand a weight of 250 pounds applied at the outer strand of barbed wire without causing any permanent deflection of the arm. Each strand of barbed wire shall be pulled taut to remove all sag before the strand is attached to the extension arm.

607.10.3.5 Post braces shall be installed for each gate, corner, pull and end post. The brace shall extend from the mid point of the gate, corner, pull and end post to the midpoint of the adjacent line post. A truss rod shall be connected to the midpoint of the line post and run back to the bottom of the gate, corner, pull and end post. The truss rod shall be equipped with a turnbuckle or other equivalent device for adjustment.

607.10.4 Method of Measurement. Measurement of chain-link fence will be made to the nearest linear foot, measured along the slope of the fabric, but shall not include gates. Measurement for gates will be made for each unit assembled, installed and complete in place. Double drive gates will be considered a single unit.

Measurement for the 3-strand barbed wire extension will be made to the nearest linear foot, measured along the slope of the fence, but will not include gates.

607.10.5 Basis of Payment. The accepted quantity of chain-link fence, walk and drive gates, and barbed wire extensions, complete in place, will be paid for at the contract unit price for each of the pay items included in the contract. No direct payment will be made for concrete footings, post hole excavation or for excavation and embankment necessary to smooth the area under the fence.

SECTION 607.20 WOVEN WIRE FENCE.

607.20.1 Description. This work shall consist of furnishing and erecting woven wire fence and gates as shown on the plans or as directed by the engineer.

607.20.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Woven Wire Fence	1043.4
Wood Posts for Fencing	1050.2

607.20.3 Construction Requirements.

607.20.3.1 Posts shall be set plumb, true to line and grade. Wood corner, end, brace and pull posts shall be set in drilled or dug holes and backfilled with soil thoroughly tamped around the post. Steel corner, end, brace and pull posts and braces shall be set in concrete footings in accordance with Sec 607.10.3. Steel and wood line posts may be driven in lieu of setting the posts in drilled or dug holes. If the contractor elects to drive the line posts, the posts shall be of the length and driven to the depth shown on the plans. If the posts cannot be driven to the correct depth, posts shall be removed and placed in dug or drilled holes and set with the appropriate backfill. Posts damaged during installation shall be removed and replaced at the contractor's expense.

607.20.3.2 Wood line posts that are to be driven shall be pointed before being treated. If surfaces of treated wood posts have been damaged, or if framing at the site is required, the damaged or resulting untreated surfaces shall be field treated with two coats of commercially available preservative of the same type used for the original treatment. The second coat shall be applied after the first coat is absorbed. Creosote preservative shall be hot when applied.

607.20.3.3 Corner post assemblies shall be set at all horizontal angle points greater than 15 degrees in the line of fence. Pull post assemblies shall be set at all vertical angle points greater than 15 degrees but at no greater than 660-foot intervals.

607.20.3.4 Fabric and barbed wire shall be pulled taut before attaching to any line post. The bottom of the fabric shall be no more than 3 inches above the ground at any point and necessary excavation along the fence shall be performed to obtain the specified clearance. Filling of depressions will not be permitted except where approved by the engineer. Spaces left by depressions shall be filled with strands of barbed wire as shown on the plans.

607.20.3.5 Walk and drive gates shall be constructed in accordance with the requirements of gates for chain-link fence, except the filler shall be woven wire fabric of the same material as used for the fence.

607.20.3.6 The contractor shall modify the typical installation for water gates to fit the conditions in the field and shall be approved by the engineer.

607.20.4 Method of Measurement. Measurement of woven wire fence will be made to the nearest linear foot, measured along the slope of the fabric, but will not include gates. Measurement for gates will be made for each unit assembled, installed and complete in place. Double drive gates will be considered a single unit.

607.20.5 Basis of Payment. The accepted quantity for woven wire fence and gates, complete in place, will be paid for at the contract unit price for each of the pay items included in the contract. No direct payment will be made for post hole excavation, backfilling, clearing of fence rows, trenching for fabric, placing extra strands of barbed wire for depressions, construction of water gates and all other incidental work or material.

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SECTION 608
CONCRETE MEDIAN, MEDIAN STRIP, SIDEWALK, CURB RAMPS, STEPS AND PAVED APPROACHES

608.1 Description. This work shall consist of constructing concrete medians, median strips, sidewalks, curb ramps, steps and paved approaches as shown on the plans or as directed by the engineer. Concrete medians shall consist of a paved median constructed on a prepared subgrade. Concrete median strips shall consist of paved median strips laid over and tied to a previously constructed pavement.

608.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Reinforcing Steel for Concrete Structures	1036
Steel Welded Wire Reinforcement for Concrete Pavement	1036
Epoxy Resin Material	1039
Red Concrete Tinting Material	1056
Material for Joints	1057
Truncated Domes	1067

608.2.1 Concrete sidewalks, curb ramps, and steps shall be constructed of Class B concrete.

608.2.2 Concrete medians, median strips and paved approaches 6 inches thick or greater shall be constructed of Pavement concrete. Concrete medians, median strips and paved approaches less than 6 inches thick shall be constructed of either Class B concrete or Pavement concrete.

608.2.3 Material, proportioning, air entraining, mixing, slump and transporting of concrete shall be in accordance with Sec 501.

608.3 Construction Requirements.

608.3.1 Placement, finishing and curing of concrete shall be in accordance with Sec 502 When items are constructed on a subgrade, the subgrade shall be compacted to the specified density of the applicable subgrade material in accordance with Sec 209. The subgrade shall have a sufficient moisture content such that moisture is not drawn out of the concrete. Transparent membrane shall be used in lieu of pigmented membrane for curing concrete median strips, sidewalks, curb ramps and steps.

608.3.2 Where tinted concrete is specified, the colored pigment shall be applied in accordance with the manufacturer's recommendations. The final concrete surface coloration shall be medium to dark red, as approved by the engineer. If membrane curing is allowed by the manufacturer's recommendations, the membrane shall be a clear or transparent type.

608.3.3 Required reinforcement and tie bars shall be positioned by bar chairs or other approved devices during the placing of concrete.

608.3.4 Concrete median strips shall be attached to the pavement with tie bars as shown on the plans. Tie bars shall be adjusted to a minimum of 6 inches from any transverse joint.

608.3.5 Joints for all items shall be constructed at such intervals and locations as shown on the plans or as directed by the engineer.

608.3.5.1 Longitudinal joints between the median and curb, or median and adjacent concrete pavement shall be constructed of either non-extruding preformed joint material, or one layer of commercially available 55-pound roll roofing. Sawed joints shall be sealed in accordance with Sec 502.5.4.

608.3.5.2 Transverse joints in concrete median strips shall be constructed as shown on the plans and as directed by the engineer.

608.3.6 After form removal, the area adjacent to the concrete shall be backfilled with suitable material, compacted and finished to the satisfaction of the engineer.

608.3.7 Concrete strength and air content shall be tested at the required QC and QA frequencies. Concrete strength shall be tested with either cylinders or the maturity method. Concrete shall have a minimum 28-day strength of 4000 psi. Air content shall be in accordance with Sec 501.10.2.

608.3.7.1 The contractor shall measure concrete strength and air content at a frequency of one test per 100 cubic yards. The engineer shall measure concrete strength and air content at a frequency of one test per 500 cubic yards.

608.3.7.2 No concrete strength and air content testing will be required on any day when the total volume of concrete placed in a day is less than 3 cubic yards.

608.3.8 During cold weather, the limitations and protection in accordance with Secs 502.4.1 and 502.4.2 will apply to this work.

608.3.9 Transitions from curb ramps to sidewalks, gutters or streets shall be flush and free of abrupt changes. All curb ramps at streets, signalized commercial entrances, and railroad crossings shall include truncated domes that contrast visually with the adjoining surface light on dark or dark on light.

608.3.9.1 Truncated domes shall be aligned on a square or radial grid pattern, 24 inches deep in the direction of travel, and the full width of curb ramp, landings or blended transition, exclusive of flares.

608.3.9.2 Truncated domes shall be installed as per manufacturer's specifications.

608.4 Method of Measurement.

608.4.1 Measurement of concrete median and of concrete median strip will be made to the nearest 1/10 square yard.

608.4.2 Concrete sidewalk and curb ramps will be measured to the nearest 1/10 square yard.

608.4.3 Truncated domes will be measured to the nearest 0.5 square foot.

608.4.4 Paved approaches will be measured from the beginning of the return on one side of the approach to the end of the return on the other side of the approach, to the nearest 1/10 square yard. Integral curb constructed on paved approaches will not be measured or paid for separately but will be included in the contract unit price for paved approaches.

608.4.5 Final measurement of any of the above items will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity for that item.

608.5 Basis of Payment.

608.5.1 The accepted quantities of concrete median, median strip, sidewalk curb ramps, truncated domes .and paved approach, complete in place, will be paid for at the contract unit price for each of the pay items included in the contract.
608.5.2 The accepted quantities of concrete steps will be paid for in the following manner:

(a) Class B concrete will be paid for in accordance with Sec 703 for miscellaneous concrete.

(b) Reinforcing steel will be paid for in accordance with Sec 706.

608.5.3 No direct payment will be made for the following:

(a) Furnishing or installing reinforcement.

(b) Any incidental work required for furnishing and installing tie bars.

(c) Excavating or preparing the subgrade for any item contained in this specification.

(d) Tinting of concrete surface as required in the plans.

(e) Vertical curbs or flares constructed as part of the curb ramp or landing.

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SECTION 609
PAVED DRAINAGE

SECTION 609.10 CONCRETE CURB, GUTTER AND PAVED DITCH.

609.10.1 Description. This work shall consist of constructing curb, gutter or combination curb and gutter and paved ditches as shown on the plans or as directed by the engineer.

609.10.2 Material. Material, proportioning, air-entraining, mixing, slump and transporting of concrete shall be in accordance with Sec 501. Concrete shall be either Class B or Pavement concrete. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Reinforcing Steel for Concrete Structures	1036
Concrete Curing Material	1055.2
Material for Joints	1057

609.10.3 Construction Requirements.

609.10.3.1 These items shall be placed on a prepared subgrade of uniform density. Forms joined neatly and tightly, set accurately to alignment and grade and securely held in place by connections and bracing shall be used for this work. Forms for curved form lines shall be provided in a manner similar to that required for setting forms for concrete pavement in Sec 502. Slip-form methods may be used for placement of concrete curb, concrete gutter, curb and gutter and paved ditch, provided proper lines, grades and typical sections are maintained.

609.10.3.2 Required reinforcement and tie bars shall be held in the specified position during the placing of concrete by bar chairs or other devices approved by the engineer. Joints shall be constructed at intervals and locations shown on the plans or as directed by the engineer.

609.10.3.3 Concrete shall be placed, finished and cured in accordance with Sec 703.

609.10.3.4 Concrete shall be placed on the prepared and sprinkled subgrade, consolidated and struck off to the required thickness. Concrete shall be tamped or vibrated sufficiently to eliminate all voids and to bring mortar to the top, after which the surface shall be finished smooth and even. All edges shall be rounded with an edging tool having a 1/4-inch radius. Faces of curb shall be rounded at the top and bottom, by means of an approved tool, to the radius shown. After finishing, concrete shall be cured in the same manner as required for concrete pavement, except transparent membrane shall be used in lieu of pigmented membrane.

609.10.3.5 After the concrete has set sufficiently, the forms shall be removed, and where necessary, the contractor shall backfill adjacent to the concrete with suitable material, compacted and finished in a satisfactory manner.

609.10.3.6 During cold weather, the weather limitations and protection requirements of Sec 502 will apply to this work.

609.10.4 Method of Measurement.

609.10.4.1 Curb, gutter and combination curb and gutter will be measured to the nearest linear foot. Measurement will be made along the curb face or along the flow line of gutters exclusive of paved approaches.

609.10.4.2 Paved ditches will be measured to the nearest 1/10 square yard.

609.10.5 Basis of Payment. The accepted quantities of curb, gutter, curb and gutter, and paved ditch, complete in place, will be paid for at the contract unit price for each of the pay items included in the contract. No direct payment will be made for the following:

(a) Excavation below the upper surface of the concrete of these items.

(b) Any work necessary for preparing the subgrade and backfilling the completed item.

(c) Furnishing or installing reinforcement.

SECTION 609.20 INTEGRAL CURB.

609.20.1 Description. This work shall consist of curb constructed on the edge of concrete pavement as shown on the plans or as directed by the engineer.

609.20.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Concrete Curing Material	1055
Material for Joints	1057

609.20.2.1 Integral curb shall be constructed of concrete conforming to that required for concrete pavement, except coarse aggregate in accordance with the gradation requirements of Sec 1005 may be used.

609.20.2.2 The quantity of coarse aggregate in the mix may be reduced to obtain better workability.

609.20.3 Construction Requirements.

609.20.3.1 The curb shall be an integral part of the supporting concrete pavement. The curb may be placed immediately after all pavement finishing operations have taken place and before the pavement has taken initial set, or tie bars may be set in the freshly finished pavement to serve ultimately as a tie between the pavement and the curb, which may be constructed later. Neither of these methods will be required for the distance needed for paving equipment to be backed up near a construction joint. The pavement surface within this relatively short distance shall be roughened throughout the area to be covered by the curb.

609.20.3.2 Forms joined neatly and tightly, set accurately to alignment and grade, and securely held in place by connections and bracing shall be used for this work. Forms for curved form lines shall be provided in a manner similar to that required for setting forms for concrete pavement in Sec 502. Slip-form methods may be used for placement of integral curb provided all other requirements of Sec 609.20 are met.

609.20.3.3 The finished curb shall be true to line, grade and cross section, with the top and face finished smooth. The top edges of the curb shall be rounded with approved edging tools. Curing shall be accomplished in the same manner as required for concrete pavement, except transparent membrane shall be used. Joints of preformed material shall be placed through the curb and into each underlying transverse pavement joint to the full depth of the joint in the pavement. The preformed material shall extend entirely through the curb to within 1/4 inch of the top and face of the curb.

609.20.3.4 Where tie bars are set in freshly finished pavement surface and membrane curing is used on the pavement, care shall be taken to avoid spraying the membrane on the protruding tie bars or the area on which the integral curb is to be placed. One of the other curing methods allowed in accordance with Sec 502 shall be used for curing this area of the pavement.

609.20.3.5 Integral curb straightedged parallel to the centerline shall not show a variance greater than 1/4 inch from a 10-foot straightedge.

609.20.4 Method of Measurement. Final measurement of the completed integral curb will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, integral curb will be measured to the nearest linear foot along the curb face, exclusive of paved approaches. The revision or correction will be computed and added to or deducted from the contract quantity.

609.20.5 Basis of Payment. The accepted quantity of integral curb, complete in place, will be paid for at the contract unit price for each of the pay items included in the contract. Payment for curb constructed on paved approaches will be included in the contract unit price for paved approaches.

SECTION 609.30 ASPHALT CURB.

609.30.1 Description. This work shall consist of constructing a curb of asphaltic concrete as shown on the plans or as directed by the engineer. All applicable provisions of Sec 403 will apply to this construction.

609.30.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Coarse Aggregate	1002
Fine Aggregate	1002
Mineral Filler	1002
Asphalt Binder, Performance Graded (PG)	1015

609.30.3 Composition of Mixture. The asphaltic concrete mixture shall consist of aggregate, filler if needed, and asphalt binder combined in such proportions that the composition by weight of the finished mixture shall be within the limits specified for BP-3 or SP048 mixture in accordance with Sec 401 and Sec 403. The contractor shall submit in writing to Construction and Materials for approval of the job mix formula the contractor proposes to use for asphalt curb. A mixture demonstrating satisfactory results provided by the contractor may be used in lieu of the above mixtures.

609.30.4 Construction Requirements.

609.30.4.1 The curb shall be placed in position on a primed surface by means of an approved automatic curb machine that shapes and compacts the mixture to the specified cross section. The placement temperature of the mixture shall be approximately 260 F. All joints shall be carefully made in such a manner as to ensure a continuous bond between the old and new sections of the curb.

609.30.4.2 The newly laid curb shall be protected from traffic until the heat of the asphalt mixture has dissipated. Immediately after the asphalt curb has hardened, the curb shall be backfilled where required with suitable material.

609.30.4.3 If painting of the asphalt curb is specified in the contract, a primer coat of commercial grade asphalt base aluminum paint shall be applied first.

609.30.5 Method of Measurement. Asphalt curb will be measured to the nearest linear foot.

609.30.6 Basis of Payment. The accepted quantity of asphalt curb will be paid for at the contract unit price. No direct payment will be made for priming prior to placing the curb or for painting the completed curb.

SECTION 609.40 DRAIN BASIN ASPHALT CURB.

609.40.1 Description. This work shall consist of furnishing and constructing a drain basin as shown on the plans or as directed by the engineer.

609.40.2 Material. Drain basins shall consist of a drop inlet of the size and type shown on the plans, grates and bearing plates for drop inlet, Group C pipe in the size shown on plans and concrete slope protection at pipe outlet as shown on plans. These items shall be in accordance Division 1000, Material Details, and specifically as follows:

Item	Section
Rock Ditch Lining	609.60
Grates and Bearing Plates	614
Drop Inlet	1033

609.40.3 Construction Requirements. Excavation and backfilling shall be in accordance with Secs 604 and 725. The adjustment shall be made to the line and grade shown on the plans or as directed by the engineer. The concrete slope protection for the drain basin outlet shall be placed as shown on the plans or as directed by the engineer.

609.40.4 Basis of Payment. Payment for the accepted drain basin, complete in place, will be paid for at the contract unit price per each. Payment for the accepted quantities of Class 3 excavation required for installing the

drop inlet for the drain basin will be paid for at the contract unit price.

SECTION 609.50 BLANK.

SECTION 609.60 ROCK DITCH LINER.

609.60.1 Description. This work shall consist of constructing rock ditch liners at locations shown on the plans or as directed by the engineer.

609.60.2 Material. The material for rock ditch liner shall consist of a predominantly one-sized, durable stone, shot rock or broken concrete. Acceptance by the engineer may be made by visual inspection. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Geotextile Fabric	1011

609.60.2.1 Type 1 Rock Ditch Liner shall consist of material with a predominant rock size of 3 inches, a maximum rock size of 6 inches and a gradation such that no more than 15 percent will be less than one inch.

609.60.2.2 Type 2 Rock Ditch Liner shall consist of material with a predominant rock size of 6 inches, a maximum rock size of 10 inches and a gradation such that no more than 15 percent will be less than 3 inches.

609.60.2.3 Type 3 Rock Ditch Liner shall consist of material with a predominant rock size of 12 inches, a maximum rock size of 20 inches and a gradation such that no more than
15 percent will be less than 4 inches.

609.60.2.4 Type 4 Rock Ditch Liner shall consist of material with a predominant rock size of 19 inches, a maximum rock size of 28 inches and a gradation such that no more than 15 percent will be less than 6 inches.

609.60.2.5 Bedding material shall be used under Type 3 and Type 4 Rock Ditch Liner. Bedding material shall consist of crushed stone or gravel with a gradation consisting of 100 percent passing the 3-inch sieve, 30 to 70 percent passing the 1 1/2-inch sieve and 0 to 15 percent passing the No. 4 sieve.

609.60.3 Construction Requirements. Rock ditch liner shall be placed to the approximate shape and thickness shown on the plans for the specified ditch or as directed by the engineer. The rock shall be dumped on a subgrade of reasonably uniform density and left in a rough condition meeting the approval from the engineer.

609.60.4 Method of Measurement. Rock ditch liner and bedding material will each be measured to the nearest cubic yard of material.

609.60.5 Basis of Payment.

609.60.5.1 If shown on the plans that the material for rock ditch liner is to be obtained from the right of way or other sources furnished by the Commission, the excavating, including all breaking, loading, and hauling, regardless of distance, to the site of the rock ditch liner will be paid for and considered completely covered under such contract items as Class A Excavation, Class C Excavation, Unclassified Excavation, Excavation for Structures or other applicable items. If payment is made under these conditions, separate payment for furnishing rock ditch liner will not be made.

609.60.5.2 If the plans show material for rock ditch liner to be secured from sources cited in Sec 609.60.5.1 and this material is made unsuitable or unattainable by the contractor's operations, the contractor shall provide suitable material and dispose of any surplus material at the contractor's expense.

609.60.5.3 If the contract documents provide for obtaining material from the right of way or other source furnished by the Commission, but all or part of the required quantity of acceptable material is not available, unless the shortage is due to the contractor's operations, payment for such additional rock base material that the contractor will be required to furnish and haul will be made per square yard at the fixed contract unit price in Sec 109, and will be measured in accordance with Sec 109.1.

609.60.5.4 If the plans do not provide for a source of material, the contractor shall provide the material. All

costs for securing the source, quarrying, excavating, breaking and hauling the material to the site will be paid for at the contract unit price for Furnishing Rock Ditch Liner.

609.60.5.5 Placing Rock Ditch Liner will be paid for at the contract unit price per cubic yard.

609.60.5.6 The accepted quantity of bedding material, complete in place, will be paid for at the contract unit price. No direct payment will be made for excavation or for any work necessary to prepare the subgrade for the bedding material.

609.60.5.7 No direct payment will be made for excavation below the upper surface of the rock ditch liner, or for any work necessary for preparing the subgrade and backfilling the completed item.

SECTION 609.70 ROCK LINING.

609.70.1 Description. This work shall consist of constructing rock lining at the locations shown on the plans or as directed by the engineer.

609.70.2 Material. The material for rock lining shall be in accordance with Sec 611.30 for Type 2 Rock Blanket.

609.70.3 Construction Requirements. The rock lining material shall be placed by dumping and left in a rough condition to the approximate shape of the channel bottom.

609.70.4 Method of Measurement. Final measurement of the completed rock lining will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. Where required, measurement will be made to the nearest cubic yard of material in place in the completed rock lining. The revision or correction will be computed and added to or deducted from the contract quantity.

609.70.5 Basis of Payment. The accepted quantity of rock lining, complete in place, will be paid for at the contract unit price. No direct payment will be made for any excavation required to place the rock lining.

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SECTION 610
PAVEMENT SMOOTHNESS

610.1 Description. This work shall consist of measuring the smoothness of the final pavement surface. Smoothness shall be measured using the International Roughness Index (IRI). The following pavement types shall comply with this specification:

a) Multi-lift asphalt construction greater than 3 inches contained in Secs 401 and 403.

b) Concrete pavement construction contained in Secs 502 and 506.

c) Combination of surface planning, such as diamond grinding or milling, and single lift asphalt construction or multi-lift asphalt construction less than or equal to 3 inches contained in Secs 401 and 403.

d) Single lift asphalt construction contained in Secs 401 and 403.

610.2 Material Requirements.

610.2.1 Inertial Profiler. IRI shall be computed from profile data collected with an inertial profiler (IP) that meets the requirements of AASHTO M 328

610.2.2 ProVAL Software. The ProVAL software program shall be used to compute IRI smoothness and locate areas of localized roughness (ALR) in accordance with MoDOT TM-59.

610.2.3 Straightedge. A rolling 10-foot straightedge shall be used for checking longitudinal elevation changes. A 4-foot straightedge shall be used for checking transverse elevation changes.

610.3 Certification. All inertial profilers used to collect data on MoDOT projects shall be annually certified at the MoDOT certification site in accordance with TM-59. The operator of the IP shall be certified through the MoDOT technician certification program.

610.4 Construction Requirements.

610.4.1 Smoothness Increments. Length of pavement shall be defined in the following increments for the purpose of smoothness acceptance:

a) Section – A section is a day's paving and shall begin and terminate at the construction joints. Interruptions designated by the engineer which cause placement to cease and begin at a new location will considered as a separate section for that day's operation if the separate section is greater than 250 feet.

b) Segment – Sections shall be divided into segments of 0.1 mile lengths with the exception of the last segment. If the last segment is greater than 250 feet and less than 0.1 mile, then the segment shall be measured for smoothness as an independent segment. If the last segment is 250 feet or less, the profile for that segment shall be included in the evaluation for the previous segment. The combined segment IRI shall be weighted for the length.

610.4.2 Profiling Areas.

610.4.2.1 Profiling will be applicable to the surface of all the following:

a) Mainline paving

b) Auxiliary lanes, turning lanes and ramps for projects or combination of projects, consisting of more than 0.5 mile of total profilable pavement.

610.4.2.2 Profiling will not be required for the following exceptions:

(a) Bridge decks, bridge approach slabs and concrete approach pavements.

(b) Pavement on horizontal curves with centerline radius of curve less than 1000 feet and pavement within the superelevation transition of such curves.

(c) Pavement on vertical curves having a "K" value less than 90 and a length less than 500 feet.

(d) Pavement width transitions.

(e) Fifty feet in direction of travel on each side of utility appurtenances such as manholes and valve boxes.

(f) Fifty feet in direction of travel on each side of intersecting routes.

(g) Shoulders.

(h) Interruptions designated by the engineer which provide independently placed sections shorter than 50 feet.

(i) The last 15 feet of any section where the prime contractor is not responsible for the adjoining surface.

(j) Any lane which abuts an existing lane not constructed under the same contract.

610.4.2.3 In addition to the exceptions in Sec 610.4.2.2, profiling may be waived by the engineer if staging of the overall project; such as multiple entrance lane gaps, lane staging, etc.; affects the normal paving operation, or if multiple profile exceptions continuously exist on a large portion of the same roadway. Upon waiver, exempted areas shall be checked with a 10-foot straightedge.

610.4.3 Longitudinal Straightedging. Any pavement surface not measured with an inertial profiler shall be measured with a 10-foot straightedge. The straightedge path in the longitudinal direction for driving lanes will be located three feet from the outside edge and for shoulders will be located in the center. Additional paths with suspect roughness may be selected at the engineer's discretion. Shoulders that are paved integrally with an adjacent driving lane will not require straightedging. The engineer also has discretion to use a straightedge for spot checking pavement that had been measured with an inertial profiler. Any variations in the longitudinal direction exceeding 1/4 inch in 10 feet on shoulders and 1/8 inch in 10 feet on all other pavements shall be marked for correction in a manner approved by the engineer.

610.4.4 Transverse Straightedging. The engineer shall randomly check driving lanes, regardless of the smoothness measurement method used, for variations in the transverse direction with a 4-foot straightedge. Any variations in the transverse direction more than 1/4 inch shall be marked for correction in a manner approved by the engineer.

610.4.5 Full Depth Pavement and Multi-lift Overlays > 3 Inches. These construction procedures apply to pavement treatments described in Sec 610.1 (a) and (b).

610.4.5.1 Quality Control Testing. The contractor shall perform quality control (QC) testing on all eligible profiling areas and provide electronic files for smoothness data in .PFF file format to the engineer in accordance with the testing and reporting procedures in MoDOT TM-59. Reported IRI for each segment is the average of both wheel paths. Furnishing inaccurate test results may result in decertification of the inertial profiler operator. Average segment IRIs shall meet the threshold require,ent in Table 1.

610.4.5.2 Quality Assurance Testing. The engineer will perform quality assurance (QA) testing with a MoDOT inertial profiler to verify the QC test results. The engineer shall select a continuous portion of roadway; not adjacent to the beginning or ending of the project limits and free to the degree possible of exempted areas, such as bridges; that constitute at least 10 percent of the project lane-miles, which will be designated as the QA test length. The beginning and ending of the QA test length shall be clearly marked with paint. Both the contractor and engineer shall measure the IRI in both wheel paths for the entire QA test length with their respective inertial profilers. The start and stop of the inertial profiler runs shall be triggered automatically. The contractor inertial profiler run on the QA test length may constitute the regular QC test result or may be run independently from previous QC test results. The contractor shall provide the electronic file for

the QA test length run in .PFF format to the engineer within 24 hours of testing. The IRI value for each segment within the QA test length shall be computed as the average of both wheel paths. The absolute value of the difference between the contractor and engineer IRIs shall be computed for each segment within the QA test length. The average of the absolute values of the IRI difference shall be 8 inches/mile or less. The absolute value of the IRI difference for any single segment shall be 12 inches/mile or less.

610.4.5.3 Areas of Localized Roughness. An area of localized roughness (ALR) is any length of pavement with a continuous 25-foot average IRI measured in the right wheel path that exceeds the maximum threshold set in Table 1. ALRs shall be corrected.

610.4.5.4 Method of Correction. Corrective action to eliminate ALRs and improve the average IRI shall be accomplished by a method approved by the engineer. Diamond grinding may be used for bumps, but the use of an impact device, such as a bush hammer, will not be permitted. Total grinding depth shall be limited to ¼ inch. Satisfactory longitudinal grinding is acceptable as the final surface of the corrected pavements. All corrective work shall be completed prior to determination of pavement thickness. The contractor shall reprofile the corrected lengths to verify smoothness compliance and submit an electronic data file in .PFF format to the engineer within 48 hours after testing.

Table 1

Treatment Type	Posted speed > 45 mph		Posted speed ≤ 45 mph	
	Maximum Segment IRI (in/mi)	**Maximum ALR IRI (in/mi)**	**Maximum Segment IRI (in/mi)**	**Maximum ALR IRI (in/mi)**
Full Depth Pavement or Multi-Lift Overlay > 3-inches Sec 610.1 (a) and 610.1 (b)	80.0	125.0	125.0	175.0
Multi-Treatment and Multi-Lift Overlays ≤ 3-inches	**Posted speed > 45 mph and AADT > 3500**		**Posted speed ≤ 45 mph or AADT ≤ 3500**	
	Maximum Segment IRI (in/mi)	**Maximum ALR IRI (in/mi)**	**Maximum Segment IRI (in/mi)**	**Maximum ALR IRI (in/mi)**
	80.0	175.0	125.0	175.0

610.4.6 Multi-treatment Overlays or Multi-lift Overlays ≤ 3 Inches. These construction procedures apply to pavement treatments described in Sec 610.1 (c).

610.4.6.1 Quality Control Testing. The requirements are the same as Sec 610.4.5.1, except that segment average IRIs shall meet the threshold requirements for multi-lift overlays less than or equal to 3 inches in Table 1.

610.4.6.2 Quality Assurance Testing. The requirements are the same as Sec 610.4.5.2.

610.4.6.3 Areas of Localized Roughness. All ALRs, as defined in Sec 610.4.5.3, that exceed the maximum threshold set in Table 1 shall be corrected.

610.4.6.4 Method of Correction. Corrective action to eliminate ALRs and improve the average IRI shall be accomplished with a method approved by the engineer. Diamond grinding bumps shall only be permitted for a 1½ inch or greater single lift overlay. Grinding depth shall be limited to ¼ inch. The contractor shall reprofile the corrected lengths to verify smoothness compliance and submit an electronic data file in .PFF format to the engineer within 48 hours after testing.

610.4.7 Single Lift Overlays. These construction procedures apply to pavement treatments described in Sec 610.1 (d).

610.4.7.1 Pre-Construction Quality Control Testing. Prior to performing any surface work or pavement repairs, the contractor shall profile the right wheel path in accordance with TM-59. This control profile will serve as the baseline for calculating percent improvement for the project.

610.4.7.2 Post-Construction Quality Control Testing. As soon as practical after resurfacing, the contractor shall profile the right wheel path again. The same stationing shall be used to ensure a direct comparison with the pre-construction profile.

610.4.7.3 Post-Construction Quality Assurance Testing. The requirements are the same as Sec 610.4.5.2, except that the testing shall only be performed in the right wheel path.

610.4.7.4 Method of Correction. Corrective action to improve the average IRI shall be accomplished with a method approved by the engineer. Diamond grinding bumps shall only be permitted for a 1½ inch or greater single lift overlay. Grinding depth shall be limited to ¼ inch. The final surface texture of corrected pavement shall be comparable to adjacent sections that do not require correcting.

610.4.8 Marred Surface Area. Any area of a segment that has corrective diamond grinding performed without grinding the entire segment shall be defined as a marred surface area.

610.5 Basis of Payment.

610.5.1 Fixed Value Improvement. The following basis of payment procedures shall apply to all pavement treatments described in Sec 610.1 (a), (b) and (c).

610.5.1.1 Smoothness Adjustment. Smoothness adjustments will be paid per segment based on the IRI before any corrections, except for the allowances in Sec 610.5.1.4. Any segment with an IRI above the maximum limit in Tables 2 and 3 must be corrected through a method approved by the engineer to achieve the desired smoothness. When paving widths are greater than the travel lane widths, incentive payment will apply to the driving lane design width only.

610.5.1.2 Incentives. Incentive payment for smoothness shall be based on either Table 2 or Table 3. Table 2 shall be used for all pavements, having a final posted speed greater than 45 mph, except multi-lift overlays less than or equal to 3 inches on routes with AADT less than or equal to 3500 and multi-treatment overlays on routes with AADT less than or equal to 3500. Table 3 shall be used for pavements having a final posted speed of 45 mph or less and multi-lift overlays less than or equal to 3 inches on routes with AADT less than or equal to 3500 and multi-treatment overlays on routes with AADT less than or equal to 3500 at any posted speed. Constant-width acceleration and deceleration lanes shall be considered as mainline pavements.

Table 2	
International Roughness Index, Inches Per Mile	**Percent of Contract Price**
40.0 or less	105
40.1 - 54.0	103
54.1 - 80.0	100
80.1 or greater	100[a]

Table 3	
International Roughness Index, Inches Per Mile	**Percent of Contract Price**
70.0 or less	103
70.1- 125.0	100
125.1 or greater	100[b]

[a]After correction to 80.0 inches per mile or less.
[b]After correction to 125.0 inches per mile or less.

610.5.1.3 Segment Correction. If the contractor elects to diamond grind an entire segment and the corrected surface drops below the maximum IRI limits in the designated Table, then the contractor cannot receive any incentives, but the marred surface area deductions for that segment will be waived.

610.5.1.4 Section Correction. If the contractor elects to diamond grind an entire section then all segments within the section will be eligible for their respective incentives and the marred surface area deductions for that section will be waived.

610.5.2 Percent Improvement. The following basis of payment procedures shall apply to all pavement treatments described in Sec 610.1 (d).

610.5.2.1 The contract price for resurfacing will be adjusted based on the improvement in profile index

according to Table 4 for each segment with an initial IRI greater than 60 inches per mile. Any segment with an initial IRI less than or equal to 60 inches per mile shall receive no percent improvement price adjustment if the segment IRI after placement of the overlay is also less than or equal to 60 inches per mile. Any segment with an initial IRI less than or equal to 60 inches per mile that has an IRI greater than 60 inches per mile after placement of the overlay shall be paid at 97 percent of the contract unit price for pavement, but no correction shall be required.

Table 4

Percent Improvement (Change in IRI / Initial IRI) X 100	Percent of Contract Unit Price For Pavement
35.0 or greater	103
20.0 to 34.9	100
0.0 to 19.9	97[c]

[c]After correction to 0.0 or greater

610.5.3 Marred Surface Deductions. A minimum deduction of 20 percent of the contract unit price of the paving quantities will be made for marred surface areas as defined in Sec 610.4.7. The deduction will be applied to an area of pavement extending from edge of the pavement to a longitudinal joint or between longitudinal joints in that section of pavement affected. If the length of the section affected is less than 10 feet, the deduction will be computed for 10 feet.

610.5.4 Testing Cost. The contract unit price for pavement will be considered as full compensation for all items entered into the construction of the pavement including the cost of smoothness testing.

610.5.5 Dispute Resolution. Any dispute between the engineer and contractor regarding IRI QC/QA comparisons that cannot be settled at the project office level shall be arbitrated with the MoDOT reference profiler per the test procedure in TM-59. The results of the reference profiler shall be binding for the engineer and contractor.

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SECTION 611
EMBANKMENT PROTECTION

SECTION 611.10 BLANK.

SECTION 611.20 BLANK.

SECTION 611.30 ROCK BLANKET.

611.30.1 Description. This work shall consist of constructing a protective blanket of rock or broken concrete on slopes or stream banks.

611.30.2 Material. The material for rock blanket shall be durable stone or broken concrete containing a combined total of no more than 10 percent of soil, sand, shale or non-durable rock. The material shall contain a large percentage of pieces as large as the thickness of the blanket will permit, with enough smaller pieces of various sizes to fill the larger voids. For Type 1 Rock Blanket, at least 40 percent of the mass shall be of pieces having a volume of one cubic foot or more. For Type 2 Rock Blanket, at least 60 percent of the mass shall be of pieces having a volume of one cubic foot or more. Acceptance of quality and size of material will be made by visual inspection at the job site.

611.30.3 Construction Requirements. A trench at the toe of the slope shall be excavated to the depth shown on the plans, or to a depth of 2 feet if not otherwise shown. The slopes shall be in accordance with the proper cross section and shall be compacted to a uniform density as required for adjacent material. The rock or broken concrete shall be placed on the slope, to the specified thickness, elevation and extent, and manipulated such that most of the flat sides are in contact, thereby eliminating large voids. The finished surface of the blanket shall present an appearance free from segregation and with a proportionate quantity of the larger pieces showing.

611.30.4 Method of Measurement. Measurement will be made to the nearest cubic yard of material in place in the completed blanket.

611.30.5 Basis of Payment.

611.30.5.1 If shown on the plans that the material for rock blanket is to be obtained from the right of way or other source furnished by the Commission, the excavating, including all breaking, loading and hauling, regardless of distance to the site of the rock blanket, will be paid for and considered completely covered under such contract items as Class A Excavation, Class C Excavation, Unclassified Excavation, Excavation for Structures, or other applicable items. If payment is made under these conditions, separate payment for furnishing rock blanket will not be made.

611.30.5.1.1 If the plans show material for rock blanket to be secured from such sources and this material is made unsuitable or unattainable by the contractor's operations, the contractor shall provide suitable material and dispose of any surplus material at the contractor’s expense.

611.30.5.1.2 If the plans provide for obtaining material from the right of way or other source furnished by the Commission, but all or part of the required quantity of acceptable material is not actually available, payment will be made under Sec 109 for the purchase and delivery of any additional rock blanket material that will be required.

611.30.5.2 If the plans do not provide for a source of the material, the contractor shall provide the material, and all costs of securing the source, quarrying, excavating, breaking and hauling the material to the site will be paid for and completely covered by the contract unit price per cubic yard for furnishing rock blanket. If material suitable for rock blanket is encountered within the limits of the right of way or other sources furnished by the Commission, and the material is used in the construction of the rock blanket, then payment will be made in accordance with Sec 611.30.5.1.

611.30.5.3 Payment for placing rock blanket will be made at the contract unit price per cubic yard. No direct payment will be made for excavating the trench or for backfilling.

SECTION 611.40 BLANK

SECTION 611.50 REVETMENT.

611.50.1 Description. This work shall consist of slope or bank protection of the type specified in the plans, constructed at locations shown on the plans or as directed by the engineer.

611.50.2 Material. Acceptance of quality and size of material will be made by visual inspection at the job site.

611.50.2.1 Stone for light stone revetment shall be sound, durable and free from cracks and other structural defects that would cause the revetment to deteriorate. The stone shall not contain any soapstone, shale or other material easily disintegrated. The stone shall be in blocks at least 7 inches thick perpendicular to the slope and shall have approximately rectangular faces 7 inches wide or more. All blocks shall weigh at least 25 pounds, and at least 75 percent shall weigh no less than 50 pounds.

611.50.2.2 Stone for heavy stone revetment shall be in accordance with Sec 611.50.2.1, except that the blocks shall be at least 12 inches thick perpendicular to the slope and all blocks shall weigh no less than 50 pounds, and at least 60 percent shall weigh no less than 100 pounds.

611.50.2.3 At the contractor's option, concrete blocks may be substituted for stone, provided the concrete blocks meet the size and weight specifications for stone. The blocks shall be made of either Class B concrete or concrete of a commercial mixture with material, proportioning, mixing, slump and transporting of concrete in accordance with Sec 501. Blocks may be precast and then laid in the required location, or the blocks may be cast in place on the slope, provided joints are spaced such that the joints will completely sever the concrete into blocks no larger than 2 x 4 feet with the long dimension horizontal and with vertical joints broken. If cast in place, concrete shall be placed, finished and cured in accordance with Sec 703.

611.50.2.4 The contractor may use broken concrete as blocks for revetment provided all protruding reinforcement, trash, asphaltic concrete, and other extraneous materials are removed prior to placement in waters of the United States, and their associated floodplains.

611.50.2.5 Broken concrete used as revetment shall be reasonably well graded, and contain a combined total of no more than 15 percent of soil or gravel. The gradation shall consist of pieces ranging in volume from 0.1 cubic foot to 1 cubic foot. The contractor shall break larger slabs to conform to this requirement. The maximum volume of any piece shall not exceed 3 cubic feet. Acceptance of the quality and size of this material will be made by visual inspection at the job site.

611.50.3 Construction Requirements. Unless otherwise approved, the slopes upon which revetment are to be placed shall be in accordance with the section shown on the plans. The slopes shall be compacted to a uniform density as required for adjacent material. The revetment shall be started in a trench below the toe of the slope shown on the plans and shall progress upward. Each stone or block shall be laid perpendicular to the slope, shall be firmly bedded against the slope and against adjoining stones or blocks, and shall be laid with well-broken joints. Only one layer of stone or blocks perpendicular to the slope will be permitted. After revetment has been placed, the voids shall be filled with spalls or small stones in such a manner that all revetment stones or blocks are tightly wedged. The finished surface shall present a uniform appearance true to line, grade and section.

611.50.4 Method of Measurement. Measurement of revetment will be made to the nearest square yard.

611.50.5 Basis of Payment. The accepted quantity of revetment will be paid for at the contract unit price for each of the pay items included in the contract. No direct payment will be made for excavating the trench or for any required backfilling.

SECTION 611.60 CONCRETE SLOPE PROTECTION.

611.60.1 Description. This work shall consist of constructing a concrete slope protection by placing concrete on the finished earth slope as shown on the plans.

611.60.2 Material. Slope protection shall be of Class B concrete, with material, proportioning, mixing, slump and transporting of concrete in accordance with Sec 501. Concrete shall be placed, finished and cured in accordance with Sec 703.

611.60.3 Construction Requirements.

611.60.3.1 Concrete shall be placed on a prepared, compacted subgrade of uniform density, and shall be consolidated and struck off to the required thickness. Joints shall be the full depth of the concrete and shall consist of material in accordance with Sec 1057.6.

611.60.3.2 The surface of the paved slope shall have a broom or burlap drag finish and shall be cured in the same manner as required for concrete pavement, except that transparent membrane shall be used in lieu of pigmented membrane.

611.60.4 Method of Measurement. Measurement will be made to the nearest square yard.

611.60.5 Basis of Payment. The accepted quantity of concrete slope protection will be paid for at the contract unit price. No direct payment will be made for any excavating or for other work necessary in preparing the subgrade or for any backfilling required.

SECTION 611.70 GABIONS.

611.70.1 Description. This work shall consist of installing welded wire fabric gabions and gabion mattresses, and twisted hexagonal mesh gabions and revet mattresses at locations shown on the plans or as directed by the engineer, and shall be of the size included in the contract.

611.70.2 Material.

611.70.2.1 The gabion baskets or mattresses shall be made of welded wire fabric or twisted hexagonal mesh. The baskets shall be in accordance with ASTM A 974 for welded wire fabric gabions and gabion mattresses and ASTM A 975 for twisted hexagonal mesh gabions and revet mattresses.

611.70.2.2 Rock used in the gabions or mattresses shall be crushed limestone with a maximum and minimum size according to the basket manufacturer’s recommendation.

611.70.3 Construction Requirements.

611.70.3.1 The contractor shall follow the manufacturer's recommended procedures for installation.

611.70.3.2 Cut compaction shall be performed in all Class A material areas where the baskets are constructed. The exposed material, to a depth of 6 inches, shall be manipulated and compacted to no less than the required density. The material above this compacted plane shall be spread in layers, each being wetted or dried as necessary and compacted to the specified density. The entire volume of material so handled and compacted, including the 6-inch layer compacted in place, will be considered as Compacting in Cut. All Class A material having a liquid limit of 40 or more, including the 6-inch layer compacted in place, shall be compacted at no less than the optimum moisture content.

611.70.3.3 Excavated material beyond the limits of the baskets shall be backfilled with gravel or crushed rock material meeting the approval of the engineer.

611.70.4 Method of Measurement.

611.70.4.1 The pay limits for excavation for gabions and mattresses will be a line coincidental with the bottom and non-exposed side of the baskets. Excavation quantities will be measured to the nearest cubic yard.

611.70.4.2 Measurement of gabions and mattresses will be made to the nearest cubic yard.

611.70.5 Basis of Payment.

611.70.5.1 The quantity to be paid for gabions and mattresses will be the number of cubic yards of gabions and mattresses measured in the final position. Job conditions and availability will determine the actual size of baskets to be used. Any costs that might occur will be included and paid for in the cost per cubic yard of gabions and mattresses.

611.70.5.2 Gabions and mattresses will be paid for at the contract unit price per cubic yard.

611.70.5.3 Excavation quantities will be paid for under the appropriate classified excavation items.

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SECTION 612
IMPACT ATTENUATORS

612.1 Description. This work shall consist of furnishing, installing, operating, maintaining, cleaning, relocating, replacing and removing impact attenuators as shown on the plans or as directed by the engineer in accordance with the manufacturer's recommendations.

612.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as shown below. Rock salt shall meet the satisfaction of the engineer.

Item	Section
Sand	1005
Retroreflective Sheeting	1042
Temporary Traffic Control Devices	1063

612.3 Safety Requirements. All impact attenuators shall be manufactured specifically for traffic control purposes and shall be in accordance with the MUTCD and any applicable safety and design codes. The contractor shall submit the manufacturer's certification that units supplied comply with crash test requirements of NCHRP 350, Test Level 3 and have received FHWA acceptance.

612.4 Construction Requirements.

612.4.1 Truck or Trailer Mounted Attenuator. A truck mounted attenuator or trailer mounted attenuator (TMA) shall be used for all moving operations conducted under traffic and as specified in the contract. Each TMA shall consist of an impact attenuator unit, a support vehicle, and a truck-mounted or trailer mounted flashing arrow panel. Any damaged TMA shall be removed from service and either repaired or replaced to the satisfaction of the engineer.

612.4.2 Sand Filled Impact Attenuator. Configuration, location, and relocation of the sand filled impact attenuators shall be as shown on the plans or as directed by the engineer.

612.4.2.1 Sand shall be measured and placed in accordance with the manufacturer's recommendations and weights shown for each module. Sand shall have a maximum moisture content of five percent at the time of installation. Rock salt shall be five percent of the required weight in each module, and shall be uniformly dispersed in the sand.

612.4.2.2 A decal designed as a Type I object marker with MoDOT fluorescent orange retroreflective sheeting or a Type 3 object marker with MoDOT Type 3 yellow sheeting shall be applied to the lead module facing traffic for arrays located 12 feet or less from the edge of the traveled way.

612.4.2.3 Damaged or deficient modules shall be replaced by the contractor in accordance with Sec 616.4.

612.4.2.4 When no longer needed, modules and sand shall be removed and shall remain the property of the contractor.

612.5 Basis of Payment.

612.5.1 Impact attenuators, including relocation, will be paid for at the contract unit price for each of the pay items included in the contract.

612.5.2 Furnishing and installing replacement sand barrels will be paid for at the contract unit price. Final payment for this item will be based on the actual number of modules replaced.

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SECTION 613
PAVEMENT REPAIR

613.1 Description. This work shall consist of performing full depth pavement repair, partial depth pavement repair, retrofitting dowel bars, or cross stitching pavement at locations as shown on the plans or as directed by the engineer.

613.2 Material. All material, unless specified otherwise in this specification, shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Epoxy or Polyester Bonding Agents for Dowels	1039
Concrete Curing Material	1055
Material for Joints	1057

613.3 Construction Requirements.

613.3.1 All pavement repair subsequent to sawing or removal of any pavement shall be accomplished in the same day, except as follows. If approved by the engineer, sawing may be accomplished the day before removal, but shall be repaired the following working day. Any damage caused to the pavement due to pre-sawing, such as edge spalling, shall be repaired by the contractor at the contractor's expense.

613.3.2 Repairs shall be made to only one lane at a time, unless the traffic control plan specifies otherwise. Any material that cannot be recycled shall be disposed of at a location furnished by the contractor, or at locations on the right of way approved by the engineer. If the material is disposed of outside the right of way, an acceptable written agreement with the property owner on whose property the material is placed shall be submitted to the engineer by the contractor.

613.3.3 If the repaired area is not to be resurfaced, the overcut from the sawing operation shall be filled with an expansive mortar, epoxy, polyester or joint material as approved by the engineer.

613.3.4 Weather limitations shall be in accordance with Sec 502 for placement of concrete material and Sec 403 for placement of bituminous material.

613.3.5 All repaired areas shall be finished to provide a smooth ride, and to the satisfaction of the engineer. Repaired areas shall be checked by stringline if required by the engineer. When stringlined, the surface of the repaired area shall not vary more than ⅛ inch per 10 feet
from a straight line between the surface of the existing pavement on each side of the repaired area, regardless of whether the repair is to be resurfaced or not.

613.3.6 Any damage to the existing pavement, joints and cracks adjacent to the pavement repair, caused by the contractor's operation shall be repaired at the contractor's expense.

SECTION 613.10 FULL DEPTH PAVEMENT REPAIRS.

613.10.1 Description. Full depth pavement repairs shall consist of removing specified areas of existing variable thickness Portland cement concrete pavement and subsequent bituminous overlays and replacing the removed material with non-reinforced Portland cement concrete as shown on the plans.

613.10.2 Construction Requirements.

613.10.2.1 Specified areas of full depth pavement repair shall be saw cut full depth around the perimeter of the patch prior to removal, except that cuts along the shoulder line may be waived by the engineer when the pavement can be removed without damage to the shoulder. An approved saw, such as a diamond saw, shall be used for perimeter cuts. A rock saw shall not be used for a perimeter cut, but may be used to make cuts through the interior portion of the area to be removed for stress relief. The full depth of the pavement shall be removed without mechanically breaking in place, and with a minimum disturbance of sound base. Any aggregate base disturbed by the contractor shall be recompacted or removed. Unstable base aggregate shall be removed and replaced in accordance with Sec 304 as directed by the engineer. Subgrade compaction shall be performed in areas of unstable subgrade in accordance with Sec 210, if directed by the engineer. If subgrade compaction is

performed, the aggregate base shall be replaced. Compaction shall be to the satisfaction of the engineer and inspection will be made visually.

613.10.2.2 All full depth pavement repairs exceeding 30 feet in length shall be constructed with tie bars along the longitudinal centerline joint in accordance with Sec 502. Dowel bars, tie bars and holes shall be as shown on the plans. Dowel bars and tie bars shall be epoxy coated. Bar holes shall be drilled to the specified diameter and to the depth shown on the plans. Equipment designed to drill multiple holes simultaneously will only be allowed provided such equipment causes no damage to existing pavement. The holes shall be blown clean and allowed to dry. The holes shall be injected with an approved epoxy or polyester bonding agent in accordance with Sec 1039.30 and shall fill the voids around the bar. The bonding agent shall be thoroughly mixed in accordance with the manufacturer's recommendations prior to injection into the holes. The bonding agent shall be injected into the hole by inserting the injection device to the back of the hole and slowly withdrawing the device while dispensing sufficient material to completely fill the void around the bar when inserted. Other methods may be used as approved by the engineer. The contractor shall use a method to prevent the bonding agent from flowing from the hole during placement of the bar and to create an effective face at the entrance of the hole. The bar shall be inserted into the hole with a twisting motion so the material in the back of the hole is forced up and around the bar. The bars shall be placed parallel to the surface and the centerline of the traveled way and shall not vary more than ¼ inch in alignment. Bars shall be firmly seated prior to placing concrete.

613.10.2.3 All material, proportioning, air-entraining, mixing and transporting of concrete shall be in accordance with Sec 501 as applicable to pavement concrete. The concrete may contain Type III cement, calcium chloride, an accelerator or other admixtures approved by the engineer.

613.10.2.4 Construction of full depth repairs shall be in accordance with Sec 502 except as follows.

613.10.2.4.1 The concrete shall have a minimum 28-day strength of 4000 psi. The design strength shall be verified by compressive strength testing of cylinders cured under the same conditions as the full depth repair patches. For QC testing by the contractor three 4- by 8-inch or two 6- by 12-inch cylinders of concrete from a single batch shall be cast for every 250 square yards of full depth repair. For QA testing by the engineer three 4- by 8-inch or two 6- by 12-inch cylinders of concrete from a single batch shall be cast for every 1000 square yards of full depth repair or at least once per project. The compressive strength shall be the average of the cylinder breaks.

613.10.2.4.2 The concrete shall have an air content in accordance with Sec 501.10.2. The air content shall be measured once for every day's production.

613.10.2.4.3 The concrete opening strength to all traffic shall be 2000 psi. The opening strength shall be verified by either compressive strength testing of cylinders in accordance with Sec 613.10.2.4.1, the maturity method in accordance with Sec 507, or in accordance with MoDOT TM-7 using a rebound hammer. If MoDOT TM-7 is used, the minimum rebound ratio number (RNN) for opening strength shall be 60.

613.10.2.5 If the concrete pavement has been previously resurfaced, the repair area shall be filled with Portland cement concrete to the surface of the existing bituminous overlay, even when the existing surface is to be removed by milling, unless contract provisions allow the milling to occur prior to the pavement repair operation.

613.10.2.6 When the concrete pavement requires all milled areas to be resurfaced in the same work day prior to opening the pavement to traffic, pavement repairs identified after milling will be marked for future repair, and the area shall be resurfaced as planned for that work day. No additional lifts of hot-mix asphalt will be allowed until the marked pavement is repaired. The pavement repair shall be performed in accordance with Sec 613.10.2.5.

613.10.2.7 Immediately after finishing and as soon as marring of the concrete will not occur, the entire surface of the newly placed concrete shall be cured in accordance with one of the following methods.

613.10.2.7.1 If the existing pavement has been or is to be resurfaced, an asphalt emulsion shall be applied at a rate of 0.1 gallon per square yard, or as directed by the engineer.

613.10.2.7.2 If the existing pavement surface is concrete and will not be resurfaced, curing shall be in accordance with Sec 502.

613.10.2.7.3 When the ambient air temperature is below 50 F, insulated curing mats, approved by the engineer, shall be used throughout the curing period. Curing compound or asphalt emulsion shall be applied prior to placing the insulated blankets. The insulated curing mats shall not be applied until the curing material has dried sufficiently to prevent adhesion.

613.10.2.8 Sawing of internal transverse and longitudinal joints and mitigation of uncontrolled cracking shall be in accordance with Sec 502.5.3.

613.10.3 Method of Measurement.

613.10.3.1 Measurement for full depth sawing will be made to the nearest linear foot for the combined length of perimeter diamond saw cuts and of internal transverse saw cuts at 6 foot or greater intervals.

613.10.3.2 Measurement for drilling dowel or tie bar holes and furnishing and installing dowels or tie bars will be made per dowel or tie bar.

613.10.3.3 Measurement for furnishing and placing Portland cement concrete will be made to the nearest 1/10 square yard.

613.10.3.4 Measurement of subgrade compaction will be made to the nearest square yard.

613.10.3.5 Measurement of aggregate base will be made to the nearest square yard.

613.10.4 Basis of Payment. Accepted quantities of full depth pavement repair will be paid for at the contract unit price for each of the pay items included in the contract. No direct payment will be made for aggregate base material used to replace unstable subgrade.

SECTION 613.20 CLASS A PARTIAL DEPTH PAVEMENT REPAIRS.

613.20.1 Description.

613.20.1.1 Class A partial depth pavement repair shall consist of repairing spalled areas or reestablishing joints or cracks in concrete pavement. Reestablishment of a joint or crack shall consist of removing concrete on each side of the joint or crack, placing a compressible insert to reestablish the joint or crack, and filling the area with Portland cement concrete, elastomeric concrete or epoxy mortar. This work shall be performed on concrete pavements that have not been resurfaced and are either not to be resurfaced as part of the contract work or the resurfacing is to be less than 3 inches thick.

613.20.1.2 If dowel bars are structurally damaged during the removal process, if the concrete below one half of the slab depth is unsound or damaged during removal, or if the area indicates pumping, movement of the subbase, or structural pavement failure, full depth pavement repair shall be performed in accordance with Sec 613.10.

613.20.2 Material.

613.20.2.1 Concrete coarse aggregate for Portland cement concrete shall be Gradation E or Grade F in accordance with Sec 1005 or an optimized aggregate gradation approved by the engineer. The optimized aggregate gradation shall have 100 percent passing the ¾ inch sieve. Portland cement concrete mix shall have an air content in accordance with Sec 501.10.2.

613.20.2.2 Elastomeric concrete components shall be in accordance with manufacturer recommendations. The Construction and Materials Division shall be consulted for product approval.

613.20.2.3 Epoxy mortars shall be in accordance with Sec 623.

613.20.2.4 Compressible inserts shall be rectangular and shall have a minimum thickness of ¼ inch. The material shall be preformed fiber expansion joint filler in accordance with Sec 1057 or, if approved by the engineer, other material may be used.

613.20.2.5 Type 2, Class B liquid membrane-forming compounds, in accordance with AASHTO M 148, shall

be used for curing Portland cement concrete patch material. Prior to use, the contractor shall provide to the engineer the manufacturer's certification that the curing material is in accordance with this specification. Elastomeric concrete and epoxy mortar patch materials shall be cured in accordance with manufacturer recommendations.

613.20.3 Construction Requirements.

613.20.3.1 Removal of Concrete. Repair limits shall extend beyond the delaminated or spalled area by one to two inches. Boundaries of any removal shall be kept square or rectangular. If repair areas are less than 2 feet apart, the areas shall be combined as one repair. The maximum amount of spalling allowed on the edges of the channel will be ⅜ inch. The minimum depth of removal shall be 2 inches for Portland cement concrete and according to manufacturer's recommendations for elastomeric concrete and epoxy mortar. The maximum depth of removal shall not exceed half the slab thickness. Concrete shall be removed by a milling process. Residue slurry from milling operations shall be removed in accordance with Sec 622.30.3.8. If the top of dowel bars are exposed but not structurally damaged, the exposed section of the dowel bar shall be coated with an approved bond breaker.

613.20.3.1.1 Milling. Milling equipment shall be in accordance with Sec 622.10, and shall be equipped with a device for stopping at a preset depth. Milling may be performed either across lanes or parallel to the pavement centerline. After milling, the bottom of the repair area shall be checked by sounding to ensure all unsound material has been removed. Any unsound material remaining shall be chipped free. All transverse sides of the removal shall be uniform and tapered 30° to 60° from vertical by milling or chipping. If excessive concrete is removed, or dowel bars are damaged to the extent to require full depth pavement repair, the cost for the repair shall be at the contractor's expense.

613.20.3.1.2 Full Depth Pavement Repair Required. If during the removal of material for partial depth pavement repair the pavement constituted full depth pavement repair in accordance with Sec 613.20.1.2, removal operations shall cease at that location. The contractor may conduct full depth pavement repair at that time, or temporarily patch the area and perform full depth pavement repair at a later date. If the location is opened to traffic prior to the full depth pavement repair, all loose material shall be removed and either a bituminous material approved by the engineer or a concrete mixture in accordance with Sec 613.20.2 shall be used to patch the location. Reestablishing joints or cracks in temporary repairs by sawing will not be required. Material provided for temporary patches shall be provided at the contractor's expense.

613.20.3.2 Cleaning. The exposed faces of the concrete shall be free of loose particles, oil, dust, traces of bituminous material and any other contaminants before repair material is placed. The procedure shall produce a clean, roughened surface, such as can be produced by sandblasting or, shotblasting. Containment and disposal of material from sandblasting or shotblasting shall be in accordance with Sec 202.2. All remaining loose material shall be removed with air blasting equipment just prior to placement of material. The air from the air blasting equipment shall be free of contaminants.

613.20.3.3 Joint and Crack Preparation.

613.20.3.3.1 Transverse Joints and Cracks. When placing a partial depth pavement repair directly against a transverse joint or crack, a compressible insert shall be placed against the joint or crack to form a bond breaker between the patch material and joint or crack. A pliable material shall be used to reform cracks along the existing paths. The new joint or crack shall be formed to the same width as the existing joint or crack. The compressible insert shall be placed into the existing joint to a minimum depth of one inch below the bottom of the repair and shall extend a minimum of one inche beyond each end of the prepared repair boundaries.

613.20.3.3.2 Longitudinal and Centerline Joints. When placing a partial depth pavement repair directly against the centerline or an adjacent lane joint, a compressible insert, a thin polyethylene strip no less than ⅛ inch thick or asphalt impregnated roofing felt shall be placed along the joint prior to placing the patching material.

613.20.3.3.3 Shoulder Joints. When placing a partial depth pavement repair along a lane and shoulder joint, the repair edge shall be formed if the shoulder is either soil, aggregate or bituminous material. The form shall be placed even with the surface and slightly below the repair depth. If the shoulder is concrete, then the repair interface at the joint shall be in accordance with Sec 613.20.3.3.2.

613.20.3.3.4 Reestablishment of Joint and Cracks. At locations where repairs include existing pavement joints, both longitudinal and transverse, the initial reestablishment of the joint in the plastic concrete shall be accomplished with an approved preformed joint filler and shall be made to the same width as the existing joint. Existing cracks shall be reestablished using a compressible insert of a width equal to the existing crack width, except the insert shall be no less than ¼ inch thick. The material insert shall be placed into the existing joint or crack to a minimum depth of one inch below the bottom of the repair, shall extend the full length of the joint or crack and shall extend to the top of the proposed pavement profile. The material shall prevent the concrete from flowing into the existing joint or crack. Sawing to reestablish the joint or crack will not be permitted.

613.20.3.4 Material Placement.

613.20.3.4.1 Bonding Material. Bonding material shall be applied in a thin even coat, shall cover the entire area, including the repair walls, shall overlap the pavement surface and shall be in accordance with the following.

613.20.3.4.1.1 For Portland concrete, Type II or Type III epoxy resin material in accordance with Sec 1039 or grout shall be used. When epoxy material is used, the concrete shall be placed while the epoxy is still tacky. If the epoxy sets prior to placement of the concrete, the hardened epoxy material shall be removed and the pavement repair area shall be cleaned in accordance with Sec 613.20.3.2. When grout is used, mortar shall be in accordance with Sec 1066, except it shall consist of equal parts of cement and sand. If the grout dries prior to placing the concrete, the dried or hardened grout shall be removed and the pavement repair area shall be cleaned in accordance with Sec 613.20.3.2.

613.20.3.4.1.2 For elastomeric concrete, the bonding material properties and application shall be in accordance with manufacturer recommendations.

613.20.3.4.1.3 For epoxy mortar, a neat low viscosity epoxy in accordance with Sec 623.20 shall be used.

613.20.3.4.2 Placement of Repair Material. Epoxy mortar shall not be used to repair spalls caused by reinforcing steel corrosion. No standing water shall be present at the time of placement of the material. Retempering of the Portland cement concrete mixture with water will not be permitted. Concrete material shall be placed into the channel and consolidated with a small spud vibrator. Vibrators with diameters greater than one inch will not be permitted. Care shall be taken not to touch the compressible insert with a vibrator. On very small repairs and as approved by the engineer, hand tools may be used to work the repair material and attain adequate consolidation. Elastomeric concrete shall be handled, prepared and mixed in accordance with manufacturer recommendations. Epoxy mortar components shall be handled, prepared and mixed in accordance with Sec 623. Any segregated areas shall be removed and replaced at the contractor's expense.

613.20.3.4.3 Finishing and Texturing. Repair material shall be finished to match the cross section of the existing pavement. The repair material shall be screed from the center of the repair out to the repair boundaries. Excess patch material from finishing may be used to fill any saw cut run-outs that extend beyond the repair perimeter, if the material can fully penetrate the run-outs, otherwise, an approved low viscosity epoxy shall be used to fill the saw cut run-outs. After finishing, the repair shall be appropriately textured to approximate the texture of the existing pavement.

613.20.3.4.4 Sealing and Curing. For Portland cement concrete patch material the repair and slab interface shall be sealed by painting the repair perimeter with a 1:1 cement-water grout. Concrete repair material shall be cured in accordance with Sec 502.6.1, except a double application of curing material in accordance with Sec 613.20.2.5 shall be placed over the repaired area. Elastomeric concrete shall be cured in accordance with manufacturer recommendations. Epoxy mortar shall be cured in accordance with Sec 623.

613.20.3.5 Opening to Traffic. Traffic shall not be permitted on the repaired pavement until the patch material has attained a minimum compressive strength of 1,600 psi, but shall be a minimum of two hours after placement or the time recommended by the manufacturer.

613.20.3.6 Acceptance. All pavement repairs will be sounded by the engineer prior to acceptance. Sounding will not be performed until the repair material has reached design compressive strength and the repair has been open to traffic for a minimum of 30 days. If sounding indicates unsound material, the entire pavement repair shall be removed to the limits designated by the engineer and replaced by the contractor at the contractor's expense.

613.20.4 Method of Measurement.

613.20.4.1 Measurement for repairing spalled areas, cracks or joints will be made to the nearest 1/10 square yard. Any material removed beyond the repair area designated by the engineer due to the removal methods used by the contractor will not be included in the measurement for pavement repair. Measurement of all concrete material furnished and placed in the repair of spalled areas, cracks or joints will be made to the nearest 1/10 cubic yard.

613.20.4.2 If an area designated for partial depth pavement repair requires full depth pavement repair in accordance with Sec 613.20.1.2, measurement for material removed as part of the partial depth pavement repair work at that location will be made to the nearest 1/10 square yard.

613.20.5 Basis of Payment. The accepted quantities for Class A partial depth pavement repair will be paid for at the contract unit price for each of the pay items included in the contract. Full depth pavement repairs required due to negligence by the contractor will be at the contractor's expense. All other full depth pavement repairs will be paid for in accordance with Sec 613.10.

SECTION 613.30 CLASS B PARTIAL DEPTH PAVEMENT REPAIRS.

613.30.1 Description.

613.30.1.1 Class B partial depth pavement repair shall consist of removing areas of unsound concrete or bituminous material to a maximum depth of one half of the concrete pavement thickness and replacing the unsound material with an approved bituminous mixture. This work shall be performed on projects that include resurfacing as part of the contract.

613.30.1.2 If dowel bars are structurally damaged during the removal process, if the concrete below one half of the slab depth is unsound or damaged during removal, or if the area indicates pumping, movement of the subbase or structural pavement failure, full depth pavement repair shall be performed in accordance with Sec 613.

613.30.2 Material. The material used for Class B partial depth pavement repairs shall be either the bituminous surface mix specified in the contract for resurfacing the existing pavement or a bituminous commercial mix in accordance with Sec 401.5.3 Tack material shall be in accordance with Sec 407.2.

613.30.3 Construction Requirements.

613.30.3.1 Removal of Bituminous and Concrete Material.

613.30.3.1.1 At areas shown on the plans or where unsuitable material is exposed during coldmilling operations and identified by the engineer to be repaired, all loose and unsuitable bituminous material shall be removed by milling or other approved methods. Concrete material shall be removed in accordance with Sec 613.20.3.1. Around the perimeter of the repair, the sides shall be relatively vertical, and concrete surfaces shall have a roughened face, such as can be produced by milling or other means approved by the engineer. The minimum depth of the repair shall be 2 inches. The area shall be cleaned to remove loose material and shall have a relatively uniform depth. If the top of dowel bars are exposed but not structurally damaged, the exposed section of the dowel bar shall be coated with an approved bond breaker.

613.30.3.1.2 If during the removal of material for partial depth pavement repair, the pavement constitutes full depth pavement repair in accordance with Sec 613.30.1.2, removal operations shall cease at that location. The contractor may conduct full depth pavement repair at that time, or the contractor may temporarily patch the exposed area in accordance with Sec 613.20.3.1.2, and perform full depth pavement repair at a later date.

613.30.3.2 Cleaning. The exposed faces of the concrete shall be free of loose particles, dust and any other contaminants before repair material is placed. The procedure shall produce a clean, roughened surface, such as can be produced by sandblasting, or shotblasting. Containment and disposal of material from sandblasting or shotblasting shall be in accordance with Sec 202.2. All remaining loose material shall be removed with air blasting equipment just prior to placement of material. The air from the air blasting equipment shall be free of contaminants.

613.30.3.3 Placement of Repair Material. The repair area shall be suitably tacked on the sides and bottom to ensure bonding of any remaining loose material, as well as bonding of the repair material. There shall be no ponding of the tack liquid at the time the area is filled. The repair area shall be filled with an approved bituminous surface mixture, and thoroughly compacted over the entire repair area to a density approved by the engineer. Areas greater than 3 inches in depth shall be filled in two lifts, each thoroughly compacted. Reestablishing of joints by sawing will not be required.

613.30.4 Method of Measurement.

613.30.4.1 Measurement of Class B partial depth pavement repairs for removing material will be made to the nearest 1/10 square yard. Any material removed beyond the repair area designated by the engineer due to the removal methods used by the contractor will not be included in the measurement for pavement repair. Measurement for furnishing and placing the bituminous material will be made to the nearest 0.1 ton.

613.30.4.2 If an area designated for partial depth pavement repair requires full depth pavement repair in accordance with Sec 613.30.1.2, measurement for material removed as part of the partial depth pavement repair work at that location will be made to the nearest 1/10 square yard.

613.30.5 Basis of Payment. The accepted quantities for Class B partial depth pavement repair will be paid for at the contract unit price for each of the pay items included in the contract. Payment for tack liquid is incidental to the pay item for furnishing and placing bituminous material. Full depth pavement repairs required due to improper means and methods by the contractor will be at the contractor's expense. All other full depth pavement repairs will be paid for in accordance with Sec 613.10.

SECTION 613.35 CLASS C PARTIAL DEPTH PAVEMENT REPAIR

613.35.1 Description. Class C partial depth pavement repair shall consist of performing repairs in asphalt pavements, including composite pavements that have an asphalt surface. This work includes removal of unsound pavement to the depth specified on the plans, or as directed by the engineer, and replacement with an approved asphalt mixture.

613.35.2 Material. The material used for Class C partial depth repairs shall be the asphalt surface mix specified in the contract, or a mix approved by the engineer.

613.35.3 Construction Requirements.

613.35.3.1 Removal of Bituminous Material. All unsuitable pavement shall be removed by milling or other method approved by the engineer. For composite pavements, the repair may extend into the underlying concrete pavement if deterioration is found at that depth. The minimum depth of repair shall be 2 inches. The repair area shall be square or rectangular in shape. The exposed faces of the repair area shall be cleaned to remove loose material. Material removed from the repair area shall be disposed of off right of way unless otherwise approved by the engineer.

613.35.3.2 Placement of Repair Material. The repair area shall be adequately tacked on the sides and bottom to ensure bonding of the repair material. The repair area shall be filled with the approved asphalt mixture and thoroughly compacted over the entire area to a density approved by the engineer. Areas greater than 3 inches in depth shall be filled and thoroughly compacted in two lifts. For pavements that will receive a final overlay, the final compacted surface of the repair shall be level with, or not more than ¼ inches above, the surrounding pavement. If the repair will be the final driving surface, smoothness shall be in accordance with Sec 610.4.3 and Sec 610.4.4.

613.35.4 Method of Measurement.

613.35.4.1 Removal of Bituminous Material. Measurement of removal for Class C partial depth repairs will be made to the nearest 1/10 square yard. For composite pavements, this removal includes both asphalt and concrete material. Any material removed beyond the repair area designated by the engineer due to the removal methods used by the contractor will not be included in the measurement.

613.35.4.2 Furnishing and Placement of Repair Material. Measurement for furnishing and placing the

asphalt repair material will be made to the nearest 0.1 ton.

613.35.5 Basis of Payment. The accepted quantities for Class C partial depth pavement repair will be paid for at the contract unit price of the pay items included in the contract. Payment for tack liquid is incidental to the pay item for furnishing and placing bituminous material.

SECTION 613.40 DOWEL BAR RETROFIT.

613.40.1 Description of Work. This work shall consist of sawing partial depth slots across cracks, cleaning the slots, placing dowel bars in the slots, placing a joint forming insert to reestablish the crack and backfilling the slots with concrete.

613.40.2 Material.

613.40.2.1 Repair Material. Rapid set concrete patching material shall be used. The maximum aggregate size in the gradation shall be ½ inch. Prior to use, the material shall be approved by the engineer. Material having completed current testing through AASHTO's NTPEP will be considered for qualification upon submittal of a written request by the manufacturer with accompanying documentation. The material shall be handled, prepared and mixed in accordance with the manufacturer's recommendations. The contractor shall supply a manufacturer's certification to the engineer for each lot of material furnished. Certification shall include the name of the manufacturer and a manufacturer's certification statement that the material supplied is the same as the material that was qualified.

613.40.2.2 Dowel Bars. Dowel bars shall be 1½ x 18 inches and in accordance with Sec 1057, except the entire dowel bar shall be coated.

613.40.2.3 Expansion Caps for Dowel Bars. Caps shall be tight fitting and made of ¼ inch thick non-metallic material that will allow ¼ inch movement at each end of the dowel bar.

613.40.2.4 Joint Insert. To re-establish the crack, a compressible insert, in accordance with Sec 613.20.2.4, shall be used. The material shall fit tight around the dowel bar and to the bottom and edges of the slot. The material shall be capable of remaining in a vertical position and tight to all edges during placement of the repair material to prevent the concrete backfill from flowing into the existing crack and pavement voids.

613.40.2.5 Bar Chairs. Bar chairs may be metal epoxy-coated chairs or a non-metallic material.

613.40.3 Construction Requirements.

613.40.3.1 Preparation of Slots. Two saw cuts shall be made in the pavement to outline the longitudinal sides of each dowel bar slot. The slots shall be sawed to a depth and length that allows the center of the dowel to be placed at mid-depth in the pavement slab. The slots shall be 2½ inches wide. The contractor shall provide a method, approved by the engineer, that will align the slots parallel to centerline of the roadway with a maximum variation of ⅛ inch from a true parallel line. Slots in a wheel path shall be created by using saws with gang-mounted diamond blades, capable of simultaneously making six saw cuts for three dowel bar slots at the desired slot spacing. Equipment shall not cause damage to the existing pavement. All saw slurry shall be removed from the slot and pavement. No water residue or paste shall be allowed to flow onto lanes open to traffic or into closed drainage systems. If pneumatic hammers or other equipment used during concrete removal operations cause damage to pavement that is to remain, the concrete removal operations shall be discontinued and shall not resume until the contractor has taken corrective measures. The pneumatic hammer will not be permitted to break through the concrete, and if this occurs, a full depth pavement repair shall be conducted at the contractor's expense. The bottom of slots shall be flat. The edges of the slots shall be cleaned by sandblasting to produce a rough surface. Blasting operations shall not damage the surrounding pavement. Containment and disposal of material from sandblasting shall be in accordance with Sec 202.2. The newly exposed concrete surface shall be free of spalls, burrs, latence and all contaminants detrimental to achieving an adequate bond. The maximum amount of spalling allowed on the edges of the slots will be ⅜ inch. The point of curvature at the bottom of either end of the slot shall be ½ inch beyond the dowel bars end.

613.40.3.1.1 After the construction of a slot, the pavement shall not be opened to traffic until all six retrofit dowel bars are in place, cured, and the work is completed at that location. The tires of construction vehicles will not be permitted to travel on slots where concrete has been removed.

613.40.3.1.2 Multiple saw cuts parallel to the centerline within the slot removal boundaries may be sawed to allow removal of material from the dowel bar slots and to provide a level surface for the feet of the dowel bar chairs.

613.40.3.1.3 All slots shall be cleaned with moisture-free, oil-free, compressed air to remove any remaining dust, residue, debris and moisture. The contractor shall then seal the existing transverse joint and all cracks at the bottom and the sides of the dowel bar slot with a silicone sealant to prevent any repair material from entering into these areas.

613.40.3.2 Placement of Dowel Bars, Joint Inserts and Repair Material.

613.40.3.2.1 Prior to inserting a dowel bar in a slot, expansion caps shall be placed on each end of the bar. A minimum ¼ inch gap shall be maintained in the expansion caps. A dowel bar chair shall hold the bar firmly centered in the slot and at a minimum of ½ inch above the bottom of the dowel slot. The dowel bar chairs shall not allow movement of the dowel.

613.40.3.2.2 When placing the dowel bar in the slot, care shall be taken to avoid getting any graphite grease onto the sides or bottom of the slot. If the debonding agent on the dowel bar contaminates any of the surfaces of the slot, the dowel bar shall be removed and the slot sandblasted to remove the contamination.

613.40.3.2.3 The dowel bar shall be inserted into the slot such that the chair legs are in the saw cut kerfs at the bottom of the slot. The bars shall vary no more than ¼ inch from the pavement surface and shall be parallel to the centerline of the pavement. Bars shall be firmly centered in the slot at the midpoint of the pavement slab. The legs of the bar chairs shall be snug against the slot wall.

613.40.3.2.4 A joint insert shall be placed into the slot as a filler material to maintain the crack as shown on the plans. When in place, the insert shall extend from the bottom of the slot to the surface of the pavement, with half the dowel length extending on each side of the insert. If for any reason the insert or dowel bars shift during placement of the repair material, the work will be rejected and shall be redone at the contractor's expense.

613.40.3.2.5 Just prior to placement of the repair material, one or more passes of an air blast shall be used to provide a dust free, clean slot.

613.40.3.2.6 The rapid set concrete patching material shall be placed in the slot, consolidated, textured and cured as recommended by the manufacturer.

613.40.3.3 Opening to Traffic. Traffic shall not be permitted on the repaired pavement until the rapid set concrete patching material has attained a minimum compressive strength of 1,600 psi, but shall be a minimum of 2 hours or the time recommended by the manufacturer.

613.40.4 Basis of Payment. The accepted quantity for dowel bar retrofit will be paid for at the contract unit price per dowel bar, complete in place.

SECTION 613.50 CROSS STITCHING.

613.50.1 Description of Work. The work shall consist of repairing longitudinal pavement cracks by pinning the pavement slabs together with a series of alternating tie bars.

613.50.2 Material.

613.50.2.1 Tie Bars. Tie bars shall be in accordance with Sec1057 and as shown on the plans.

613.50.2.2 Epoxy. Epoxy or Polyester Bonding Agents for Dowels shall be in accordance with Sec1039.

613.50.3 Construction Requirements

613.50.3.1 At each cross-stitch location, holes shall be drilled at a 35 degree angle to the pavement surface, starting a variable distance from the longitudinal joint, in a direction perpendicular to the crack. The drill bit diameter shall not exceed 1⅛ inch. Drilling shall alternate back and forth on either side of the longitudinal crack

from hole to hole. Drilled holes shall not penetrate through the bottom of the slab. Drilled holes shall contain no loose debris and be completely clean.

613.50.3.2 Epoxy shall be injected or poured into each hole. A tie bar shall be inserted in each hole such that the epoxy material is evenly distributed around the bar and extruding from the surface opening. Each bar shall be inserted far enough to allow 1½ inch of cover as shown in the plans.

613.50.3.3 The pavement surface shall have all excess epoxy removed and have a flush finish.

613.50.3.4 Traffic shall not be permitted on the repaired pavement until the epoxy bonding material has cured in accordance with the manufacturers recommendations.

613.50.4 Method of Measurement. Measurement of cross stitching will be made per tie bar at each individual location.

613.50.5 Basis of Payment. The accepted quantity for cross stitching will be paid for at the contract unit price per cross stitch tie bar, complete in place. No direct payment will be made for any drilling, cleaning or epoxy material necessary to complete the work.

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SECTION 614
DRAINAGE FITTINGS

SECTION 614.10 GRATES AND BEARING PLATES.

614.10.1 Description. This work shall consist of furnishing and installing parallel bar grates and bearing plates, and curved vane grates and frames of the size and design shown on the plans.

614.10.2 Material.

614.10.2.1 Parallel bar grates and bearing plates, and curb inlets shall be constructed of structural steel meeting the requirements of ASTM A 36 and shall be fabricated as shown on the plans. Welds shall be of full section and sound throughout. Obvious dimensional defects and structural discontinuity of welds will be cause for rejection. All welding residue shall be removed. All tightly contacting surfaces shall be completely sealed by welding. Removal of welding beads will not be required except on bearing surfaces. Parallel bar grates and bearing plates, and curb inlets shall be hot-dip galvanized after fabrication in accordance with AASHTO M 111. Bolts, nuts and washers shall be galvanized in accordance with AASHTO M 232 or shall be mechanically galvanized. If mechanically galvanized, the coating thickness, adherence and quality requirements shall be in accordance with AASHTO M 232, Class C. Damaged spelter coating shall be repaired in accordance with Sec 1081.

614.10.2.2 Curved vane grates and frames shall be constructed of cast gray iron, meeting the requirements of AASHTO M 306 and shall be fabricated as shown on the plans. Stainless bolts and washers shall be in accordance with Sec 901.3.

614.10.3 Construction Requirements. Parallel bar grates and bearing plates, curb inlets, and curved vane grates and frames shall be installed as shown on the plans. Curved vane grates shall be properly oriented to the direction of water flow. Curved vane grates installed at low points shall be oriented as directed by the engineer.

614.10.4 Basis of Payment. The accepted quantity of parallel bar grates and bearing plates, and curved vane grates and frames will be paid for at the contract unit price for each of the items included in the contract.

SECTION 614.20 AUTOMATIC FLOODGATE.

614.20.1 Description. This work shall consist of furnishing and installing automatic floodgates of standard design to fit the opening shown on the plans. Type 1 floodgates shall be installed on concrete structures. Type 2 floodgates shall be installed on corrugated metal pipe. Gates shall be of the off-vertical type if shown on the plans.

614.20.2 Material.

614.20.2.1 Automatic floodgates shall have a frame and flap constructed of cast iron meeting the requirements of AASHTO M 105, minimum Class 30.

614.20.2.2 Each link shall be provided with commercial grade bronze bushings permanently lubricated and installed at the factory. For hydraulic heads greater than 10 feet, the bottom of the links shall be provided with an adjusting screw to align seating faces on the cover properly with respect to the seat. For hydraulic heads less than 10 feet, adjusting screws will not be required, however, the seating faces on the cover shall properly align with respect to the seat. The links shall be designed to prevent the cover from rotating far enough to become wedged in the open position.

614.20.2.3 The seat shall be one-piece cast iron with a raised section around the perimeter of the waterway opening to provide the seating face, and shaped to provide two pivot bosses extended above the top of the waterway opening.

614.20.2.4 All anchor bolts, assembly bolts, screws and nuts shall be of stainless steel having ample section to withstand safely the forces created by operation of the gate under a hydraulic head. Quantity and size of anchor bolts shall be as recommended by the manufacturer, except there shall be a minimum of four bolts. Each anchor bolt shall be furnished with two nuts to facilitate installation and alignment of the flat back gates when attached to concrete.

614.20.2.5 The contractor shall furnish a manufacturer's certification that the floodgate being supplied is in accordance with the specified material requirements and that the floodgate will operate properly under the specified hydraulic head. If the hydraulic head is not specified, the height of fill above the pipe will be considered the hydraulic head.

614.20.3 Construction Requirements. Automatic floodgates shall be carefully machined, watertight and automatic in operation. Floodgates shall react to any difference in water level, and shall be hinged to seat accurately. Floodgates shall be attached in accordance with the manufacturer's recommendations for corrugated metal pipes or concrete structures.

614.20.4 Basis of Payment. The accepted quantity of automatic floodgates, complete in place including connection to concrete structure or corrugated metal pipe, will be paid for at the contract unit price for each of the items included in the contract.

SECTION 614.30 MANHOLE FRAME AND COVER AND CURB INLET.

614.30.1 Description. This work shall consist of furnishing and installing manhole frames and covers, curb inlets or any items of similar nature. Manhole frames and covers, curb inlets or any items of similar nature shall be of the size and type necessary to fit appurtenant details shown on the plans, shall be of a standard design and shall meet the approval of the engineer.

614.30.2 Material. The manhole frames and covers, curb inlets or any items of similar nature shall be constructed of cast iron in accordance with AASHTO M 105. Specific classes, if required, will be shown on the plans.

614.30.3 Construction Requirements. Bearing surfaces of both the frame and cover shall be finished to a non-rocking fit. The fixture shall be set securely as shown on the plans to prevent displacement during the placing of concrete. All concrete placed adjacent to the fixture shall be thoroughly vibrated.

614.30.4 Basis of Payment. The accepted quantity of these items or items of similar nature, complete in place, will be paid for at the contract unit price for each of the pay items included in the contract.

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SECTION 616
TEMPORARY TRAFFIC CONTROL

616.1 Description. This work shall consist of furnishing, installing, operating, maintaining, cleaning, relocating and removing temporary traffic control devices and equipment, and the removal and relocation or covering and uncovering of existing signs and other traffic control devices in accordance with the contract documents or as directed by the engineer. For purposes of this specification, the work zone will be defined as the area between the first and last temporary traffic control device as shown on the plans for the work being performed.

616.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Temporary Traffic Control Devices	1063

616.3 Safety Requirements.

616.3.1 All traffic control devices shall be in accordance with the MUTCD and any applicable safety and design codes.

616.3.2 The contractor shall furnish a manufacturer's certification of crashworthiness, per NCHRP 350 or AASHTO Manual for Assessing Safety Hardware (MASH) Evaluation Criteria, for FHWA Category 1 traffic control devices and appurtenances. The contractor shall furnish the FHWA acceptance letter for FHWA Category 2 and Category 3 traffic control devices and appurtenances. The FHWA acceptance letter shall indicate that the device and appurtenance complies with the crash test requirements of NCHRP 350 or (MASH), Test Level 3 (TL-3). Regardless whether the device meets NCHRP 350 or (MASH) criteria, the engineer reserves the right of final approval. Installation of a device prior to the engineer's approval will be at the contractor's risk.

616.3.3 The contractor shall:

(a) Designate an individual as the Work Zone Specialist (WZS) who is knowledgeable and competent by training and/or certification in the principles of proper temporary traffic control in accordance with Chapter 6 of the MUTCD, and who has the primary responsibility, with sufficient authority, for implementing the traffic management plan and other safety and mobility aspects of the project. The WZS shall be directly involved with daily traffic management, and shall communicate pertinent information with the engineer either in person or via telecommunication. Duties of the WZS shall include monitoring the work zone to ensure an efficient flow of traffic, correcting any failed or misaligned traffic control signs or devices, and recommending traffic management improvements to the engineer. The name, certification, and a 24-hour contact number for the WZS shall be provided to the engineer prior to the start of work. If the contractor makes a change in the designated WZS, the engineer shall be notified immediately. The WZS shall be trained and certified by a qualified person as defined by the Occupational Safety and Health Administration. The WZS shall have a card and/or certificate that includes the WZS's name, instructor's name and title, training entity/agency, date of training, and signature of the instructor. Re-certification shall be required a minimum of every four years.

(b) Ensure all contractor personnel are trained in traffic control to a level commensurate with their responsibilities.

(c) Obtain authorization from the engineer for any lane closure or traffic shift at least two working days prior to the planned closure or lane shift. Requests for complete road closures, or any imposition of height, width or weight restrictions shall be submitted to the engineer for approval at least 15 calendar days prior to the planned closure or restriction. The engineer reserves the right to deny any request for lane closure, traffic shift, road closure or restrictions of height, width or weight that the engineer determines could be in conflict with other known or anticipated traffic impacts, including but not limited to, outstanding permits that have been issued by the Commission for oversized or overweight loads.

(d) Perform quality control of work zones to promote consistency and ensure compliance with contract

documents, policies and guidelines.

616.4 Construction Requirements.

616.4.1 Performance and operational aspects of the devices shall be in accordance with the latest editions of the MUTCD and the Missouri Quality Standards for Temporary Traffic Control Devices.

616.4.1.1 All traffic control devices shall be removed as soon as practical when the devices are no longer needed. When work is suspended for short periods of time, traffic control devices that are no longer appropriate shall be turned away from traffic, removed or covered. All temporary traffic control devices shall be removed after the completion of construction and shall remain the property of the contractor unless specified otherwise. All permanent traffic control devices that are in conflict with temporary traffic control devices shall be covered or removed as shown on the plans or as directed by the engineer. Upon completion of the work, all permanent traffic control devices to remain in place shall be restored to original condition.

616.4.1.2 All sign covers shall meet the requirements of the MoDOT Quality Standards for Temporary Traffic Control Devices.

616.4.1.3 All permanent traffic control devices relocated on a temporary basis shall be moved in the timeframe designated by the engineer, and shall remain visible to the traveling public during all stages of construction. The contractor shall place temporarily relocated permanent traffic control devices in the final location when construction is complete. Damaged devices shall be replaced by the contractor at the contractor's expense.

616.4.2 The contract will indicate the minimum requirements for traffic control. With the engineer's approval, the contractor may add to the traffic control plan any temporary traffic control devices or services the contractor considers necessary to adequately protect the public and the work. Device quantities may be adjusted accordingly.

616.4.2.1 Signs and sign quantities for blasting areas will not be included in the contract traffic control plan. The contractor will be responsible for furnishing, installing, maintaining and removing blasting zone signs in accordance with the MUTCD, at the contractor's expense. Placement of blasting zone signs will be subject to approval from the engineer.

616.4.2.2 All changes to the traffic control plan resulting from contractor staging revisions, including proposed total road closures for the contractor's convenience, shall be submitted in writing to the engineer for review and acceptance prior to implementation. Device quantities may be adjusted accordingly.

616.4.2.3 If the engineer determines the need for additional traffic control devices not included in the traffic control plan, the contractor will be notified in writing to provide the additional devices. Reimbursement for authorized changes to the traffic control plan will be made in accordance with Sec 104.3, unless covered by contract unit prices.

616.4.2.4 The contractor shall monitor traffic flow through the project and verify that all traffic control devices are in place and functioning properly during both daytime and nighttime conditions, as applicable. If the contractor determines that a deficiency in any traffic control device exists, the contractor shall take corrective action. No additional payment will be made for the corrective action.

616.4.2.5 As soon as possible after observing a traffic control deficiency, the engineer will report the deficiency to the contractor, either verbally or in writing. After receiving notification, if the contractor does not make corrections within an agreed upon timeline, order records or suspension of the work may occur. Regardless of the severity of the deficiency, corrections shall be made as soon as possible to maintain a quality work zone.

616.4.2.5.1 The severity of a deficiency will be categorized as follows:

(a) Category 1 – Presents an immediate danger to the traveling public or workers and needs to be addressed immediately.

(b) Category 2 – The situation doesn't pose an immediate threat to either the public or the workers, but can impact the proper functioning of the work zone.

(c) Category 3 – The situation doesn't impact the functioning of the work zone but is more of a maintenance or aesthetic issue.

616.4.2.5.2 When the engineer determines that the contractor has not made a good faith effort in correcting a deficiency as agreed upon in Sec 616.4.2.5, an order record will be issued and the contractor will be notified of the following timelines to correct the deficiency.

(a) A Category 1 deficiency shall be corrected within one hour.
(b) A Category 2 deficiency shall be corrected within 24 hours.
(c) A Category 3 deficiency shall be corrected within 96 hours.

616.4.2.5.3 When the engineer determines the contractor has not made a good faith effort in complying with an order record issued in accordance with Sec 616.4.2.5.2, the following action may be taken:

(a) A second order record will be issued.
(b) The engineer may find the contractor in violation of the contract in accordance with Sec 105.

616.4.2.5.4 For reoccurring deficiencies of similar nature within the contractor's control, the engineer may issue order records in accordance with Sec 616.4.2.5.3, bypassing Sec 616.4.2.5.2 requirements.

616.4.2.6 The contractor shall provide written notice to the engineer of any pedestrian or vehicular accident when physical evidence or other information suggests an accident has occurred in the work zone. The contractor shall obtain and provide to the engineer copies of law enforcement accident reports for any accidents in the work zone.

616.4.3 Each flagger, automated flagger assistance devices (AFAD) operator, portable signal flagging device (PSFD) operator and pilot vehicle operator shall maintain a valid flagger certification card that certifies the individual has been trained by a qualified person as defined by the Occupational Safety and Health Administration, in the principles and procedures of flagging in accordance with Chapter 6 of the MUTCD. Flagger certification cards shall include the flagger's name, instructor's name and title, training entity/agency, date, and signature of the instructor. Flagger certifications shall be provided to the engineer prior to flagging operations. Flagger re-certification shall be required a minimum of every four years. Certifications will not be required in emergency situations that arise due to actions beyond the contractor's control when flagging is necessary to maintain safe traffic control on a temporary basis. All flagging, AFAD, PFD and pilot vehicle operations shall be in accordance with the MUTCD. Flaggers and pilot vehicles shall be provided as shown on the plans or as approved or directed by the engineer. When not specified in the plans, the contractor may use a Type B (Red/Yellow Lens) AFAD PSFD or pilot vehicle to supplement the flagging operation upon approval from the engineer. When two-way traffic is maintained over a single lane, each flagger, AFAD operator, if used in tandem, and pilot vehicle operator involved in the traffic flagging operation shall be equipped with a portable, two-way, communication system approved by the engineer. When the AFED or PSFD are not in use they shall be removed from the roadside.

616.4.4 Crossovers for hauling material will be permitted only at locations indicated in the traffic control plan or as authorized by the engineer. Modifications to specified locations shall be in accordance with applicable portions of Sec 104. Crossovers shall be signed in accordance with the traffic control plan. When the project has been completed, temporary crossovers shall be removed and the area restored to original condition. Existing crossovers shall be restored to original condition, including surface material.

616.5 Lighting Requirements.

616.5.1 Amber or Amber and White Warning Lights. All on-road construction-related vehicles and equipment shall operate with amber or amber and white warning lights having 360 degrees of total coverage and as follows:

(1) For daytime operations, SAE Class 1 or 2 lights shall be used.

(2) For dusk to dawn operations, SAE Class 2 lights shall be used, or SAE Class 1 lights with dimming capabilities to minimize glare experienced by travelers.

616.5.1.1 Red or Red and Blue Warning Lights. The contractor may elect to use red or red and blue warning

lights in accordance with Missouri law and the following requirements:

(1) Use of red or red and blue lights shall be limited to use on a total of two vehicles per work zone and/or project.

(2) Use of red or red and blue warning lights shall be limited to areas in advance of tapers or lane shifts and at the active work location.

(3) Lights shall be SAE Class 2 or SAE Class 1 with dimming capabilities to minimize glare experienced by travelers.

The awarded contract will serve as a permit by the Commission, granting the prime contractor and approved sub-contractors to utilize red or red and blue lights as required by Missouri law.

616.5.2 Work zone lighting shall be provided between dusk and dawn as specified in Secs 616.5.2.1 and 616.5.2.2. Lighting systems shall be positioned such that the lighting systems do not cause glare or hot spots, i.e. concentrated areas of high lighting intensity when compared to the average, for motorists, spillover to adjacent properties or become safety concerns. When work zone lighting is required, a lighting plan shall be submitted to the engineer for review 14 days prior to the start of operations. The lighting plan shall show the areas to be illuminated, the type and layout of the lighting systems and calculations of average maintained footcandles.

616.5.2.1 Work area lighting shall be provided in areas where construction equipment and labor are active. Lighting shall provide a minimum maintained intensity of 5 footcandles.

616.5.2.2 Overhead lighting shall be provided for flaggers and other specified locations shown on the plans. Lighting in these areas shall provide a minimum maintained intensity of 5 footcandles.

616.5.2.3 Type A, Type C, and Sequential lights shall be visible on a clear night from a distance of 3,000 feet (2). Type B lights shall be visible on a sunny day when viewed without the sun directly on or behind the device from a distance of 1,000 feet (2).

(1) Length of time that instantaneous intensity is equal to or greater than effective intensity.

(2) This visibility must be maintained within a solid angle 9-degrees on each side of the vertical axis, and 5-degrees above and 5-degrees below the horizontal axis.

Sequential flashing warning lights shall be placed within the merging taper and be able to communicate with other lights with the sequence. The lights should be capable of being spaced at least 60 feet apart with an offset capability of at least 6 feet.

Warning lights shall be battery- or solar-powered and consist of a single unit (head and housing).

616.6 Flashing Arrow Panel. The contractor shall deploy, operate and maintain flashing arrow panels as specified on the plans for the duration of the project, in accordance with the manufacturer's recommendations, at the contractor's expense. A minimum vertical clearance of 7 feet shall be maintained from the edge of pavement to the bottom of the flashing arrow panel.

616.6.1 When not in use, trailer-mounted flashing arrow panels shall be stored in accordance with Sec 107.5.

616.6.2 Control programs shall be as follows:

(a) Flashing Caution: Flash the two highest and two lowest lamps on panel simultaneously.

(b) Alternating Diamond Caution: Flash eight lamps in a form of a diamond and alternates diamonds from left side to right side.

(c) Flashing Left or Right Arrow: Flash five lamps in the arrowhead and five lamps in the horizontal shank simultaneously.

(d) Sequential Arrow Left or Right Arrow: Five lamps in the arrowhead will move across the panel.

The horizontal shank increases in length as the arrowhead moves across the panel.

(e) Double Arrow: Flash five lamps in both the left and right arrowheads and three lamps in the horizontal shank simultaneously.

The contractor has the option to use the sequential arrow or alternating diamond caution modes on mobile operations.

616.7 Changeable Message Signs. The contractor shall place the changeable message sign (CMS) at the location shown on the plans or as directed by the engineer. The CMS shall not be located in the median.

616.7.1 The contractor shall deploy, operate and maintain the CMS as specified in the traffic control plan and in accordance with the manufacturer's recommendations for the duration of the project at the contractor's expense. The contractor shall program the CMS as directed by the engineer.

616.7.2 When the CMS is not in use, the message board shall be turned away from traffic. When not required for longer than a 24-hour period, the CMS shall be stored in accordance with Sec 107.5.

616.8 Work Zone Traffic Signals. Work Zone Traffic Signals (WZTS) provide one-lane, two-way temporary traffic control through the use of a temporary traffic signal or a portable traffic signal programmed for two-phase operation. WZTS shall be in accordance with the provisions of this section. Unless otherwise shown on the plans, the contractor may choose either method to fulfill the WZTS requirement.

616.8.1 The contractor shall notify the engineer at least 48 hours prior to the work zone traffic signal installation. After installation, the contractor shall receive approval from the engineer prior to activating the WZTS system. The contractor shall provide a service technician to be available for day, night and weekend trouble calls as required under test period requirements in Sec 902. The contractor shall furnish the telephone number or other contact information where the technician can be reached.

616.8.1.1 The contractor shall operate and maintain the WZTS, at the contractor's expense, as specified in the traffic control plan until two-way traffic is restored.

616.8.1.2 When the WZTS is not in use, the signal heads shall be covered to the satisfaction of the engineer.

616.8.1.3 Adequate traffic control, including flaggers, shall be provided at the contractor's expense during the startup and shutdown of the WZTS installation. If the WZTS installation becomes inoperable due to alterations, malfunctions or periods of shutdown for required maintenance when one-way traffic control is required, the contractor shall provide adequate traffic control, including flaggers, at the contractor's expense.

616.8.1.4 All signal timing and programming shall be provided by the contractor and furnished to the engineer for approval prior to use. The contractor shall ensure proper signal timing is provided for the duration of the project. The contractor shall provide the locations of the vehicle detection zones.

616.8.1.5 The WZTS and lighting system shall be removed after two-way traffic has resumed or as directed by the engineer. All equipment shall remain the property of the contractor.

616.8.1.6 Measurement of WZTS systems, consisting of lighting and traffic signals at both ends of a one-lane, two-way section, will be made per each.

616.8.2 Temporary Traffic Signals. Temporary traffic signals and lighting shall be in accordance with Sec 902.3.

616.8.3 Portable Traffic Signals. Portable traffic signals shall be in accordance with Sec 1063. The contractor shall place the portable traffic signal (PTS) units a minimum of 6 feet beyond the edge of shoulder at the location shown on the plans or as directed by the engineer. Each unit shall be level to the satisfaction of the engineer. Each PTS shall be delineated with a minimum of five non-metallic drum-like channelizers. The PTS shall not be located in the median.

616.8.3.1 When not required for a longer than a 24-hour period, the PTS shall be stored in accordance with Sec 107.5.

616.8.3.2 The contractor shall deploy, operate and maintain the PTS in accordance with the manufacturer's recommendations. The contractor shall provide two copies of the operating manual to the engineer.

616.8.3.3 Overhead lighting with an average maintained intensity of 0.6 footcandles shall be provided and maintained at each PTS location as authorized by the engineer.

616.9 Portable Signal Flagging Device. Portable signal flagging devices (PSFD) shall be installed on each side of roadway per direction and in accordance with Sec 1063.9.

616.10 Radar Speed Advisory System.

616.10.1 The contractor shall place the changeable message sign Radar Speed Advisory System at the location shown on the plans or as directed by the engineer.

616.10.2 The contractor shall deploy, operate and maintain the Radar Speed Advisory System as specified in the traffic control plan an in accordance with the manufacturer's recommendations for the duration of the project at the contractor's expense. The contractor shall program the Radar Speed Advisory System as directed by the engineer and shall not include advertising, animation, rapid flashing, dissolving, exploding, scrolling, or other dynamic elements as stated in Chapter 2L of the MUTCD.

616.10.3 When the Radar Speed Advisory System is not in use, it shall be turned away from traffic. When not required for longer than a 24-hour period, the Radar Speed Advisory System shall be stored in accordance with Sec 107.5.

616.11 Method of Measurement. Measurement for relocation of post-mounted signs will be made to the nearest square foot of sign area.

616.12 Basis of Payment. All temporary traffic control devices authorized for installation by the engineer will be paid for at the contract unit price for each of the pay items included in the contract. No direct payment will be made for the following:

(a) Incidental items necessary to complete the work, unless specifically provided as a pay item in the contract.

(b) Installing, operating, maintaining, cleaning, repairing, removing or replacing traffic control devices.

(c) Covering and uncovering existing signs and other traffic control devices.

(d) Relocating temporary traffic control devices, including permanent traffic control devices temporarily relocated, unless specifically included as a pay item in the contract.

(e) Worker apparel.

(f) Flaggers, AFADs, PFDs, pilot vehicles, and appurtenances at flagging stations.

(g) Furnishing, installing, operating, maintaining and removing construction-related vehicle and equipment lighting.

(h) Construction and removal of temporary equipment crossovers, including restoring pre-existing crossovers.

(i) Provide and maintaining work zone lighting and work area lighting.

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SECTION 617
CONCRETE TRAFFIC BARRIER

SECTION 617.10 PERMANENT CONCRETE TRAFFIC BARRIER.

617.10.1 Description. This work shall consist of constructing permanent concrete traffic barrier as shown on the plans or as directed by the engineer. For purposes of this specification, permanent concrete traffic barrier will be defined as Type A, B, C, D or any modification of these types.

617.10.2 Material. All reinforcing steel shall be Grade 60 deformed bar, and all reinforcing steel and dowels shall be epoxy coated. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section/Specification
Reinforcing Steel for Concrete	1036
Concrete Curing Material	1055
Dowel Bars	1057
Preformed Fiber Expansion Joint Material	1057
Joint Sealer	1057
Joint Filler	1057
Prestressing Strands	AASHTO M 203

617.10.3 Construction Requirements.

617.10.3.1 Permanent concrete traffic barrier shall be constructed of Class B or B-1 concrete. Concrete shall be air-entrained with 28-day compressive strength of 4,000 psi. Material, proportioning, air-entraining, mixing, slump and transporting shall be in accordance with Sec 501. Concrete shall be placed and finished in accordance with Sec 703. Permanent concrete traffic barrier shall be cured in accordance with Sec 502.

617.10.3.2 Permanent concrete traffic barrier shall be constructed using an extrusion machine or forms specifically designed for constructing cast-in-place reinforced concrete traffic barrier. Precast units will not be permitted. Barriers that do not exhibit a consistent surface shall be corrected to the satisfaction of the engineer.

617.10.3.3 When extruded construction is used, station numbers shall be indented into the 10-inch high sloped face of the Type A and B barrier and 10 inches above the base of Type C and D barrier in accordance with Sec 502. Station numbers will not be required in the pavement when placed on the concrete traffic barrier.

617.10.3.4 For retrofit installation, dowels shall be installed in accordance with Sec 1039.30.

617.10.4 Method of Measurement. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity. Where required, measurement for each type of permanent concrete traffic barrier, including barrier height transitions, will be made to the nearest 1/2 linear foot for each continuous length and totaled to the nearest linear foot for the sum of the lengths.

617.10.5 Basis of Payment. Accepted permanent concrete traffic barrier will be paid for at the contract unit price for each of the types specified in the contract. No direct payment will be made for reinforcing steel, dowels, joint filler material, and sawed joints.

SECTION 617.20 TEMPORARY TRAFFIC BARRIER.

617.20.1 Description. This work shall consist of furnishing, installing, relocating and removing temporary traffic barrier as shown on the plans or as directed by the engineer. For purposes of this specification, temporary concrete traffic barrier will be defined as Type F concrete traffic barrier or approved alternate barrier system that meets MASH or NCHRP 350 criteria and has FHWA acceptance.

617.20.2 Material. All material shall be in accordance with Division 1000 Materials Details and Sec 1064.2.2.1.

617.20.2.1 All Type F temporary barrier shall be in a serviceable condition during installation and relocation as determined by the engineer.

617.20.2.2 Two-loop or three-loop temporary Type F concrete traffic barrier may be used at the option of the contractor.

617.20.2.2.1 For two-loop style temporary traffic barrier, as well as two-loop and three-loop styles used in combination, the bottom washer, retainer bolt and nut will be required. Visual cracks in the loop steel will be cause for rejection of the barrier unit by the engineer.

617.20.2.2.2 Existing two-loop concrete barrier owned by contractors or previously accepted two-loop concrete barrier in a manufacturer's stockpile (inventory) will be allowed for use on MoDOT projects if:

(a) The barrier was fabricated prior to January 1, 2004.

(b) Either the MoDOT acceptance stamp is legible on the barrier or certification is provided by the contractor stating that the barrier was fabricated prior to January 1, 2004, and in accordance with MoDOT specifications.

(c) The barrier is in acceptable condition.

617.20.2.3 Other types of temporary traffic barrier will be allowed if the barrier has been approved in accordance with Sec 1064 and meets the project specific need as approved by the engineer.

617.20.3 Certification. The contractor shall provide to the engineer a barrier manufacturer's certification that the barrier furnished is in accordance with the contract documents prior to use.

617.20.4 Construction Requirements.

617.20.4.1 As directed by the engineer, damaged units shall be immediately replaced and removed from the right of way at the contractor's expense.

617.20.4.2 All barrier sections shall remain the property of the contractor unless specified otherwise in the contract.

617.20.4.3 Equipment or material shall not be stored near temporary barriers within the limits shown on the plans or as approved by the engineer.

617.20.4.4 Anchoring of Type F temporary concrete traffic barrier shall be as shown on the plans. Other types of temporary traffic barrier shall be anchored in accordance with the manufacturer's recommendations.

617.20.5 Method of Measurement. Measurement of temporary traffic barrier and relocated temporary traffic barrier will be made to the nearest 1/2 linear foot for each continuous length and totaled to the nearest linear foot for the sum of the lengths. Measurement of temporary traffic barrier height transitions and relocated temporary traffic barrier height transitions will be made per each.

617.20.6 Basis of Payment. Accepted temporary concrete traffic barrier and temporary concrete traffic barrier height transitions will be paid for at the contract unit price for each of the pay items included in the contract. Accepted relocated temporary concrete traffic barrier and relocated temporary concrete traffic barrier height transitions will be paid for at the contract unit price for each of the pay items included in the contract.

SECTION 617.30 TRAFFIC BARRIER DELINEATORS.

617.30.1 Description. This work shall include furnishing, installing and maintaining retroreflectorized traffic barrier delineators as shown on the plans or as designated by the engineer.

617.30.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Delineators	1065

617.30.3 Construction Requirements.

617.30.3.1 Delineators shall be placed on all traffic barrier spaced at 50-foot intervals.

617.30.3.2 Delineator reflector colors shall correspond with pavement marking. Delineators shall be sheeted on one side, facing oncoming traffic, unless otherwise specified. Where permanent concrete traffic barrier divides opposing lanes of travel, the delineators shall have retroreflective sheeting on both sides corresponding to adjacent pavement marking.

617.30.3.2.1 Delineators mounted on permanent concrete traffic barrier shall be anchored with galvanized mechanical fasteners that prevent movement in accordance with the manufacturer’s recommendations.

617.30.3.2.2 Delineators mounted on temporary concrete traffic barriers shall be mounted to the traffic barrier in accordance with the manufacturer's recommendations.

617.30.3.3 Any damaged or missing delineators shall be replaced by the contractor at the contractor's expense.

617.30.4 Basis of Payment. No direct payment will be made for traffic barrier delineators provided on new permanent concrete traffic barrier or temporary traffic barrier. Delineators specified for installation on existing permanent concrete traffic barrier will be measured and paid for per each.

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SECTION 618
MOBILIZATION

618.1 Description. This item shall consist of the preparatory work and operations, including, but not limited to, those necessary for the movement of personnel, equipment, supplies and incidentals to the project site, for the establishment of all offices, buildings and other facilities necessary for work on the project, except as provided in the contract as separate pay items, payment for the actual cost of the contract bond and railroad liability insurance and for all other work and operations that must be performed or costs incurred prior to beginning work on the various items on the project site.

618.2 Basis of Payment. Payment for mobilization will be made incrementally as stated herein.

618.2.1 Reimbursement for Contract Bond and Railroad Liability Insurance. The contractor can receive reimbursement for expenditures incurred for contract bond and railroad liability insurance prior to the first incremental mobilization payment by submitting invoices to the engineer showing the amount expended for these services. The reimbursement payment will be made on the first estimate following the contractor's request. The amount of the reimbursement, not to exceed the contract price for mobilization, will be deducted from the contract price for mobilization and the remaining amount will be used to establish the partial payments defined in Sec 618.2.2.

618.2.2 Partial Payments. Each partial payment will be 25 percent of the contract price for mobilization, after any deductions made in accordance with Sec 618.2.1, or 2.5 percent of the original contract price, whichever is less. For purposes of this calculation, the original contract price will be construed as the total dollar value of all contract line items. The partial payments for mobilization will be paid incrementally as follows:

(a) The first partial payment will be made when five percent of the original contract amount is earned.

(b) The second partial payment will be made when ten percent of the original contract amount is earned.

(c) The third partial payment will be made when 25 percent of the original contract amount is earned.

(d) The fourth partial payment will be made when 50 percent of the original contract amount is earned.

(e) When the engineer has accepted the contract for maintenance in accordance with Sec 105, any remaining amount will be paid.

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SECTION 619
PAVEMENT EDGE TREATMENT

619.1 Description. This work shall consist of the elimination of pavement edge differential.

619.2 Material. Wedge slopes shall be constructed of an approved material or an approved preformed unit. Acceptance of wedge slope material will be based on visual examination.

619.3 Construction Requirements. At the contractor's option, elimination of pavement edge differential may be accomplished by either conducting operations in such a manner that traffic is exposed to no more than a two-inch differential, by constructing a wedge shaped slope adjacent to the pavement edge or by furnishing and installing temporary concrete traffic barrier in accordance with Sec 617.

619.3.1 Wedge slopes shall be constructed as shown on the plans or as directed by the engineer. Slope material, other than preformed units, shall be compacted to the satisfaction of the engineer.

619.3.2 Wedge slope material shall be removed and the pavement edge returned to a vertical face prior to placement of adjacent shoulder or pavement material. Material used to construct wedge slope shall be disposed of as approved by the engineer.

619.3.3 Temporary concrete traffic barrier shall be installed as shown on the plans or as directed by the engineer.

619.4 Method of Measurement. Final measurement will not be made except for authorized changes during construction or when appreciable errors are found in the contract quantities. Where required, measurement will be made to the nearest linear foot along each edge of pavement for all locations actually treated. No location will be measured more than once, regardless of the number of applications. The revision or correction will be computed and added to or deducted from the contract quantity.

619.5 Basis of Payment. The accepted quantity of pavement edge treatment will be paid for at the contract unit price for the units constructed. Payment will be considered full compensation for all labor, equipment and material to construct, maintain, replace, remove and dispose of pavement edge treatment. No direct payment will be made for more than one application at any location.

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SECTION 620
PAVEMENT MARKING

620.1 Description. This work shall consist of furnishing, installing, maintaining and removing temporary and permanent pavement marking as shown on the plans, as specified herein or as directed by the engineer.

620.2 General.

620.2.1 All roadways open to traffic shall have either temporary or permanent pavement markings. Temporary pavement marking may be used in lieu of permanent marking for no more than 14 days after completion of final paving operations or, in the case of pavement markings placed in rumble strips, for no more than 14 days after completion of rumble strips, except as otherwise allowed in Sec 620.10.2.3.1.

620.2.2 All pavement marking shall be in accordance with the latest edition of the MUTCD and the FHWA Standard Highway Signs at the time of the bid opening.

620.2.3 All pavement marking shall be uniform in appearance with crisp, well-defined edges and shall be uniform in width and thickness. Surface distribution of the beads shall be uniform.

620.2.4 Longitudinal pavement marking shall not be placed on longitudinal joints.

620.2.5 The contractor will be responsible for the protection of all liquid pavement marking until the pavement marking has reached a no-track state as determined by the engineer.

620.2.6 Damage to pavement marking as a result of the contractor's operations, including resurfacing of shoulders, shall be repaired or replaced at the contractor's expense.

620.2.7 All pavement marking shall be installed in accordance with this specification and all manufacturer's recommendations. Manufacturer's written application or installation instructions shall be provided by the contractor to the engineer.

620.2.8 When surface preparation is required, the area prepared shall be 1 inch wider than the final pavement marking and shall meet the requirements of Sec 620.20.1.4. The method of surface preparation shall not cause structural damage to the pavement and shall meet the approval of the engineer.

SECTION 620.10 TEMPORARY PAVEMENT MARKING.

620.10.1 General.

620.10.1.1 Quality Control and Quality Assurance. Quality Control and Quality Assurance shall be in accordance with Sec 620.40.

620.10.1.2 Temporary Pavement Marking following Obliteration of Existing Markings. When the contractor obliterates existing pavement markings by cold milling, grinding, resurfacing or for any other operation, the contractor shall, at the contractor's expense, provide and maintain temporary pavement marking in accordance with the plans and as specified in Sec. 1048.10 until permanent pavement markings are in place. The contractor shall place temporary or permanent pavement markings on all open lanes of traffic at the completion of each daily operation prior to leaving the work zone unattended. At no time shall more than one mile of roadway be unmarked. Pavement marking shall be replaced in the same configuration as the previously existing pavement marking unless otherwise shown on the plans or directed by the engineer.

620.10.1.3 Two-lane, two-way roadways shall be marked as shown on the plans. When TRPMs or tape is used to mark the centerline of two-lane, two-way roadways, no-passing zone signs shall be posted as shown on the plans in lieu of marking the no-passing zones. When paint is used for temporary markings the no-passing zone signs are not required, however the temporary paint shall be applied according to Sec 620.10.2.3.6 No-Passing Zones.

620.10.1.4 On resurfacing projects, when the adjacent layer of resurfacing has not been placed and the existing centerline or lane line marking has been obliterated, the temporary marking shall be placed on the higher layer at the centerline of the roadway or lane. Any temporary pavement marking damaged, displaced or missing before

the final pavement marking is installed shall be replaced at the contractor's expense within two hours upon notification from the engineer.

620.10.1.5 If temporary pavement marking is to be in place for more than the time limit specified in Sec 620.2.1, the engineer may require that temporary paint be placed and maintained at the contractor's expense. See Sec 620.10.2 for paint specifications.

620.10.1.6 For temporary marking durations of less than two weeks and when removal of the temporary marking is not required, temporary non-removable pavement marking tape may be used as specified in Sec 620.10.4.

620.10.1.7 Temporary Pavement Marking for Traffic Pattern Changes.. The contractor shall place temporary pavement markings for bypasses, lane shifts, narrow lanes and other traffic pattern changes as shown on the plans. Temporary paint shall not be used in lieu of tape without approval from the engineer. The contractor shall install and maintain temporary pavement marking until the permanent marking material has been placed as specified in the contract.

620.10.1.8 For temporary pavement marking of traffic pattern changes on the final driving surface that will require subsequent removal of the temporary markings, temporary removable pavement marking tape shall be used as specified in Sec 620.10.3, unless otherwise shown on the plans or approved by the engineer.

620.10.2 Temporary Pavement Marking Paint.

620.10.2.1 Description.. This work shall consist of furnishing and placing temporary pavement marking paint at locations shown on the plans or as directed by the engineer. The type of paint used for temporary pavement marking shall be standard waterborne, except that high build waterborne may be used in lieu of standard waterborne at no additional cost to the Commission. The weather limitations for standard and high build waterborne shall be as specified in Sec 620.20.2.4. When ambient air and surface temperatures are below 60° F, cold weather paint may be used in accordance with Sec 620.10.6 at no additional cost to the Commission.

620.10.2.2 Material.. Temporary pavement marking material paint and glass beads shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Standard Acrylic Waterborne Pavement Marking Paint	1048.20.1.1
Type P Drop-On Glass Beads	1048.30

620.10.2.3 Construction Requirements.

620.10.2.3.1 Temporary paint may be used as temporary pavement markings for the duration of the project. Retrorefletivity shall be maintained as specified in Sec 620.40.2.2.4, at the contractor's expense, for as long as the temporary pavement marking paint is in place.

620.10.2.3.2 The minimum thickness of the painted markings shall be no less than 15 mils. Lane lines, edge lines and no-passing lines shall be 4 inches in width. Type P beads shall be applied at a minimum rate of 15 lbs./100 sq.ft. of the painted surface area.

620.10.2.3.3 It is allowable to place a temporary paint line prior to cutting the rumble strip along that line. After cutting the rumble, the remaining portion of the temporary paint line is considered sufficient temporary pavement marking until the permanent line can be placed.

620.10.2.3.4 When temporary pavement marking paint is used on the final driving surface, and durable pavement marking is to be used for the permanent marking, all temporary paint shall be removed prior to applying the durable pavement marking. Removal will be at the contractor's expense unless otherwise specified in the contract. Removal shall be in accordance with Sec 620.20.1.4.

620.10.2.3.5 When temporary pavement marking paint is used on the final driving surface and paint is to be used for the permanent marking, all temporary paint shall be installed in the same location and in the same sequence as the final pavement marking such that no temporary pavement marking will be visible after the final pavement marking is installed. Any temporary pavement marking that remains visible after final pavement

marking shall be removed at the contractor's expense.

620.10.2.3.6 No-Passing Zones. When paint is used for temporary marking on two-lane, two-way roadways, all no passing zone lines shall be marked prior to leaving the work zone unattended.

620.10.2.4 Equipment. All equipment for application of pavement marking paint shall be as specified in Sec 620.20.2.3.

620.10.3 Temporary Removable Pavement Marking Tape.

620.10.3.1 Description. This work shall consist of furnishing, placing and maintaining temporary removable pavement marking tape at locations shown on the plans or as directed by the engineer.

620.10.3.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Temporary Removable Pavement Marking Tape	1048.10.2

620.10.3.3 Construction Requirements. All temporary removable pavement marking tape within the project limits shall be maintained by the contractor at the contractor's expense in a manner approved by the engineer. All temporary removable marking tape shall be installed according to the manufacturer's recommendations.

620.10.4 Temporary Non-Removable Pavement Marking Tape.

620.10.4.1 Description. This work shall consist of furnishing, placing and maintaining temporary non-removable pavement marking tape at locations shown on the plans or as directed by the engineer.

620.10.4.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Temporary Non-Removable Pavement Marking Tape	1048.10.3

620.10.4.3 Construction Requirements. Temporary non-removable pavement marking tape shall be installed according to the manufacturer's recommendations.

620.10.5 Temporary Raised Pavement Markers.

620.10.5.1 Description. This work shall consist of providing, installing, maintaining and removing retroreflective temporary raised pavement markers (TRPMs) on roadway lane lines, centerlines or edge lines as shown on the plans or as directed by the engineer.

620.10.5.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Temporary Raised Pavement Markers	1048.10.4

620.10.5.3 Construction Requirements.

620.10.5.3.1 TRPMs shall be of the colors shown on the plans unless otherwise directed by the engineer. Reflective faces shall be oriented to face traffic. TRPMs shall be installed according to the manufacturer's recommendations and placed as shown in the Missouri Standard Plans for Highway Construction

620.10.5.3.2 TRPMs, with covers, shall be used for Seal Coat as defined in Sec 409 and for surface treatment projects as defined in Sec 413 with the exception of Sec 413.30 and Sec 413.31.

620.10.5.3.3 On resurfacing projects, TRPMs shall be removed prior to placement of the next lift of asphalt. TRPMs placed on final wearing surfaces shall be removed in their entirety after permanent striping is placed.

No TRPMs, shall be left on Commission Right of Way.

620.10.6 Cold Weather Pavement Markings.

620.10.6.1 Description. Cold weather pavement marking paint is described as cold weather waterborne paint or cold weather acrylic copolymer fast drying paint that is manufactured for use within the weather limitations specified herein.

620.10.6.2 Applications. Cold weather pavement marking paint may only be used for temporary pavement marking or as a substitute for standard waterborne paint when approved by the engineer, at no additional cost to the Commission. Cold weather pavement marking paint shall not be used as a permanent pavement marking in lieu of high build waterborne paint or any durable pavement marking.

620.10.6.3 Weather Limitations. Cold weather paint shall not be used except when the ambient air temperature and pavement surface temperature is greater than 35° F but less than 60° F. The pavement surface temperature and ambient air temperature shall be ascending from 35° F before striping operations begin. Cold weather pavement marking shall not be applied if the weather forecast for the eight hour period immediately following final application includes precipitation or temperatures below 35° F.

620.10.6.4 Material. Cold weather pavement marking paint and glass beads shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Type P Drop-On Glass Beads	1048.30.2
Acrylic Copolymer Fast Dry Pavement Marking Paint	1048.10.1.1.1
Cold Weather Waterborne Pavement Marking Paint	1048.10.1.1.2

620.10.6.5 Construction Requirements. Cold weather pavement marking paint shall be applied to a wet thickness of no less than 15 mils. The mil thickness shall be increased as needed to account for the porosity of the pavement to achieve a target bead embedment of 60%. The wet film thickness of the applied paint may be tested with a paint thickness gauge as directed by the engineer. Type P beads shall be applied at a minimum rate of 15 lbs./100 sq.ft. of the painted surface area.

620.10.6.5.1 Paint may be heated before application to a maximum temperature of 120° F for waterborne paint and 125° F for acrylic copolymer paint.

620.10.7 Method of Measurement. Final measurement of temporary pavement marking paint, temporary removable tape, temporary non-removable tape and temporary raised pavement markers will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. No measurement will be made for any temporary pavement markings, regardless of type, when used as temporary pavement marking due to obliteration of existing markings as defined in Sec 620.10.1.2.

620.10.7.1 Measurement of temporary pavement marking paint, temporary removable marking tape and temporary non-removable marking tape, when required, will be measured per linear foot.

620.10.7.2 Measurement of Temporary Raised Pavement Markers (TRPMs), when required, will be measured per each.

620.10.8 Basis of Payment.

620.10.8.1. The accepted quantity of temporary pavement marking paint, temporary removable tape, temporary non-removable tape and temporary raised pavement markers will be paid for at the contract unit price for each of the pay items included in the contract. Payment will be made for initial installation only and not for repair or replacement.

620.10.8.2 No payment will be made for any temporary pavement markings, regardless of type, when used as temporary pavement marking due to obliteration of existing markings as defined in Sec 620.10.1.2.

SECTION 620.20 PERMANENT PAVEMENT MARKING.

620.20.1 General.

620.20.1.1 Quality Control and Quality Assurance. Quality Control and Quality Assurance shall be in accordance with Sec 620.40.

620.20.1.2 When installing permanent pavement marking, the contractor shall match the pavement marking sequence on the roadway just in advance of the project limits in order to provide a seamless and continuous marking from old to new pavement for future striping operations.

620.20.1.3 If the permanent pavement marking cannot be placed according to these specifications and the road is to be opened to traffic with no permanent pavement marking in place, the contractor shall, at the direction of the engineer, place and maintain temporary pavement marking at the contractor's expense. The contractor shall remove, collect and properly dispose of all temporary pavement marking and place the permanent pavement marking according to these specifications and as directed by the engineer.

620.20.1.4 Surface Preparation. The surface on which permanent pavement marking is to be placed shall be clean, dry and free of all debris, laitance, curing compound and any other contaminants that may hinder the adhesion of the system to the surface. Permanent pavement marking shall not be applied in damp conditions or if there is any evidence of surface moisture on the pavement.

620.20.1.4.1 Prior to the installation of durable pavement markings, any pre-existing pavement markings shall be removed to prepare the surface for the new application. Payment for the removal of pre-existing markings will be paid separately except when the pre-existing markings were placed by the contractor as temporary pavement markings.

620.20.1.5 Tolerance for Pavement Marking Lines.

(a) Lateral deviation from the planned alignment shall not exceed one inch in 100 feet.

(b) Width tolerance shall be as follows:

Pavement Marking Line Width	Tolerance
4-inch	± 1/4 inch
6-inch and 8-inch	± 1/4 inch
10-inch or greater	± 1/2 inch

(c) Length of intermittent lines shall be ±3 inches of the planned length.

620.20.2 Pavement Marking Paint.

620.20.2.1 Description. This work shall consist of furnishing and placing waterborne pavement marking paint and drop-on glass beads in accordance with these specifications at locations shown on the plans or as directed by the engineer.

620.20.2.2 Material. Material for application of pavement marking paint shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Drop-On Glass Beads	1048.30
Standard Acrylic Waterborne Pavement Marking Paint	1048.20.1.1
High Build Acrylic Waterborne Pavement Marking Paint	1048.20.1.2

620.20.2.3 Construction Requirements.

620.20.2.3.1 All equipment shall be designed for pavement marking and shall be maintained in such a condition to properly and evenly apply marking paint and drop-on glass beads per these specifications.

620.20.2.3.2 Paint shall be applied with self-propelled equipment using spray guns designed and adjusted to apply paint at the required thickness and width. Finished markings shall have well-defined edges, uniform cross section thickness and uniform bead distribution across the surface of the line. If there is any evidence of gun

clogging, splattering or uneven paint distribution, painting operations shall cease until equipment is restored to proper operation.

620.20.2.3.3 Waterborne paint shall not be heated above 120° F before application.

620.20.2.3.4 Waterborne paint shall only be used as specified in the contract and plans. Waterborne paint shall not be used for stop lines, arrows, words and symbols.

620.20.2.4 Weather Limitations.

620.20.2.4.1 The pavement surface temperature and air temperature shall be determined by the contractor each day prior to the pavement marking operation and at any other time deemed necessary by the engineer. Temperatures shall be obtained in accordance with MoDOT Test Method TM20.

620.20.2.4.2 For waterborne paint applications, the pavement surface temperature and ambient air temperatures shall be above 50° F and rising before marking operations may begin. Waterborne paint shall not be applied if the forecast conditions for the eight hours immediately following final application include precipitation or temperatures below 50° F.

620.20.2.5 Standard Waterborne Paint. Standard waterborne paint shall be applied to a wet thickness of no less than 15 mils. The mil thickness shall be increased as needed to account for the porosity of the pavement and to achieve a target bead embedment of 60%. The wet film thickness of the applied paint shall be tested by the contractor with a paint thickness gauge or by other methods approved by the engineer.

620.20.2.5.1 Type P drop-on glass beads, in accordance with Sec 620.30, shall be used for standard waterborne build paint applications.

620.20.2.6 High Build Waterborne Paint. High build waterborne paint shall be applied to a wet thickness of no less than 25 mils. The mil thickness shall be increased as needed to account for the porosity of the pavement and to achieve a target bead embedment of 60%. The wet film thickness of the applied paint shall be tested by the contractor with a paint thickness gauge or by other methods approved by the engineer.

620.20.2.6.1 Type L drop-on glass beads, in accordance with Sec 620.30.3, shall be used for high build waterborne paint applications.

620.20.2.6.2 For open-graded pavement surfaces such as UBAWS Type B and C, it is allowable to apply a primer coat of temporary paint prior to applying the High Build Waterborne Paint. When a primer coat is used, it shall be applied in accordance with Sec 620.10.2 and shall be fully cured prior to application of the surface coat in accordance with the manufacturer's recommendation or for a minimum of 12 hours, whichever is greater. No additional payment will be made for the primer coat except for locations where Temporary Pavement Marking Paint is provided in the contract.

620.20.3 Durable Pavement Markings

620.20.3.1 Durable Pavement Marking Lines.

620.20.3.1.1 Description. This work shall consist of furnishing and placing durable pavement marking lines in accordance with manufacturer's recommendations at locations shown on the plans or as directed by the engineer. Glass beads, when required, shall be in accordance with Sec 620.30.

620.20.3.1.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Durable Pavement Marking Materials	1048.20.2
Drop-On Glass Beads	1048.30

620.20.3.1.3 Equipment. The application equipment shall have a system capable of applying the material per manufacturer's recommendations.

620.20.3.1.4 Weather Limitations. The pavement marking shall only be applied during dry weather and on dry pavement surfaces. The pavement surface temperature and ambient air temperature shall be in accordance with the material manufacturer's recommendations throughout the application and during the specified time for curing of the material.

620.20.3.2 Durable Intersection Pavement Markings.

620.20.3.2.1 Description. This work shall consist of furnishing and placing white stop lines, arrows, words and symbols in accordance with the manufacturer's recommendations at locations shown on the plans or as directed by the engineer. Glass beads, when required, shall be in accordance with Sec 620.30.

620.20.3.2.2 Material. All material shall be in accordance with Division 1000, Material Details, and as specified in Sec 1048.20.2.3.

620.20.3.2.3 Construction Requirements.

620.20.3.2.3.1 Durable Intersection Pavement Markings shall be installed according to the manufacturer's recommendations. Material used shall be from the MoDOT Qualified Products list available at MoDOT.org. A copy of the manufacturer's installation instructions shall be provided to the engineer prior to the intersection pavement marking pre-activity meeting.

620.20.3.2.3.2 Intersection markings shall be installed in a groove when recommended by the material manufacturer and at no additional cost to the Commission. Surface mounting is allowable when that option is listed in the manufacturer's recommendations and the product is approved for surface mounting on MoDOT's Qualified Products list.

620.20.3.2.3.3 Arrows, words and symbols shall be white and may be formed from one piece or multiple pieces of preformed pavement marking material or a durable liquid marking method specifically designed for intersection marking.

620.20.3.2.4 Acceptance. Acceptance for durable intersection pavement markings shall be in accordance with Sec 620.40.2.2.1, except that a night time visual inspection will be made in lieu of measurement of retroreflectivity. If, in the opinion of the engineer, the retroreflectivity appears to be unacceptable, measurement of retroreflectivity will be made per MoDOT Test Method TM 80 for each intersection marking.

620.20.4 Method of Measurement.

620.20.4.1 Final measurement of permanent pavement marking will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

620.20.4.2 Where required, measurement of 4-inch, 6-inch, 8-inch, 12 inch and 24-inch pavement marking will be made to the nearest linear foot. Where intermittent lines are specified, deductions will be made for the gaps in pavement marking.

620.20.4.3 Where required, measurement of durable intersection markings will be made per each.

620.20.5 Basis of Payment.

620.20.5.1 The accepted quantity of permanent pavement marking lines and intersection markings will be paid for at the contract unit price for each of the pay items included in the contract, except as specified in Sec 620.20.5.2.

620.20.5.2 Payment for permanent pavement marking lines shall be adjusted based on retroreflectivity measurements per Sec 620.40.2.2.4.

SECTION 620.30 DROP-0N GLASS BEADS

620.30.1 Drop-On Glass Bead Application. Drop-on glass beads shall be mechanically applied to the pavement marking directly behind the material application guns. The glass beads shall be applied in a manner

that prevents the glass bead from rolling and covering the surface of the glass bead with pavement marking material. The application shall result in approximately 60% embedment of the glass beads into the pavement marking. Glass beads shall be applied evenly and shall completely cover the painted area. If beads are not embedding properly all operations shall cease until corrective actions are made.

620.30.2 Material. All material shall be in accordance with Division 1000, Material Details, and as specified in Sec 1048.30.

620.30.3 Type P Glass Beads. Type P glass beads shall be applied at a minimum application rate of 10 lbs. per 100 sq.ft. of surface area of pavement marking material.

620.30.4 Type L Glass Beads. Type L glass beads shall be applied at a minimum application rate of 15 lbs. per 100 sq.ft. of surface area of pavement marking material in order to achieve desired wet reflectivity characteristics.

620.30.5 Basis of Payment. No payment will be made for drop-on glass beads. The cost of providing and placing glass beads is included in the cost of pavement marking paint and durable pavement marking.

620.40 Quality Control and Quality Assurance.

620.40.1 Quality Control. The contractor shall control and monitor the quality of the work for all temporary and permanent pavement markings and removal.

620.40.1.1 QC for Temporary and Permanent Pavement Marking Paint. The contractor shall ensure paint and bead applications meet all contract requirements by conducting quality control (QC) evaluations including, but not limited to, calibration of the paint and bead application guns for the predetermined striping speed before beginning pavement marking operations, periodic verification of wet mil thickness, periodic measurement of line width, monitoring of the bead application rate and visual inspections of the bead embedment, distribution and retention.

620.40.1.1.1 Initial QC evaluations shall be conducted at the start of each pavement marking operation each day as well as at the start of marking on each type of pavement surface. Thereafter, periodic checks shall be conducted as needed to ensure quality work is maintained throughout the marking operation.

620.40.1.1.2 Air and surface temperatures shall be checked in accordance with Sec 620.20.2.4.1 at the start of each day prior to beginning pavement marking operations.

620.40.1.2 QC for Durable Pavement Marking. All applicable QC measures in Sec 620.40.1.1 shall also apply to durable pavement markings, as well as any additional QC measures included in the manufacturer's recommendations.

620.40.1.3 QC for Temporary Raised Pavement Markers. Temporary raised pavement markers shall be monitored and maintained in place as specified in the Missouri Standard Plans for Highway Construction.

620.40.2 Quality Assurance. The engineer or designated representative will be responsible for monitoring the work and quality control efforts of the contractor. Measurement of retroreflectivity of the pavement markings shall be done by the engineer.

620.40.2.1 Retroreflectivity. The engineer will measure the average retroreflectivity of pavement markings with a 30-meter geometry mobile retroreflectometer for each 0.1 mile segment per line. At the engineer's discretion, such as for small quantities of permanent pavement markings or for any quantity of temporary pavement marking, the engineer may use a hand held retroreflectometer in accordance with MoDOT Test Method TM 80 to measure retroreflectivity.

620.40.2.1.1 Measurement of retroreflectivity will not be done within the first fourteen (14) days following completion of all pavement marking. The contractor is responsible for ensuring the pavement markings are clean and protected from damage prior to measurements being taken. Any failed retroreflectivity readings due to unclean pavement markings or for other surface damage shall not be grounds for dispute of the readings.

620.40.2.2 Acceptance.

620.40.2.2.1 Pavement marking will be evaluated by the engineer for acceptance following installation. The engineer will notify the contractor of any pavement markings that fail to meet acceptance. Reasons for failure could include, but are not limited to, failed retroreflectivity readings, incorrect color, incorrect location, poor alignment, poor adherence to the pavement surface, insufficient thickness, width or length and insufficient bead embedment.

620.40.2.2.2. Once notified by the engineer of any failed permanent pavement markings, the contractor shall repair or replace the failed areas within 30 days at no cost to the commission.

620.40.2.2.3 After acceptance of the permanent pavement markings by the engineer the contractor shall be released from further performance responsibility except for latent defects.

620.40.2.2.4 Retroreflectivity (millicandelas/m2/lux) acceptance requirements and payment adjustments for painted and durable lines shall be as follows and as defined herein:

Standard Waterborne Paint (Type P Beads)		
White	**Yellow**	**% Payment**
≥350	≥275	105%
300-349	225-274	100%
270-299	196-224	80%[a]
High Build Waterborne Paint (Type L Beads)		
White	**Yellow**	**% Payment**
≥450	≥350	105%
400-449	300-349	100%
300-399	225-299	80%[a]
Durable Pavement Marking Lines (Type L Beads)		
White	**Yellow**	**% Payment**
≥450	≥350	105%
400-449	300-349	100%
300-399	225-299	80%[a]
Waterborne Paint on Seal Coat Surfaces		
White	**Yellow**	**% Payment**
≥150	≥150	100%
Temporary Pavement Marking Paint		
White	**Yellow**	**% Payment**
275[b]	200[b]	100%
≥200[c]	≥175[c]	Maintain

[a]Contractor has the option to accept this deduction or to correct and improve payment.
[b]Minimum requirement for initial application of temporary paint.
[c]Temporary paint shall be maintained to this level at the contractor's expense until permanent marking is installed.

620.40.2.2.4.1 Paint markings that fail to meet acceptance requirements, including retroreflectivity readings, shall be reapplied at the contractor's expense. Durable markings that fail to meet acceptance requirements, including retroreflectivity readings, shall be removed and replaced at the contractor's expense.

620.40.2.2.4.2 Payment Adjustment. After all 0.1 mile segment of permanent painted and durable pavement marking lines have been completed, and corrected when necessary, to a level that meets or exceeds all acceptance criteria, payment adjustments will be applied to each 0.1 mile segment for final retroreflectivity readings in accordance with Sec 620.40.2.2.4.

620.40.2.2.4.2.1 When a subsequent measurement of retroreflectivity is necessary due to corrective work, and the 30-meter geometry mobile retroreflectometer is needed to perform the subsequent measurement, the actual cost to the Commission to perform the subsequent measurement will be deducted from the payment made to the contractor for pavement marking.

SECTION 620.50 PAVEMENT MARKING REMOVAL

620.50.1 Description. This work shall consist of all necessary operations for removal of existing pavement marking lines and intersection markings as shown on the plans or directed by the engineer.

620.50.2 Construction Requirements. All pavement marking designated for removal, regardless of the type of existing marking, shall be completely removed to the satisfaction of the engineer with minimal damage to the pavement. No more than five percent of the existing marking shall remain upon completion of the work. The pavement surface shall not be left scarred to such an extent that, in the opinion of the engineer, the obliterated area is misleading to motorists. Any excess damage or scarring of the pavement shall be repaired at the contractor's expense.

620.50.3 Method of Measurement.

620.50.3.1 Final measurement will not be made, except for authorized changes, during construction or where significant errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

620.50.3.2 Where required, measurement for the removal of pavement markings will be made to the nearest linear foot per 4-inches of width. For intermittent lines, deductions will be made for gaps in the removal. Measurement will not be made for removal of pavement marking within the limits of a bypass roadway or other roadway to be obliterated at the completion of the project. Measurement of symbols will be made per each.

620.50.4 Basis of Payment. The accepted quantity of pavement marking removal will be paid for at the contract unit price for each of the pay items included in the contract.

SECTION 620.60 Contrast Pavement Markings.

620.60.1 Description. This work shall consist of furnishing and installing black contrasting pavement marking for intermittent markings (skips), dotted lines and solid intersection lane lines on concrete surfaces that have a continuous length greater than 1000 feet.

620.60.2 Material. The black contrast marking shall be compatible with the white pavement marking material specified in the plans.

620.60.3 Construction Requirements.

620.60.3.1 The contrast markings shall be accomplished by placing the black pavement marking according to manufacturer’s recommendations.

620.60.3.2 The white marking shall be centered within the black marking such that there will be a 1.5 inch border of black on both sides of the white marking. Tolerances for the width and length of the black and white markings shall be in accordance with Sec 620.20.1.5.

620.60.4 Basis of Payment. There will be no direct payment for Contrast Pavement Markings.

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SECTION 621
FLOWABLE BACKFILL

621.1 Description. This work shall consist of furnishing flowable backfill as specified on the plans or otherwise permitted for compacted backfill and other cavity filling uses.

621.2 Material.

621.2.1 All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Fly Ash	1018
Cement	1019
Admixtures	1054
Water	1070

621.2.2 Fine aggregate shall be in accordance with Sec 1005.3, except for the percent passing the No. 200 sieve. Aggregate shall be fine enough to stay in suspension in the mortar to the extent required for proper flow, and shall be in accordance with the following gradation:

Sieve Size	Percent Passing
3/4 inch	100
No. 200	0-10

621.3 Composition of Mixture. The contractor shall submit to the engineer a mix design with the proportions and source of material, admixtures, dry cubic yard batch weights and actual 28-day compressive test results. The 28-day compressive strength of the mixture shall exceed 50 psi.

621.3.1 Consistency. Flowable backfill will be tested by filling an open-ended 3-inch diameter, 6-inch high cylinder to the top with the mixture and immediately pulling the cylinder straight up. The correct consistency of the mixture shall produce an approximate
8-inch diameter circular-type spread with no segregation. Adjustments to the proportions of fine aggregate or water may be made to achieve proper solid suspension and optimum flowability with approval from the engineer, except the theoretical yield shall be maintained at one cubic yard for the given batch weights.

621.3.2 Commercial Mixtures. Approved commercial brand mixtures intended specifically for use as flowable backfill may be used, provided the specified strengths are obtained.

621.3.2.1 If approved for use, the material shall be placed in accordance with the manufacturer's recommendations, and a copy of the manufacturer’s recommendations shall be furnished to the engineer.

621.3.2.2 The manufacturer shall submit a request for approval along with appropriate documents to Construction and Materials for testing and evaluation. Upon approval of the material, the brand name will be placed on a list of qualified commercial brand flowable backfill material.

621.4 Construction Requirements.

621.4.1 The open ends of the area to be backfilled shall be plugged, and the void area filled without the use of a vibrator.

621.4.2 Care shall be taken to prevent the movement of any structure from the designated location or intrusion of flowable backfill into undesirable locations. If such movement or intrusion occurs, the engineer may require the affected structure to be excavated and replaced to the proper grade at the contractor's expense.

621.4.3 If flowable backfill is placed in more than one layer, the base layer shall be thoroughly roughened and all loose and foreign material removed before placing the next layer.

621.4.4 No flowable backfill shall be covered or accepted until a minimum compressive strength of 30 psi has been attained, as demonstrated by failure to deform or crush underfoot when a pressure of approximately 30 psi is applied. If the backfill does not harden to support the required load, the backfill shall be removed and replaced

with an acceptable material at the contractor's expense.

621.5 Method of Measurement. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added or deducted from the contract quantity. If flowable backfill is specified, where required, measurement will be made by the computed volume to the nearest 1/10 cubic yard of the voids to be filled, as determined from the dimensional area of the open area and totaled to the nearest cubic yard. If flowable backfill is used as an alternate to compacted backfill specified in the contract or as shown on the plans, measurement will be made as required for the item specified.

621.6 Basis of Payment. If flowable backfill is specified, the accepted quantity will be paid for at the contract unit price. No additional payment will be made if flowable backfill is used as an alternate to compacted backfill.

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SECTION 622
PAVEMENT AND BRIDGE SURFACE REMOVAL AND TEXTURING

622.1 Description. This work shall consist of removing or texturing the surface of existing pavement and bridge decks as shown on the plans. The term "pavement" as used in Sec 622 will be considered reference to the paved portion of the highway within the limits of construction, including bridge decks.

622.2 Construction Requirements.

622.2.1 The pavement surface shall be removed or textured to the depth, width, grade and cross slope shown on the plans or as directed by the engineer.

622.2.2 Unless specified otherwise in the contract, the contractor shall accept full ownership of all material generated by removal or texturing operations and shall indemnify the Commission of responsibility for and pay all costs relating to generation, handling, storage, treatment, transportation, disposal, or any future use of the material.

622.2.3 Depth transitions at the beginning and end of a project, side roads, bridge ends or other locations shown on the plans shall be milled by using equipment and a process approved by the engineer. The equipment will not be required to have an automatic grade leveling and slope control device or a means of removing and discharging millings from the pavement, unless specified otherwise. Any necessary pavement marking in the transition areas shall be as directed by the engineer and at the contractor's expense.

622.2.3.1 A temporary asphalt wedge transition shall be installed, maintained, and removed at the contractor's expense for each vertical lip created from a cold milled depth transition when the contractor opens the cold milled depth transition to traffic prior to resurfacing. The temporary asphalt wedge shall be, in the opinion of the engineer, of sufficient length and texture to provide a smooth transition from the existing pavement or bridge surface to the cold milled surface. Temporary asphalt wedges shall be removed prior to the resurfacing.

622.2.4 The contractor shall provide signing informing motorists of coldmilled areas open to traffic, at the contractors expense. The contractor may use static signs, changeable message signs, or a combination thereof to provide this warning. Signing shall be deployed in advance of an exit from the mainline prior to the milled area to allow motorists an opportunity to take an alternate route. Signing shall also be placed on any ramps leading into the milled area. If an alternate route cannot be provided, deployment of the signs shall be located in advance of the milled area to allow motorists to safely negotiate the section of milled pavement. Sign locations shall be approved by the engineer prior to installation. Signing shall be in accordance with Sec 616. Sign layout for static signs shall be as shown in the standard plans. Changeable message signs shall be programmed as directed by the engineer.

SECTION 622.10 COLD MILLING EXISTING PAVEMENT FOR REMOVAL OF SURFACE

622.10.1 Description. This work shall consist of coldmilling the existing pavement surface to the depth, profile and cross slope shown on the plans and removing and disposing of the milled material.

622.10.2 Equipment.

622.10.2.1 The equipment for milling and removing the pavement surface shall be capable of removing a thickness of bituminous or concrete material to the specified depth and providing a uniform profile and cross slope.

622.10.2.2 The equipment shall be capable of accurately and automatically establishing profile grades within 1/8 inch of each edge of the machine. The milling equipment shall be regulated by an automatically controlled grade leveling and slope control device. The device shall provide control for producing a uniform surface to the established grade and a cross slope in accordance with the typical section. The device shall also be equipped with the necessary controls to permit the operator to adjust or vary the slope as directed by the engineer.

622.10.2.3 The equipment shall have provisions for controlling dust and other particulate matter created by the cutting action. The equipment shall also have an effective means of removing cuttings from the pavement and discharging them into a hauling unit, all in one operation, as the pavement is milled.

622.10.3 Construction Requirements.

622.10.3.1 Except for cold milling of depth transitions sections and butt joints, all pavement that is cold milled for the purpose of resurfacing shall receive the first lift of resurfacing during the same day or night work shift as the cold milling operation.

622.10.3.2 The milling operations, except in depth transition areas, shall be regulated by an automatically controlled grade leveling and slope control device.

622.10.3.3 The roadway pavement surface shall be removed and planed around and over manholes, utility valves and drainage appurtenances within the limits of the work as directed by the engineer. Any damage to manholes, utility valves or drainage appurtenances by the removal and planning operation shall be repaired by the contractor at the contractor's expense. After removal of existing material around manholes, utility valves and other appurtenances, the contractor shall place a temporary wedge around the appurtenance. The temporary wedge shall consist of bituminous or another approved material at a slope that will allow safe transition over the appurtenance by through traffic and of a thickness and design that the material remains intact while under traffic. Bituminous wedges shall be removed prior to resurfacing.

622.10.3.4 The milled surface of each layer shall be substantially free from waves or irregularities. The final milled surface shall not vary from a 10-foot straightedge, applied parallel to the centerline, by more than 1/4 inch. Spalled areas presenting a hazard shall be repaired using an approved bituminous pavement. The texture of the final milled surface shall be a grid surface with discontinuous longitudinal striations.

622.10.3.5 Existing shoulder material shall be removed as necessary to ensure no ponding of water on the driving surface occurs after the milling operation.

622.10.3.6 Care shall be exercised not to damage existing concrete pavement. The concrete pavement surface may be scarified as shown on the plans or approved by the engineer.

622.10.3.7 Loose material not picked up by the milling machine shall be removed from the roadway or bridge deck surface immediately behind the milling operation, except in areas with earth or stabilized aggregate shoulders. Loose material may be swept to the shoulders as approved by the engineer.

622.10.3.8 The contractor shall provide pavement marking as shown on the plans through the limits of the milled surfaces in accordance with Sec 620.

622.10.4 Method of Measurement. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, measurement for removal of the existing pavement surface will be computed to the nearest square yard. The correction will be added to or deducted from the contract quantity.

622.10.5 Basis of Payment. The accepted quantity of removal of existing surface will be paid for at the contract unit price for each of the pay items included in the contract. No direct payment will be made for removal of shoulder material by milling or other methods as required to provide drainage in accordance with Sec 622.10.3.5, unless shoulders are to be removed as part of the contract. No direct payment will be made for loading, hauling, stockpiling or disposing of milled material, repairing spalled areas, placing and removing temporary wedges, providing temporary pavement marking or performing other items incidental to completion of this work.

SECTION 622.20 COLD MILLING PAVEMENT FOR A DRIVING SURFACE.

622.20.1 Description. This work shall consist of fine-tooth coldmilling to improve the profile, cross slope or texture of an existing pavement surface as shown on the plans or as directed by the engineer. The finished profile shall provide a smooth riding surface, free from gouges, and shall have a uniform textured appearance.

622.20.1.1 Locations may be field adjusted in length by the engineer, not to exceed 1/4 mile for any one location and provided the total area for all locations is not changed, without change in payment. All specified locations shall be milled.

622.20.1.2 Contractors shall make their own conclusions concerning the quantity of material to be removed. The

actual depths of milling will vary due to rut depths, drainage and profile requirements.

622.20.2 Equipment. Equipment for profiling, texturing and removing the pavement surface shall be in accordance with Sec 622.10, except as modified herein.

622.20.2.1 The minimum drum cutting width shall be 12 feet, unless specified otherwise in the contract.

622.20.2.2 The carbide cutting teeth shall be uniform in diameter, with a uniform length of ± 0.02inch. In addition, the tooth holder blocks shall be uniform and shall not vary the cutting radius of the mandrel by more than ± 0.02 inch.

622.20.2.3 Removing millings from the pavement and discharging the millings into a hauling unit may be individual operations.

622.20.3 Construction Requirements.

622.20.3.1 Removal of material for rut removal shall be to the approximate depth of the bottom of the wheel rut in the lane being milled. The bottom of the rut shall be textured, but only minimal material removed. Milling shall be done in an approximate lane width, but may start to the right of the centerline in the approximate left wheelpath, extending into the shoulder to allow drainage, leaving the existing centerline marking in place.

622.20.3.2 Removal of material for surface texturing shall be done for the full lane width, to the depth needed in order to texture all of the described areas.

622.20.3.3 After the proper combination of mandrel speed and forward speed have been established to produce the required texture, the daily operation shall be uniform and continuous for other than repair or emergency operations. The milling machine shall not be halted to load or unload trucks, or to take on water.

622.20.3.4 The entire surface shall be textured, substantially free from waves or irregularities, and shall not vary from a 10-foot straightedge, applied parallel to the centerline, by more than 1/8 inch. There may be occasional exceptions where the bottom of a wheelpath may not be textured in order to maintain an acceptable profile. Spalled areas shall be repaired using an approved bituminous patching material.

622.20.3.5 The texture produced for the finished pavement shall be a uniform surface with longitudinal striations. There shall be a maximum lateral distance of 0.2 inch between adjacent longitudinal striation mark lines. The longitudinal distance from the center of a strike mark to the center of the next successive strike mark in line shall not exceed 5 inches. The longitudinal successive strike marks shall approximate a continuous grooved line. The difference between the high and low of the surface texture shall be approximately 1/16 inch.

622.20.3.6 The pavement surface shall be removed and milled around and over appurtenances, such as manholes, utility valves and drainage features, within the limits of the work as directed by the engineer. Any damage to appurtenances by the milling and removal operation shall be repaired by the contractor at the contractor's expense. The final milled pavement surface shall be smoothly transitioned at all appurtenances located in the pavement to maintain an acceptable profile.

622.20.3.7 Material adjacent to the lane being milled shall be removed as necessary to provide a smooth transition and to ensure no ponding of water on the driving surface after the milling operation. There will be no pay for additional milling width beyond lane width as required for drainage. Removal in the traffic lanes shall be with the same equipment, providing the same texture. Removal of shoulder material may be with other milling equipment meeting the engineer's approval.

622.20.3.8 Loose material not picked up by the milling machine shall be removed from the roadway immediately behind the milling operation. In areas with earth or aggregate shoulders, the loose material may be swept to the shoulders when approved by the engineer. If required by the engineer, the finished surface shall be wetted just prior to returning to traffic to reduce traffic visibility problems due to dust.

622.20.3.9 Obliterated edgelines next to a shoulder will not be required to be replaced by the contractor, unless specified in the contract. Any other pavement marking removed by the contractor's operations shall be replaced with temporary pavement marking in accordance with Sec 620, except when permanent pavement marking is specified in the contract. Prior to installation of permanent pavement marking, all joints and cracks shall be

cleaned and sealed with hot-poured, elastic type concrete joint sealer in accordance with Sec 1057.

622.20.4 Method of Measurement. The roadway lane width will be assumed for computing milling quantities. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in contract quantity. Where required, measurement for coldmilling of the existing pavement surface will be computed to the nearest square yard. The corrections will be added to or deducted from the contract quantity.

622.20.5 Basis of Payment. The accepted quantity of coldmilling of existing pavement surface will be paid for at the contract unit price for each of the pay items included in the contract. No direct payment will be made for loading, hauling, stockpiling or disposing of milled material, repairing spalled areas, temporary pavement marking or other items incidental to completion of the work.

SECTION 622.30 DIAMOND GRINDING OF EXISTING PORTLAND CEMENT CONCRETE PAVEMENT.

622.30.1 Description. This work shall consist of grinding concrete pavement to provide good riding characteristics, a surface texture and proper drainage. The finished surface shall be as shown on the plans or as directed by the engineer.

622.30.2 Equipment. The equipment shall be of a size that will grind a strip at least 3 feet wide using diamond blades, and shall not cause spalls at cracks, joints or other locations.

622.30.3 Construction Requirements.

622.30.3.1 The construction operation shall be scheduled and proceed in a manner that produces a uniform finished surface. Auxiliary or ramp lane grinding shall transition from the edge of the mainline as required to provide drainage and an acceptable riding surface. Grinding of bridge decks will not be permitted unless specified in the contract.

622.30.3.2 Pavement undersealing or pavement repair, if required, shall be completed prior to any grinding.

622.30.3.3 Grinding shall be accomplished in a manner that eliminates joint or crack faults and provides lateral drainage by maintaining a constant cross slope between grinding extremities in each lane. A maximum tolerance of 1/16 inch will be allowed for adjacent sides of joints and cracks, except that under no circumstances shall the grinding depth exceed
1/4 inch from the top of the original surface. When grinding across faulted joints, a minimum of a 20-foot transition onto the approach side slab shall be used.

622.30.3.4 The cross slope of the pavement shall be as shown on the plans and shall have no depressions or misalignment of slope greater than 1/4 inch in 12 feet when measured with a 12-foot straightedge placed perpendicular to the centerline. Areas of deviation shall be reground. Straightedge requirements will not apply across longitudinal joints or outside the ground area.

622.30.3.5 As soon as practical after grinding, the surface will be straightedged longitudinally and all variations exceeding 1/8 inch in 10 feet will be plainly marked. Areas of deviation shall be reground.

622.30.3.6 Substantially all of the pavement surface shall be textured. Extra depth grinding to eliminate minor depressions in order to provide texturing on 100 percent of the pavement surface will not be required. No unground surface area between passes will be permitted, except as specified otherwise in the contract documents.

622.30.3.7 The grinding process shall produce a final pavement surface that is true to grade and uniform in appearance with a longitudinal line type texture. The line-type texture shall contain parallel longitudinal corrugations that present a narrow ridge corduroy-type appearance. The peaks of the ridges shall be approximately 1/32 inch higher than the bottoms of the grooves. The grooves shall be evenly spaced. There shall be approximately
50-55 grooves per foot, measured perpendicular to the centerline.

622.30.3.8 The contractor shall remove and dispose of all residue from the grinding in a manner and at a

location to satisfy environmental regulations. The contractor shall have the engineer's approval for the method of spreading and disposal of the residue prior to beginning any grinding operations.

622.30.3.8.1 Solid residue shall be removed from the pavement surface before any residue is blown by traffic action or wind.

622.30.3.8.2 Residue shall not be permitted to encroach on open lanes.

622.30.3.8.3 The residue shall not enter into gutters or closed drainage systems. Suitable means to restrict the infiltration of the residue into a closed drainage system shall be provided.

622.30.3.8.4 The contractor may disperse residue onto unpaved shoulders, adjacent roadside embankments, or median ditch areas of divided highways where the residue runoff can percolate into the soil, unless specified otherwise in the contract. The spread rate shall not generate surface runoff. If surface runoff occurs at a grinding location, the contractor shall haul the residue to an approved location at the contractor's expense.

622.30.3.8.5 Discharge of any residue runoff shall not flow into adjacent rivers, streams, lakes, ponds or other open bodies of water.

622.30.3.8.6 Residue shall not be spread within 100 feet of any streams, lakes or other open bodies of water, or within 15 feet of a water filled ditch.

622.30.3.8.7 The contractor shall use appropriate equipment and methods so the discharging of the residue does not cause erosion of soil or damage to established vegetation along the roadway. The contractor shall repair and reseed any areas where the discharge of grinding residue causes damage to roadway slopes or vegetated areas at the contractor's expense.

622.30.3.8.8 If the solids concentration of discharged residue at any particular area is determined to be excessive by the engineer, the contractor shall provide equipment and material to flush the areas with water as directed by the engineer, at the contractor's expense.

622.30.3.8.9 Obliterated edgelines next to a shoulder will not be required to be replaced by the contractor unless specified in the contract. Any centerline or lane line markings removed by the contractor's operations shall be replaced with temporary pavement marking material in accordance with Sec 620, unless permanent pavement marking material is specified in the contract. Prior to installation of permanent pavement marking material, all joints and cracks shall be cleaned and sealed if specified in the contract.

622.30.3.9 The pavement shall be cleaned prior to opening to traffic as directed by the engineer.

622.30.4 Smoothness Requirements.

622.30.4.1 Prior to performing any grinding work, but after completion of all pavement repairs,the contractor shall provide a control International Roughness Index (IRI) per pavement segment, as defined in Sec 610.4.1 (b), from the right wheel path of each lane being diamond ground in accordance with TM-59. This control IRI will be used to identify the required smoothness for the project.

622.30.4.1.1 Each segment of the finished ground surface shall be reprofiled in the right wheel path and have a final IRI per segment of 65 percent of the control IRI or 80 inches per mile, whichever is greater.

622.30.4.1.2 Depressed pavement areas due to subsidence or other localized causes and areas where the maximum cut at mid panel or a fault restricts further grinding, will be excluded from testing with the inertial profiler when approved by the engineer.

622.30.4.1.3 After the initial diamond grinding operation has been profiled, additional correction shall be performed, where determined necessary by the engineer, to reduce the average segment profile to the specified final profile requirements. The contractor will not be allowed to make corrective grinding to increase the percent of pay when the final IRI is in accordance with Sec 622.30.4.1.1. On pavement segments where corrections are necessary, additional profiles shall be made to verify that the corrections have produced an average final profile in accordance with Sec 622.30.4.1.1.

622.30.4.1.4 The engineer shall use the ProVAL software program to compute IRIs in accordance with TM-59. The contractor shall provide the raw unfiltered profile data file in .ppf format.

622.30.4.2 Inertial profile testing shall not be performed in excluded areas as defined in Sec 610.4.2.2.

622.30.4.2.1 Excluded areas shall be tested with a 10 foot straightedge in accordance with Sec 610.4.3.

622.30.5 Method of Measurement. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, measurement will be made to the nearest square yard. Measurement will be based upon the full pavement lane width. No deduction will be made for gaps within the pavement lane to avoid striping, raised pavement markers, manholes or other structures.

622.30.6 Basis of Payment. The accepted quantity of ground pavement surface will be paid for at the contract unit price for diamond grinding concrete pavement. Payment will be considered full compensation for all labor, equipment, material and incidentals to complete this work, including hauling and disposal of grinding residue and cleaning the pavement prior to opening to traffic.

622.30.6.1 The contract unit price for diamond grinding will be adjusted based on the final IRI for any segment before corrections, according to the following schedule:

IRI, inches per mile	Increase in Contract Unit Price
40.0 or less	$0.25
40.1 to 54.0	$0.15
54.1 to 80.0	None
80.1 or greater	None*

*After correction to either equal to or less than 65 percent of the control IRI or 80.0 inches per mile.

622.30.6.2 At the contractor's expense, segments with an IRI not in accordance with Sec 622.30.4.1.1, after the initial grinding, shall be corrected until the IRI is reduced in accordance with Sec 622.30.4.1.1, unless waived by the engineer.

SECTION 622.40 DIAMOND GRINDING OF NEW PORTLAND CEMENT CONCRETE PAVEMENT.

622.40.1 Description. This work shall consist of grinding new Portland cement concrete pavement to provide good riding characteristics and surface texture. The finished surface shall be as shown on the plans.

622.40.2 Equipment. The grinding equipment shall be in accordance with Sec 622.30.2.

622.40.3 Construction Requirements.

622.40.3.1 Paving. When diamond grinding is used as the final texturing for new Portland cement concrete pavement, concrete paving shall be in accordance with Sec 502, except as follows. All joints shall be protected to prevent grinding residue from entering. Joints to be diamond ground shall be cleaned and sealed in accordance with Sec 502 after diamond grinding is completed.

622.40.3.2 Smoothness Requirements.

622.40.3.2.1 No diamond grinding shall be done until the pavement has attained a strength sufficient to be opened to all types of traffic. All diamond grinding shall be completed on any section prior to opening that section to other than construction traffic, unless approved by the engineer.

622.40.3.2.2 The final pavement surface from the grinding process shall be in accordance with Sec 622.30.3.7. All grooves and adjacent passes shall be parallel to each other and the roadway, with no variation. Adjacent passes shall completely lap with no unground surface between, however, they shall not overlap more than 1 1/2 inches. Adjacent passes shall be within 1/8 inch of the same height as measured with a 3-foot straightedge. No less than
98 percent of the specified surface shall be textured by grinding. There shall be no ridge between lanes. Any

remaining ridges on the outside edge next to the shoulder greater than 1/8 inch high shall be feathered out to the satisfaction of the engineer in a separate operation.

622.40.3.2.3 Any deficiencies in the final surface due to improper contractor operations or equipment shall be corrected by the contractor, at the contractor's expense.

622.40.3.2.4 The contractor shall remove and dispose of all residue from grinding operations in accordance with Sec 622.30.3.8.

622.40.4 Basis of Payment. No direct payment for diamond grinding new concrete pavement will be made. Diamond grinding new concrete pavement will be considered as part of the work paid for under the contract unit price for Portland concrete pavement in accordance with Sec 502.

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SECTION 623
CONCRETE BONDING COMPOUND, EPOXY MORTAR AND EPOXY POLYMER CONCRETE OVERLAY

SECTION 623.10 CONCRETE BONDING COMPOUND.

623.10.1 Description. This work shall consist of preparing the surface, furnishing and applying the concrete bonding compound to be used to bond plastic concrete mortar to hardened concrete as shown on the plans or as directed by the engineer.

623.10.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Type II Epoxy	1039

623.10.3 Construction Requirements.

623.10.3.1 Surface Preparation. The surface of the hardened concrete to which the plastic concrete mortar is to be bonded shall be surface dry and thoroughly cleaned such that all loose and unsound concrete is removed prior to application of the bonding agent.

623.10.3.2 Application. The bonding agent shall be applied when both the air and surface temperature is within the manufacturer's written recommendations.

623.10.3.2.1 Components shall be mixed in accordance with manufacturer's written recommendations. The components may be warmed with indirect heat to a maximum temperature of 100 F to reduce the viscosity. No solvents shall be added to the compound.

623.10.3.2.2 The mixed bonding agent shall be applied in such a manner as to thoroughly work the bonding compound into the hardened concrete surface. The thickness of the application shall be 20 to 25 mils. If the concrete absorbs the bonding agent, additional coats shall be applied until the correct thickness is attained.

623.10.3.2.3 The plastic concrete mortar shall be placed while the bonding agent is still tacky. If there is a delay in placing the plastic concrete mortar and the bonding agent becomes tack free, another coat of bonding agent shall be applied.

623.10.4 Basis of Payment. No direct payment will be made for furnishing material, surface preparation or application.

SECTION 623.20 EPOXY MORTAR.

623.20.1 Description. This work shall consist of preparing the surface, furnishing and applying epoxy mortar as shown on the plans.

623.20.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Type III Epoxy	1039
Sand for Mortar	1039

623.20.3 Construction Requirements.

623.20.3.1 Surface Preparation. The surfaces to which the epoxy mortar is to be applied shall be free of dust, water or any other material that may affect the adhesion.

623.20.3.2 Application. The epoxy mortar shall be prepared and placed when the weather is dry and the air temperature is in accordance with the manufacturer's written recommendations.

623.20.3.2.1 The contractor shall mix only the number of containers of material that can be placed in 20 to 40 minutes.

623.20.3.2.2 Epoxy shall be thoroughly mixed in accordance with the manufacturer's written recommendations. Mixing shall continue as permitted to ensure uniformity.

623.20.3.2.3 When the epoxy material has been thoroughly mixed, sand shall be added at the manufacturer's recommended rate while mixing continues. After the proper quantity of sand has been added, mixing shall continue until the mixture is uniform.

623.20.3.2.4 Areas to be patched or leveled shall be thoroughly primed with an application of neat epoxy. After the area is primed, the mortar shall be placed and struck off to grade. The surface shall have a rough finish equal to that of a Portland cement concrete deck.

623.20.3.2.5 The patched or leveled area shall be protected during the curing period to prevent damage. Material shall be cured in accordance with the manufacturer's written recommendations. Curing acceleration by direct flame application will not be permitted.

623.20.4 Basis of Payment. No direct payment will be made for furnishing material, surface preparation or application.

SECTION 623.30 EPOXY POLYMER CONCRETE OVERLAY.

623.30.1 Description. This work shall consist of furnishing and applying thin polymer concrete overlays in a prime coat, plus two courses on designated bridge structures as shown on the plans or as directed by the engineer.

623.30.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Epoxy Resin for Epoxy Polymer Concrete Overlay	1039
Aggregate for Epoxy Polymer Concrete Overlay	1039

623.30.3 Construction Requirements.

623.30.3.1 Manufacturer Representation. The overlay manufacturer's representative shall witness the entire testing phase of each field test. The manufacturer's representative shall verify that all operations are performed by acceptable practices.

623.30.3.2 Handling and Storage of Material. Handling and storage of material shall be in accordance with the manufacturer's written recommendations.

623.30.3.3 Field Test. Prior to the start of the overlay operation, a test area of the complete overlay system shall be placed on the bridge deck in a contractor proposed location that is approved by the engineer. When multiple bridges are included in a project, a test area will be required on each bridge. The contractor may utilize one-half of the bridge deck or an area equal to one day's placement operation, whichever is smaller, as a field test. The degree of cleaning used on the test area shall be the minimum used on the remainder of the structure. The surface for the test overlay shall be prepared in accordance with the test method prescribed in ACI 503R - Appendix A of the ACI Manual of Concrete Practice to establish an approved cleaning practice. The approved cleaning practice shall remove all potentially detrimental material which may interfere with the bonding or curing of the overlay. Concrete shall be sound, with mortar soundly bonded to the coarse aggregate, with clean and open pores to be considered adequate for bond. All areas of asphalt and pavement markings shall be removed. Preparation of the surface shall produce a surface relief equal to International Concrete Repair Institute (ICRI) surface preparation level 6 or 7 or ASTM E 965 pavement macrotexture depth of 0.04 to 0.08 inch.

623.30.3.3.1 Visible moisture on the prepared deck at the time of placing the overlay will not be permitted. Moisture in the deck shall be checked by taping a plastic sheet to the deck for a minimum of 2 hours in accordance with ASTM D4263.

623.30.3.3.2 In addition to the above requirements, the cleaning practice shall provide an adhesion strength test result greater than 250 psi or a failure area into the base concrete that is greater than 50 percent of the test area. After the test area has cured for a minimum of 72 hours, adhesion shall be checked in accordance with ACI 503R. A test result will be the average of three tests on a sample area of the test patch. A minimum of three sample areas per test patch shall be tested. Successful test results will be required from each sample area.

623.30.3.3.3 If the test of a sample area fails to meet the above requirements due to a cohesive failure of the substrate concrete, the adhesive strength of the sample area will be considered acceptable.

623.30.3.3.4 Successful completion of the adhesion strength tests will be required before the full-scale overlay operation is to begin. All cleaning operations shall equal those used for the adhesion strength test areas, in both profile and cleanliness. If changes are made to the established cleaning practice, new adhesion strength testing shall be performed at the contractor's expense.

623.30.3.3.5 Test patches shall be installed with the same material, equipment, personnel, timing, sequence of operations and curing period that will be used for the installation of the overlay.

623.30.3.3.6 If the test fails, the contractor shall remove the material represented by the failed test patches and provide another test patch, at the contractor's expense, until satisfactory test results are obtained.

623.30.3.4 Surface Preparation. Before placement of the overlay, the entire deck surface shall be prepared by the cleaning practice established in the field adhesion strength tests in accordance with Sec 623.30.3.3, except that sand blasting will not be permitted. Containment and disposal of material shall be in accordance with Sec 202.2.

623.30.3.4.1 If the engineer determines that the weather has changed significantly since the application of the field test patch, the contractor shall verify through adhesion strength tests that the practice is acceptable, at the contractor's expense.

623.30.3.4.2 No traffic of any kind shall be permitted on any portion of the deck which has been shot blasted or on the overlay without approval from the engineer. The time between surface preparation and application of the first course shall not exceed 24 hours.

623.30.3.4.3 All patching and cleaning operations shall be inspected and approved prior to placing the overlay.

623.30.3.4.4 If the deck or intermediate course is contaminated by foreign material or water after initial cleaning, the contamination and any detrimentally affected overlay material shall be removed. Both courses shall be applied prior to opening the area to traffic.

623.30.3.5 Equipment. The contractor's equipment shall be as recommended by the epoxy manufacturer.

623.30.3.6 Epoxy Mixture. Mixing of epoxy components shall be in accordance with the manufacturer's recommendations, except that the use of a volumetric mixer will be required. When mineral fillers are specified, the mineral fillers shall be inert and non-settling or readily dispersible. Material showing a permanent increase in viscosity or the settling of pigments that cannot be readily dispersed with a paddle shall be replaced at the contractor's expense. At least 95 percent of the filler shall pass the No. 200 sieve.

623.30.3.7 Application. Application of epoxy shall be performed by the supplier or by a factory trained or licensed applicator with written approval from the manufacturer of the epoxy system.

623.30.3.7.1 The handling and mixing of epoxy shall be in accordance with the manufacturer's written recommendations. The overlay material shall not be placed when weather or surface conditions are such that the material cannot be properly handled, placed and cured within the specified requirements of traffic control, or when rain is forecasted within 24 hours of application.

623.30.3.7.2 The overlay shall consist of a two-course application of epoxy and aggregate. A prime coat shall be used if recommended by the manufacturer. Each of the two courses shall consist of a layer of epoxy covered with a layer of aggregate in sufficient quantity to completely cover the epoxy. The thickness of each course shall be approximately equal. The total thickness of the overlay shall be no less than 1/4 inch.

623.30.3.7.3 The temperature of the bridge deck surface at the time of application shall be less than 90 F and in accordance with the manufacturer's recommendation.

623.30.3.7.4 Dry aggregate shall be applied in such a manner as to cover the epoxy mixture completely within 5 minutes of application. The dry aggregate shall be placed in a manner such that the level of the epoxy mixture is not disturbed.

623.30.3.7.5 The first course shall be swept to remove loose aggregate prior to the second course application. Sweeping shall be done without removing embedded aggregate. First course applications which do not receive enough aggregate prior to gelling shall be removed and replaced. A second course applied with insufficient aggregate may be left in place, but additional applications shall be placed at the contractor's expense before opening to traffic.

623.30.3.7.6 The thickness of the overlay shall be verified to be at least 1/4-inch, measured from the deck surface to the top of the resin. The contractor shall provide a minimum 1/2-inch diameter hole at a rate of at least one hole per 100 feet of traffic lane. Hole placement shall be at locations designated by the engineer. Thin areas shall be recoated and reverified at the contractor's expense.

623.30.3.7.7 When additional applications or recoating are required, the engineer may require additional adhesion strength tests by the contractor, at the contractor's expense, in accordance with ACI 503R to verify the contractor's procedure.

623.30.3.7.8 All adhesion strength test areas, thickness test holes or any debonded areas shall be repaired by filling with overlay material before final acceptance.

623.30.3.7.9 The epoxy concrete overlay shall be cured at least one hour, or until brooming or vacuuming can be performed without tearing or otherwise damaging the surface. No traffic or equipment shall be permitted on the overlay surface during the curing period.

623.30.3.7.10 After the curing period, all loose aggregate shall be removed by brooming or vacuuming and the next overlay course applied as specified in the contract documents.

623.30.3.7.11 The polymer mixture shall not be permitted to run into drains.

623.30.3.7.12 Unless otherwise specified, the epoxy concrete overlay courses shall be applied over the expansion joints and joint seals of the bridge deck. The expansion joints and joint seals shall be provided with a bond breaker. Prior to opening to traffic, the overlay shall be removed over each joint by removal of the bond breaker in accordance with the overlay manufacturer's recommendations.

623.30.3.7.13 Prior to opening a section to public or construction traffic, the overlay shall be allowed to cure in accordance with the manufacturer's recommendations. First course applications shall not be opened to traffic.

623.30.3.7.14 Damaged or debonded areas of an epoxy concrete overlay course shall be removed and repaired prior to acceptance. Repair shall consist of saw-cutting in rectangular sections to the top of the concrete deck surface and replacing the various courses in accordance with this specification at the contractor's expense.

623.30.4 Method of Measurement. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, the area of polymer concrete overlay will be measured and computed to the nearest square yard. This area will be measured longitudinally from end to end of bridge deck and transversely between the roadway face of curbs, excluding the area of the expansion device, if any. The revision or correction will be computed and added to or deducted from the contract quantity.

623.30.5 Basis of Payment. The accepted quantity of epoxy polymer concrete overlay will be paid for at the contract unit price.

SECTION 623.40 POLYMER CONCRETE.

623.40.1 Description. This work shall consist of furnishing and placing polymer concrete as shown on the plans

or as directed by the engineer.

623.40.2 Manufacturer Representation. The manufacturer's representative shall be present at the start of surface preparations and polymer concrete installation for at least one day. The contractor shall furnish the manufacturer's recommendations to the engineer as to the acceptability of all aspects of the operation. The contractor shall contact the manufacturer's representative at least two weeks prior to installation.

623.40.3 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Polymer Concrete	1039

623.40.4 Construction Requirements.

623.40.4.1 Equipment. The contractor's equipment shall be in accordance with the manufacturer's recommendations.

623.40.4.2 Surface Preparation. Portland cement concrete shall be allowed to cure and dry for a minimum of seven dry days prior to installing the polymer concrete. Days with cold, wet or inclement weather which may be a detriment to curing of the Portland cement concrete will not count in this seven day minimum curing and drying time. The concrete surface shall be dry when placing the polymer concrete. The substrate shall be structurally sound and sandblasted to be free of all foreign matter, grease, dirt and laitance for all areas that will be in contact with the polymer concrete. Steel surfaces shall be cleaned in accordance with SSPC-SP 10 surface preparation requirements. Containment and disposal of material shall be in accordance with Sec 202.2. After sandblasting is completed, the joint shall be cleaned of debris by using oil and water free compressed air at a minimum of 90 psi or by vacuuming. These areas shall then be primed in accordance with the manufacturer's recommendations.

623.40.4.3 Placement. The polymer concrete shall be mixed, placed and cured in accordance with the manufacturer's recommendations and as shown on the plans. Before opening to traffic, the material shall be tack free and fully cured as determined by the engineer.

623.40.5 Method of Measurement. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, the volume of polymer concrete will be measured to the nearest 1.0 cubic feet of accepted, in-place polymer concrete. The revision or correction will be computed and added to or deducted from the contract quantity.

623.40.6 Basis of Payment. The accepted quantity of polymer concrete will be paid for at the contract unit price.

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SECTION 624
GEOTEXTILE CONSTRUCTION

624.1 Description. This work shall consist of installing geotextile for use in subsurface drainage, in erosion control, as a permeable separator or as otherwise specified.

624.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Geotextile	1011

624.3 Construction Requirements. Geotextile shall be placed in accordance with AASHTO M 288 for the appropriate application.

624.4 Method of Measurement. Geotextile used for lining drain trenches, wrapping drain pipe or for control of piping through structural joints and facing panels will not be separately measured. Geotextile used for other purposes will be measured to the nearest square yard of surface area covered without regard to any overlap.

624.5 Basis of Payment. Geotextile used for lining drain trenches, wrapping drain pipe or for control of piping through structural joints and facing panels will be considered as incidental and will be included in the contract unit price for the drain or structure. The accepted quantity of geotextile used for other purposes will be paid for at the contract unit price for each of the pay items included in the contract. No direct payment will be made for securing pins or other incidental items.

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SECTION 625
SLAB STABILIZATION

SECTION 625.10 SLAB UNDERSEALING.

625.10.1 Description. This work shall consist of stabilizing Portland cement concrete pavement by furnishing, hauling and pumping high density polyurethane or asphalt cement under the concrete slab. This work shall be completed after any required pavement repair and prior to the placement of any new overlay material.

625.10.2 Material.

625.10.2.1 High Density Polyurethane.

625.10.2.1.1 The material shall be a hydrophobic, closed cell, high density polyurethane system with the following physical characteristics and properties:

Property	Requirement
Density, min., per ASTM D 1622	4.0 ± ½lb/ft^3
Compressive Strength, min., per ASTM D 1621	80 psi
Tensile Strength, min.	90 psi
Volume Change, max.	+5.0 percent
Curing Rate	90 percent of compressive strength within 15 minutes after injection

625.10.2.1.2 The material shall be hydrophobic in the material's component reaction such that the injected product is not significantly compromised by soil moisture or free water under the pavement

625.10.2.1.3 When requested by the engineer, pumping units in service shall perform a product density test by injecting a sample of the unit's polyurethane material into a test cylinder of known volume. The sample's density shall be in accordance with Sec 625.10.2.1.1.

625.10.2.1.4 When requested by the engineer, the contractor, in the presence of the engineer, shall inject the polyurethane material into a container holding 40 gallons of ambient temperature water at 70 F. The resulting product shall demonstrate consistent, closed cell polyurethane material.

625.10.2.1.5 All stored polyurethane material shall be handled in accordance with the manufacturer's recommendations.

625.10.2.2 Asphalt Cement.

625.10.2.2.1 Asphalt cement material shall meet ASTM D3141. The Contractor shall provide a supplier certification with each shipment in accordance with Sec 1015.3.1.

625.10.3 Construction Requirements.

625.10.3.1 General.

625.10.3.1.1 Pavement stabilization operations will not be allowed when daytime temperatures are below 35 F or if the subgrade is frozen.

625.10.3.1.2 A hole pattern shall be submitted for approval at least 7 days prior to starting slab stabilization operations. Drilled holes shall be a maximum of 1 1/2 inches in diameter, drilled smooth, vertical and round. Holes drilled with a break out in excess of 1 1/2 inches outside the hole diameter will be unacceptable.

625.10.3.1.3 The Contractor shall provide equipment capable of detecting slab lift to measurements of 0.001 inch. Pavement lifted in excess of 0.125 inch or pavement cracked as a result of the undersealing will be unacceptable.

625.10.3.1.4 Proof of full undersealing, such as material seeping from joints, cracks, or edges; vertical slab

movement; or other visual indication, as determined by the engineer, will be required prior to acceptance. When required, deflection testing shall be performed in accordance with MoDOT Test Method TM 64. No testing shall be performed if the slabs are beginning to lock-up. Tests shall not be performed during Spring thaw conditions or when the subgrade is frozen.

625.10.3.1.5 Undersealing materials shall not enter into gutters or closed drainage systems. Residue shall not be spread within 100 feet of any streams, lakes or other open bodies of water or within 15 feet of a water filled ditch. All removed material shall be disposed of in an environmentally acceptable manner in accordance with all Federal, State, and local regulations.

625.10.3.1.6 All drill tailings, spilled material, and other debris shall be cleaned up at the end of each working day or before the lane is opened to traffic.

625.10.3.1.7 The drill holes shall be filled flush with the pavement surface using a material to match the existing surface.

625.10.3.1.8 The Contractor shall supply certification for the accuracy of the method used to measure the amount of material used on the project.

625.10.3.2 High Density Polyurethane.

625.10.3.2.1 Injection nozzles shall prevent leakage during injection and shall be removed at completion of the injection or driven into the injection hole to a minimum depth of 1-1/4 inches below the pavement surface.

625.10.3.2.2 Any excessive material on the pavement surface shall be removed from the area and the holes shall be sealed with polyurethane material or in accordance with Sec 625.10.3.1.7.

625.10.3.2.3 The pavement shall not be open to traffic until a minimum of 30 minutes after pumping operations have ceased.

625.10.3.3 Asphalt Cement.

625.10.3.3.1 Asphalt cement shall be heated to a temperature between 380 F and 450 F before pumping operations begin.

625.10.3.3.2 Pumping operations shall cease when asphalt cement seeps from cracks and joints. Pumping shall not resume until visible asphalt cement has congealed.

625.10.3.3.3 The Contractor shall provide adequate shielding to ensure passing traffic is not sprayed by asphalt cement.

625.10.3.3.4 The pavement shall not be open to traffic until a minimum of 30 minutes after pumping operations have ceased.

625.10.4 Method of Measurement.

625.10.4.1 High density polyurethane material shall be measured to the nearest pound.

625.10.4.2 Asphalt cement shall be measured to the nearest gallon in accordance with Sec. 1015.

625.10. 4.3 Measurement of testing for deflection will be per joint, crack or pavement repair patch per traffic lane in which testing is performed. Testing prior to undersealing and testing after undersealing will be measured separately.

625.10.5 Basis of Payment. The accepted quantities of undersealing material and deflection testing quantities will be paid for at the contract unit price. Payment will be considered full compensation for all labor, equipment and material necessary to complete the described work.

SECTION 625.20 SLAB JACKING.

625.20.1 Description. This work shall consist of injecting high density polyurethane or cementitious grout under a sunken section of concrete pavement and raising it back to the correct profile for an acceptable ride and positive drainage.

625.20.2 Material.

625.20.2.1 High density polyurethane used for slab jacking shall meet the requirements of Sec. 625.10.2.

625.20.2.2 The material used in grouting shall consist of a mixture of Portland cement, fly ash and water proportioned as specified or as approved by the engineer. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Fly Ash	1018
Cement, Type I, II or III	1019
Water	1070

625.20.2.3 Grout shall meet the following minimum requirements:

(a) Flow cone efflux time shall be 10 to 16 seconds, as determined in accordance with ASTM C 939.

(b) The minimum design strength at minimum efflux time shall be 600 psi at seven days, determined in accordance with ASTM C 942, with the exception that storage of compressive specimens after 24 hours shall be placed in a 100 percent humidity cabinet.

625.20.2.4 At least three weeks prior to the beginning of this work, the contractor shall submit the proposed mixture to the engineer. The submittal shall include the mix design, source and type of all material test results of the grout showing one-day, three-day and seven-day compressive strengths, efflux time, time of initial and final set by the Gilmore needle in accordance with ASTM C 266 and time delayed to molding specimens after mixing grout. The time delay between mixing and molding will be the maximum holding time permitted in the field. Sufficient quantities of all mixture components to permit laboratory verification of the grout properties listed herein shall accompany the mix design submittal. Approximately 10 pounds of Portland cement and 30 pounds of fly ash shall be furnished.

625.20.3 Construction Requirements. Construction requirements shall be in accordance with Sec 625.10.3.1 and specifically as follows.

625.20.3.1 General.

625.20.3.1.1 The contractor shall establish a finish target profile using an elevation measuring device or string line. Each profile shall be accepted by the engineer prior to work being performed at that location.

625.20.3.1.2 Pumping operations shall cease when the slab has achieved the target profile. The Contractor shall provide equipment capable of detecting slab lift to measurements of 0.001 inch. Pavement lifted in excess of 0.125 inch over the accepted profile or pavement cracked as a result of the slab jacking will be unacceptable.

625.20.3.1.3 The engineer may require the contractor to verify positive drainage on the lifted slab by flooding the surface area.

625.20.3.2 High Density Polyurethane. Construction requirements shall be in accordance with Sec 625.10.3.2.

625.20.3.3 Cementitious Grout.

625.20.3.3.1 Any admixtures used shall be incorporated in accordance with the manufacturer's recommendations. Admixtures may be added by hand methods. Admixtures shall be measured within a tolerance of plus or minus three percent of the required quantity.

625.20.3.3.2 Personnel, scales and equipment necessary for calibrating the proportioning devices and for verifying the accuracy of proportions shall be furnished by the contractor and shall be available at all times. All equipment shall be calibrated by the contractor in the presence of the engineer, and subject to approval from the

engineer. Verification of the accuracy of the scales and other dispensing methods may be required at any time deemed necessary by the engineer, but will be performed at least once each day of operation.

625.20.3.3.3 Weight proportioning and volume proportioning equipment, accuracy, calibration and verification shall be in accordance with Sec 501.

625.20.3.3.4 Grout may be re-tempered with water. Prior to re-tempering the grout, the engineer shall be notified.

625.20.3.3.5 The cement and fly ash for grout shall be measured by weight or volume. The quantity of cement and fly ash to be used shall be calculated from the approved mix design. Batches not containing the proper quantities of material will be unacceptable.

625.20.3.3.6 Filling holes shall be in accordance with Sec 625.10.3.1.7.

625.20.3.3.7 The contractor may disperse residue onto unpaved shoulders, adjacent roadside embankments or median ditch areas of divided highways where the residue runoff can percolate into the soil, unless specified otherwise in the contract. The spread rate shall not generate surface runoff. If surface runoff occurs at a grinding location, the contractor shall remove the residue to an approved location at the contractor's expense.

625.20.3.3.8 Traffic shall not be permitted on the undersealed pavement until three hours after the end of pumping operations, and after all drill holes have been plugged.

625.20.4 Method of Measurement.

625.20.4.1 High density polyurethane material shall be measured to the nearest pound.

625.20.4.2 Portland cement will be measured to the nearest pound.

625.20.4.3 Fly ash will be measured to the nearest pound.

625.20.4.4 Measurement of testing for deflection will be per joint, crack or pavement repair patch per traffic lane in which testing is performed. Testing prior to undersealing and testing after undersealing, will be measured separately.

625.20.5 Basis of Payment. The accepted slab jacking material and deflection testing quantities will be paid for at the contract unit price. Payment will be considered full compensation for all labor, equipment and material necessary to complete the described work.

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SECTION 626
RUMBLE STRIPS

626.1 Description. This work shall consist of constructing rumble strips as shown on the plans or as directed by the engineer.

626.2 Construction Requirements. Rumble strips shall be milled into bituminous and concrete pavements to produce a neat and uniform finish. Milled material shall be handled in accordance with Sec 622. Any damage to the pavement or pavement marking resulting from the contractor's operations shall be repaired or replaced to the satisfaction of the engineer by the contractor, at the contractor's expense. On roadways open to traffic, rumble strips shall be in place no later than five days after the final paving operations.

626.3 Method of Measurement. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, rumble strips will be measured separately for each shoulder and the centerline, which will be measured along the centerline of the travel way, and made to the nearest 1/10 station. The revision or correction will be added to or deducted from the contract quantity.

626.4 Basis of Payment. The accepted quantity of rumble strips will be paid at the contract unit price per 1/10 station. Payment will be considered full compensation for all labor, equipment, and material necessary to complete the described work, including loading, hauling, stockpiling and disposal of milled material; and any other incidental items.

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SECTION 627
CONTRACTOR SURVEYING AND STAKING

627.1 Description. This work shall consist of providing the necessary surveying and staking for the successful prosecution of the work.

627.2 Staking Requirements. Staking work shall be in accordance with general accepted surveying practices and provisions of the contract. The MoDOT's current Engineering Policy Guide (EPG), 238.4, may be used as guidance and is available on MoDOT's web site.

627.2.1 The contractor shall preserve all right of way monuments, benchmarks control points and reference marks set by the engineer. If any monumentation is damaged, destroyed or disturbed by the contractor, the cost of replacement will be at the contractor's expense and will be deducted from the payment for the work.

627.2.2 All surveying shall be documented by the contractor in a written form acceptable to the engineer. During performance of the work, all surveying documents shall be available and supplied to the engineer upon request, at the contractor's expense. All documents shall be labeled with the route, state job number, county, contractor name, survey party supervisor and date.

627.2.3 The engineer will furnish and set control points with known coordinates. The engineer will furnish all coordinate data to lay out the job and locate benchmarks as shown on the plans. The contractor shall provide all other staking necessary for the successful prosecution of the work, including all staking necessary to facilitate the relocation of utilities. All alignment control established by the contractor shall be referenced, and a copy of the references shall be furnished to the engineer.

627.2.4 Any surveying or measurements necessary for computing pay quantities will be performed by the engineer. The contractor shall notify the engineer at least two working days prior to disturbing any areas used to calculate pay quantities.

627.2.5 All surveying work performed by the contractor shall be sufficient and accurate to construct the work in accordance with the contract documents. Any delays or additional costs to the project which result from insufficient or inaccurate staking or time lost for corrective action will be considered as a nonexcusable and noncompensable delay.

627.2.6 The construction centerline shown on the plans shall be accurately established and the control points of all curves shall be referenced. If it is necessary to introduce an equation in order to match the plan stationing or if a plan equation is changed, such changes will be at the written direction of the engineer.

627.2.7 Adjustments necessary to provide accurate staking or match improvements to existing features shall be immediately brought to the attention of the engineer The engineer will determine the nature of the discrepancy and will make revisions as necessary. The contractor shall perform any restaking required by such revisions. Any reimbursement due to the contractor for additional staking due to design errors will be in accordance with Sec 109.4.3.

627.2.8 After the centerline has been established and referenced, centerline elevations shall be taken at all stations and at any other points required to ensure the computation of accurate quantities. Centerline elevations shall be based on the plan datum. All benchmarks shown on the plans shall be checked.

627.2.8.1 In the event a difference of plus or minus 0.01 foot exists in elevation for any benchmark shown on the plans, check levels shall be run and shown in the notes. The elevations shall be corrected to plan elevation at each benchmark where any difference occurs, and shall be noted in the field notes. If a plan benchmark has been disturbed or if correction of the plan elevation is not feasible, a full explanation shall be made in the notes. The contractor shall furnish to the engineer a listing of benchmarks prior to beginning construction.

627.2.8.2 If original plan cross sections differ from existing conditions by an average deviation in excess of one foot, the contractor shall immediately notify the engineer. The engineer will be responsible for taking cross-sections where deviations are determined to exist.

627.2.9 After completing any bridge, box culvert or retaining wall staking, the contractor shall furnish to the engineer structural layout plan sheets which show the location of all points that have been staked. At the time of

furnishing the marked layout sheets, the contractor shall meet with the engineer to review the layout a minimum of two working days before construction begins.

627.2.10 Upon completion of the project, the contractor shall provide to the engineer all original surveying field notes, layouts and computations in standard bound survey notebooks or in a form acceptable to the engineer.

627.3 Method of Measurement. No measurement will be made for contractor surveying and staking. This work shall be considered a lump sum unit when a pay item is provided in the contract.

627.4 Basis of Payment. When a pay item is provided in the contract, contractor furnished surveying and staking will be paid for at the contract lump sum price and will be considered full compensation for the following:

(a) Performing this work.

(b) All material, labor, tools, equipment and incidentals necessary to complete the work.

(c) For all effects, impacts, cumulative impacts, incidental and consequential costs, loss or damage arising from, relating to or produced by error or discrepancies in surveys or staking and plans based on such surveys or staking, and any cost, including time effects, to correct the errors or discrepancies.

627.4.1 Payment for surveying and staking will only be made when a pay item is provided in the contract. If no pay item is provided, all costs associated with surveying and staking shall be considered included in the cost of other bid items.

627.4.2 Payment for contractor furnished surveying and staking completed, not to exceed the contract item amount, will be made upon written request by the contractor. Such a request shall be submitted to the engineer two business days prior to the progress estimate date.

627.4.3 Complete payment will not be made until the contractor has provided all of the original surveying field notes, layouts, computations and notebooks to the engineer.

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SECTION 701
DRILLED SHAFTS

701.1 Description. This work shall consist of constructing cast-in-place reinforced concrete drilled shafts and rock sockets, as required, to serve as a structural foundation. This work shall provide reinforced concrete shafts cast in cylindrically excavated holes extending sufficiently into soil or sound rock to adequately support the structure and all externally applied loads for which the shaft was designed. The drilled shaft foundation, including the rock socket, where required, shall be constructed in accordance with these specifications, as shown on the plans and in accordance with other specifications included in the contract documents. When directed by the engineer, corrections made by the contractor will be noncompensable and any effect on time of performance nonexcusable.

701.2 Preconstruction Submittals. At least 30 days prior to drilled shaft construction, the contractor shall submit to the engineer for review an installation plan for the construction of drilled shafts. The installation plan shall be of sufficient detail to outline the contractor's intended overall construction sequence and methods of excavation for the drilled shafts, including use of slurry, placement of reinforcing steel, details of concrete delivery to the site, an emergency construction joint method, placement of concrete in a continuous pour, including operational procedures for tremie or pump, and methods to prevent and handle delays in concrete batching and delivery to the site. The installation plan shall include details of casings to be used, if applicable, including calculations showing the ability of the casing to withstand anticipated hydraulic and earth pressures, and to withstand stresses due to installation without undue deformation. These details shall include methods for casing handling, splicing, straightening and out-of-round correction. Calculations included in the installation plan shall be signed and sealed by a registered professional engineer licensed to practice in the State of Missouri.

701.3 Material. All material shall be in accordance with this specification, Division 1000, Material Details, and specifically as follows:

Item	Section
Reinforcing Steel for Concrete	1036
Concrete Admixtures	1054
Concrete Curing Material	1055
Mortars and Grout	1066
Water	1070

701.3.1 Concrete. Drilled shafts shall be constructed of Class B-2 concrete, and all material, proportioning, mixing and transporting of concrete shall be in accordance with Sec 501, except as specified herein. An air entrainment admixture shall be used. A high range water-reducing admixture may be used to increase the slump to a maximum of 9 inches ± 1 inch. If used, the water-reducing admixture shall be added only after the concrete has reached the job site to reduce the potential for flash setting. The concrete mix for drilled shafts shall be dense, homogeneous, fluid and resistant to segregation, and shall consolidate under self-weight. The concrete mix shall have a set time that ensures that fluidity is maintained throughout the shaft concrete placement and removal of temporary casing, if used. A concrete retarder in accordance with AASHTO M 194, Type B, may be incorporated into the mix to retard set approximately two hours. Concrete for drilled shafts shall have a 28-day minimum compressive strength of 4,000 psi. Portland cement shall be Type I or Type II. The maximum water to cement ratio of a concrete mix to be placed under water shall be 0.45.

701.3.2 Casing. Welded or seamless steel permanent casings shall be in accordance with ASTM A 252, Grade 2, unless otherwise specified. The contractor shall furnish two copies of certification from the fabricator detailing the designated specification with which the furnished casings comply.

701.3.2.1 Shop Drawings. Shop drawings for permanent steel casings shall be prepared in accordance with Sec 1080 and shall be submitted to the engineer prior to installation of the casings.

701.3.2.2 Condition of Casings. Casings shall be smooth, clean and watertight. For out-of-round tolerance of steel casings before and after installation, the departure of any point on the periphery of the casing from a true circle shall not exceed one inch, measured radially.

701.3.2.3 Extent of Casing Length. Permanent casings, if required, shall be continuous wherever possible or practical. The permanent casing shall terminate at the specified elevation, and the concrete shall be trimmed to

within tolerances specified in Sec 701.4.16 prior to acceptance of the completed drilled shaft. Permanent casings shall be extended into rock, as needed, to provide a positive seal and to stabilize the shaft excavation against collapse, excessive deformation, or flow of water. Casings meeting all specified requirements shall be installed from the work platform to the elevations shown on the plans. Where drilled shafts are located in open water areas, casings shall be extended from at least 18 inches above the water elevation and unless otherwise specified in the contract documents, to the specified bottom of casing elevation to protect the shaft concrete from water action during placement and curing of concrete.

701.3.2.4 Use of Teeth or Cutting Edge. The casing may be fabricated with teeth or a cutting edge to facilitate insertion into the rock.

701.3.2.5 Splices. Splicing of permanent casings is not desirable and will only be permitted when approved by the engineer. If splices are required, the welding process shall be in accordance with the requirements specified herein. The contractor shall be fully responsible for the adequacy of welds during driving.

701.3.2.6 Welding. Shop welding of casings shall be performed by a fully-automated welding process to develop the full capacity of the shell. All welding shall be in accordance with Sec 1080, except that shop welding of casings will not require radiographic inspection. Inspection will be of a visual nature. If evidence indicating poor welding is found, the engineer may require radiographing. Field-welded splices of sections of the steel casings shall be made by shielded metal-arc welding procedures performed by a MoDOT-certified field welder using properly dried low-hydrogen E7018 electrodes that have been protected from the elements to maintain the dry condition. The welds shall be full penetration, watertight and of x-ray quality in accordance with Sec 1080.

701.3.3 Slurry. Drilling slurry will be defined as mineral slurry, polymer slurry, natural slurry formed during the drilling process, water or other fluids used to maintain stability of the drilled shaft excavation to aid in the drilling process or to maintain the quality of the rock socket. In addition, the terms mineral slurry and polymer slurry, as used herein, will be defined as the final mixed composite of all additives, including manufactured mineral or polymer slurry additives required to produce the acceptable drilling slurry.

701.3.3.1 Slurry Usage. Drilling slurry shall be used if detailed in the approved installation plan, if in accordance with the contract documents or if approved in writing by the engineer. Drilling slurry may be used at the contractor's option if the slurry is not in accordance with the contract documents; however, any slurry shall be approved by the engineer prior to use. Drilling slurry, when used, will be noncompensable and effect on time of performance due to the use of the slurry will be nonexcusable.

701.3.3.2 General Properties. The material used to make the slurry shall not be detrimental to the concrete or surrounding ground strata. Mineral slurries shall have both a mineral grain size that remains in suspension and sufficient viscosity and gel characteristics to transport excavated material to a suitable screening system. Polymer slurries shall have sufficient viscosity and gel characteristics to transport excavated material to suitable screening systems or settling tanks. The percentage and specific gravity of the material used to make the slurry shall be sufficient to maintain the stability of the excavation and to allow proper concrete placement. If approved by the engineer, the contractor may use water and on-site soils as a drilling slurry. In that case, the range of acceptable values for density, viscosity and pH, as shown in the following table for bentonite slurry, shall be met, except that maximum density shall not exceed 70 pounds/cubic foot. When water is used as the drilling fluid to construct rock sockets in limestone, dolomite, sandstone or other formations that are not erodible, the requirements for slurry testing will not apply if the entire fluid column is replaced with fresh water after drilling. To do so, fresh water should be introduced at the top of the casing and existing water used during drilling should be pumped out of the excavation from near the base of the socket until the entire volume of fluid has been replaced.

701.3.3.3 Preparation. Prior to introduction into the shaft excavation, the manufactured mineral or polymer slurry admixture shall be pre-mixed thoroughly with clean, fresh water and for adequate time in accordance with the slurry admixture manufacturer's recommendations allotted for hydration. Water used for mixing shall be in accordance with Sec 1070. Slurry tanks of adequate capacity will be required for slurry mixing, circulation, storage and treatment. No excavated slurry pits will be allowed in lieu of slurry tanks without written approval from the engineer. Adequate desanding equipment will be required as necessary to control slurry properties during the drilled shaft excavation in accordance with the values provided in the table below. Desanding will not be required for signposts or lighting mast foundations unless specified in the contract documents.

701.3.3.4 Control Tests. Control tests using a suitable apparatus shall be performed by the contractor on the slurry to determine density, viscosity, sand content and pH of freshly mixed slurry, recycled slurry and slurry in the excavation. Tests of slurry samples from within one foot of the bottom and at mid-height of the shaft shall be conducted in each shaft excavation during the excavation process to establish a consistent working pattern. A minimum of four sets of tests shall be conducted during the first eight hours of slurry use on the project. When the results show consistent behavior, the testing frequency may be decreased to one set every four hours of slurry use, or as otherwise approved by the engineer. Reports of all tests, signed by an authorized representative of the contractor, shall be furnished to the engineer on completion of each drilled shaft. An acceptance range of values for the physical properties will be as shown in the table below.

701.3.3.5 Sampling. When slurry samples are found to be unacceptable, the contractor shall bring the slurry in the shaft excavation to within specification requirements. Concrete shall not be poured until resampling and testing results produce acceptable values. Prior to placing shaft concrete, the contractor shall take slurry samples from within one foot of the bottom and at mid-height of the shaft. Any heavily contaminated slurry that has accumulated at the bottom of the shaft shall be removed. Disposal of all slurry shall be done in areas approved by the engineer. The contractor shall perform final shaft bottom cleaning after suspended solids have settled from the slurry mix.

Range of Acceptable Values for Mineral and Polymer Slurries in Fresh Water Without Additives					
Property	**Bentonite**	**Emulsified Polymer**	**Dry Polymer**	**Units**	**Test Method**
Density (Unit Weight)					
At Introduction	63.5 - 66.8	< 63	< 63	lb/ft^3	Density Balance
Prior to Concreting	63.5 - 70.5	< 63	< 63		
Marsh Funnel Viscosity					
At Introduction	32 – 60	33 – 43[b]	50 – 80[b]	sec/qt	Marsh Funnel
Prior to Concreting	32 – 60	33 – 43[b]	50 – 80[b]		
pH					
At Introduction	8 – 10	8 – 11	7 – 11	--	pH Paper or pH Meter
Prior to Concreting	8 – 10	8 – 11	7 – 11	--	
Sand Content					
At Introduction	< 4	< 1	< 1	Percent by Volume	API Sand Content Kit
Prior to Concreting	< 10	< 1	< 1		
Maximum Contact Time[a]	4	72	72	Hours	

[a]Without agitation and sidewall cleaning.
[b]Higher viscosities may be required to maintain excavation stability in loose or gravelly sand deposits.

701.4 Construction.

701.4.1 Protection of Existing Structures. All precautions shall be taken to prevent damage to existing structures and utilities. These measures shall include, but are not limited to, monitoring and controlling the vibrations from the driving of casing or drilling of the shaft, and selecting construction methods and procedures that shall prevent excessive caving of the shaft excavation.

701.4.2 Technique Shafts. When required by the contract documents, the contractor shall demonstrate the adequacy of methods and equipment used during construction of the first drilled shaft, which shall be an out of position technique shaft, constructed with reinforcement as identified for production shafts on the plans. This technique shaft shall be drilled in the position as directed by the engineer and drilled to the maximum depth for any production shaft shown on the plans. If at any time the contractor is unable to demonstrate, to the satisfaction of the engineer, the adequacy of methods or equipment and alterations required, an additional technique shaft(s) may be required. Technique shafts shall be cut off 3 feet below groundline, buried or otherwise disposed of as specified in the contract documents or as directed by the engineer. Once approval has been given to construct production shafts, no changes will be permitted in the methods of equipment used to

construct the shaft without approval from the engineer. When a technique shaft is not required, construction of the first production shaft will be used to determine if the methods and equipment used by the contractor are acceptable. Failure at any time to demonstrate to the engineer the adequacy of methods or equipment will be cause for the engineer to require appropriate alterations in equipment or method by the contractor to eliminate unsatisfactory results.

701.4.3 Construction Sequence. Excavation to footing elevation shall be completed before shaft construction begins, unless otherwise authorized by the engineer. Any disturbance to the footing area caused by shaft installation shall be repaired by the contractor prior to pouring the footing. When drilled shafts are to be installed in conjunction with embankment placement, the contractor shall construct drilled shafts after placement of fills. Drilled shafts constructed prior to the completion of fills shall not be capped until the fills have been placed as near to final grade as possible, leaving only the necessary work room for construction of the caps.

701.4.4 General Equipment and Methods. The contractor shall perform excavations through whatever material is encountered to the dimensions and elevations shown on the plans. The contractor's methods and equipment shall be suitable for the intended purpose and for whatever material is encountered.

701.4.4.1 General Equipment. The contractor shall provide equipment capable of constructing shafts to a depth equal to the deepest shaft tip elevation shown on the plans plus 15 feet, or as otherwise specified in the contract documents. When a rock socket is identified on the plans at a shaft location, the definition of "shaft tip elevation", for the purposes of this subsection, shall be taken to refer to the bottom of the rock socket.

701.4.4.2 General Methods. Excavations required for shafts and rock sockets shall be completed in a continuous operation. The contractor shall be responsible for ensuring the stability of the shaft excavation and the surrounding soil. When obstructions, either expected or unexpected, are encountered, the contractor shall notify the engineer promptly. Either the dry method, wet method, temporary casing method, permanent casing method if specified, or combinations, as necessary, shall be used to produce sound, durable concrete drilled shafts free of defects. The permanent casing method shall be used only when required by the contract documents. Blasting excavation methods will not be permitted. When a rock socket is required, the engineer will be the sole judge as to what constitutes the top of sound rock. Sound rock will be considered as the point where the rock is sufficient quality to allow the permanent casing to be seated. The engineer may order in writing additional depths of rock socket below the top of sound rock as considered necessary to improve the foundation. If the top surface of the sound rock is found to be inclined across the width of the shaft, the contractor shall immediately notify the engineer. The contractor shall use an airlift, or other method approved by the engineer, to clean the bottom of the shaft excavation.

701.4.4.2.1 Dry Construction Method. The dry construction method shall be used only at sites where the groundwater table and site conditions, generally stiff to hard clays or rock above the water table, are suitable to permit construction of the shaft in a relatively dry excavation and where the sides and bottom of the shaft remain stable without any caving, sloughing or swelling and allow visual inspection prior to concrete placement. The dry method shall consist of drilling the shaft excavation, removing accumulated seepage water and loose material from the excavation and placing the shaft concrete in a relatively dry excavation. The dry construction method shall be used only when shaft excavations, as demonstrated in a technique shaft or first production shaft, have 12 inches per hour or less of seepage.

701.4.4.2.2 Wet Construction Method. The wet construction method shall be used at sites where a dry excavation cannot be maintained for placement of the shaft concrete. This method shall consist of drilling the shaft excavation below the water table, keeping the shaft filled with water, natural slurry formed during the drilling process, mineral slurry or polymer slurry to contain seepage and groundwater movement, and to maintain stability of the hole perimeter until excavation to the final depth and placement of the reinforcing cage and concrete has been completed. This procedure will require placing the shaft concrete with either a tremie or concrete pump beginning at the shaft bottom, and displacing the water or slurry as concrete is placed. Temporary partial depth casings near the ground surface shall be provided to aid shaft alignment and position and to prevent sloughing of the top of the shaft excavation. Where drilled shafts are located in open water areas, shafts shall be constructed by the wet method using casings extending from above the water elevation to the plan casing tip elevation to protect the shaft concrete from water action during placement and curing. The casing shall be installed in a manner that produces a positive seal at the bottom of the casing.

701.4.4.2.3 Temporary Casing Construction Method. The temporary casing construction method shall be

used at all sites where the stability of the excavated hole or the effects of groundwater cannot be controlled by other means. In this method, the hole shall be advanced through caving material by the wet method in accordance with Sec 701.4.4.2.2. When a formation is reached that is nearly impervious, a casing shall be placed in the hole and sealed. Drilling may proceed by the dry method to the projected depth. The placement of concrete shall proceed by the dry or wet method, except that the casing shall be withdrawn after the concrete is placed. In the event seepage conditions prevent use of the dry method, excavation shall be completed by the wet method. Before and during casing withdrawal, a 5-foot minimum head of fresh concrete above the bottom of the casing shall be maintained at such a level that fluid trapped behind the casing is displaced upward out of the shaft excavation without mixing with or displacing the shaft concrete. Casing extraction shall be at a slow, uniform rate with the pull in line with the axis of the shaft. Temporary casings shall be removed while the concrete is still workable and the slump of the concrete is between 6 and 10 inches. Vibratory hammers shall not be used for casing installation or removal within
50 feet of other shafts that have been completed less than 24 hours earlier. The reinforcing cage shall not be damaged or displaced when withdrawing the temporary casing.

701.4.4.2.4 Permanent Casing Construction Method. The permanent casing construction method shall be used only when required by the contract documents or authorized by the engineer. The casing shall be continuous between top and bottom elevations shown on the plans. Vibratory hammers shall not be used for casing installation within 50 feet of shafts that have been completed less than 24 hours earlier.

701.4.5 Slurry.

701.4.5.1 Time Limitations. When bentonite slurry is used, the contractor shall adjust construction operations such that the maximum time that slurry is in contact with the bottom 5 feet of the shaft, the time from the end of drilling to the beginning of concrete placement, does not exceed four hours without agitation. If the four-hour limit is exceeded, the bottom 5 feet of the shaft shall be overreamed prior to performing other operations in the shaft. For rock sockets constructed in shale using polymer slurry, concrete placement shall begin within 72 hours of starting the rock socket excavation to avoid degradation of the shaft sidewall. Before concrete placement begins, foundation inspection, when required, cleaning operations and reinforcing steel placement shall be completed and approved by the engineer. These operations will be included in the 72-hour time limit. If concrete placement is not begun within the time limit, the contractor shall take corrective measures to the satisfaction of the engineer.

701.4.5.2 Level of Slurry. During construction, the level of slurry shall be maintained at a height sufficient to prevent caving of the excavation. If the engineer determines that the slurry construction method is failing to produce the desired final results, the contractor shall discontinue operations and propose an alternate method for approval from the engineer. Correction for a failed slurry construction method will be noncompensable and any effect on time of performance nonexcusable.

701.4.5.3 Slurry Manufacturer's Representative. When manufactured mineral or polymer slurry additives are to be incorporated into the drilling slurry mix, the contractor shall provide the technical assistance of a representative of the mineral or polymer slurry additive manufacturer at the site prior to introduction of the slurry into the first shaft where slurry use will be required, and during drilling and completion of a minimum of one shaft to adjust the slurry mix to the specific site conditions.

701.4.5.4 Drilling Fluids for Rock Socket Excavation. For rock sockets excavated in limestone, dolomite, sandstone or other formations that are not erodible and cannot be constructed in the dry, only water shall be used as the drilling fluid, except that when other slurry types are used in drilling through overburden, that slurry shall be removed and replaced with fresh clean water prior to rock socket excavation. For rock sockets excavated in geomaterial that may be eroded by drilling water, such as shales, a polymer slurry will be required prior to beginning rock socket drilling through completion of concreting the rock socket.

701.4.6 Cleaning of Shaft or Casing Sidewalls. Cleaning of the shaft or casing sidewalls shall occur by a method approved by the engineer as necessary to remove the depth of softening or to remove excessive slurry cake buildup.

701.4.7 General Excavation Considerations. The plans will indicate the top of shaft elevations and the estimated bottom of shaft elevations between which the drilled shaft shall be constructed. Drilled shafts may be extended deeper when the engineer determines that the foundation material encountered while drilling the shaft excavation is unsuitable or is not the same as anticipated in the design of the drilled shaft. Drilled shafts may be

shortened when the engineer determines the material encountered is better than that anticipated, or based on the results of load tests.

701.4.7.1 Time Restrictions. The integrity of the drilled shaft excavation shall be maintained by the placing of reinforcement and concrete in a timely manner following completion of the excavation. No two adjacent shafts shall be excavated at the same time, and shafts shall not be constructed within 24 hours of the completion of an adjacent shaft if the center-to-center spacing is less than 3 shaft diameters.

701.4.7.2 Disposal of Excavated Material. Excavated material removed from the shaft and any drilling fluids used shall be disposed of in accordance with the contract documents, as directed by the engineer, and in compliance with federal and state laws.

701.4.7.3 Worker Entry Into Shaft Excavation. The contractor shall not allow workers to enter the shaft excavation for any reason, unless both a suitable casing has been installed and adequate safety equipment and procedures have been provided to workers entering the excavation.

701.4.8 Unexpected Obstructions. When unexpected obstructions are encountered, the contractor shall notify the engineer immediately. Obstructions are defined as a impenetrable objects that a) cannot be removed or excavated with augers fitted with soil or rock teeth, drilling buckets and/or underreaming tools and b) cause a significant decrease in the rate of excavation advancement, relative to the rate of advancement for the rest of the shaft excavation with the particular strata that the obstruction is located in. The engineer will be the sole judge of the significance of any reduced rate of shaft advancement and shall be present to evaluate the occurrence of the obstructions. Subsurface obstructions at drilled shaft locations shall be removed by the contractor. Such obstructions may include man-made materials such as old concrete foundations and natural materials such as boulders. The contractor shall employ special procedures or tools which may include but are not limited to: chisels, boulder breakers, core barrels, air tools, hand excavation, temporary casings, and increasing the hole diameter. Blasting will not be permitted. In the event, unexpected obstructions are encountered, the contractor shall strictly follow the procedure provided for a differing site condition set forth in Sec 104. Any adjustment to the contract amount or time will only be those expressly permitted by the contract documents and only to the extent expressly provided in the contract documents. No contract adjustment will be determined, as to entitlement or amount on any basis other than under the contract as a differing site condition. Specifically, but not by way of limitation, the contractor agrees that the contractor will not be entitled to any contract adjustment arising from encountering an unexpected obstruction on the basis that, with respect to the obstruction, the Commission made: (1) a positive representation; (2) of a material fact; (3) which was false or incorrect; (4) as to which positive representation of material fact the contractor lacked knowledge that the representation was false or incorrect;
(5) upon which positive representation of material fact the contractor asserts that the contractor relied; and (6) was damaged as a direct result of the positive representation of material fact.

701.4.9 Lost Tools. Drilling tools lost in the excavation will not be considered obstructions and shall be promptly removed by the contractor. All work required to remove lost tools or to perform associated corrective work, including but not limited to repair of hole degradation due to removal operations, will be noncompensable and any effect on time of performance nonexcusable.

701.4.10 Excavation Inspection.

701.4.10.1 Inspection Equipment. The contractor shall maintain at the job at all times, all equipment suitable for use in the shaft inspection.

701.4.10.2 Removal of Excess Sediment and Water. Final shaft depth shall be measured with approved methods after final cleaning by airlift, or other method approved by the engineer. Unless otherwise stated in the contract documents, a minimum of 50 percent of the base of each shaft shall have less than 1/2 inch of sediment at the time of concrete placement. The maximum depth of sediment or any debris at any place on the base of the shaft shall not exceed 1 1/2 inches. For dry excavations, the maximum depth of water shall not exceed 3 inches prior to concrete pour. Shaft cleanliness will be verified by the engineer for wet or dry shafts.

701.4.10.3 Video Camera Inspection. The primary means of inspecting a shaft excavation, steel casing and the rock socket shall be by video camera lowered into the shaft. The contractor shall furnish all equipment necessary to conduct the camera inspection. The contractor shall operate the camera and supporting equipment under the direction of the engineer in such a manner as to obtain optimum results from the equipment. The video

camera and lighting equipment shall be capable of operating in dry or submerged conditions encountered during the inspection. The excavated shaft shall have the engineer's approval prior to proceeding with construction.

701.4.10.3.1 Equipment. Methods and equipment for controlling the camera will be subject to approval from the engineer and achievement of a satisfactory video record.

701.4.10.3.2 Drawings. The contractor shall submit layout drawings to the engineer showing the relative position of all components of the video inspection system, including type and size of barge or other work area. The information submitted shall include a written description of the operating procedure in a step-by-step sequence and shall state the source of power.

701.4.10.3.3 Shaft Inspection. Inspection of a shaft by video camera shall be performed as directed by the engineer. The excavated shaft, including the rock socket when applicable, shall be thoroughly cleaned of all loose fragments, sediment and turbidity prior to inspection. The camera shall be operated such that optimum clarity of detail can be obtained and all surface areas of the shaft, including the rock socket and the rock socket's base, can be observed. All scanning of the rock surfaces shall be recorded. After completion of the inspection of a rock socket, the engineer will direct whether or not drilling of the shaft shall be continued to a greater depth. Recordings shall be furnished to and shall become the property of the engineer upon completion of the work.

701.4.11 Foundation Inspection. NX size cores will be required for drilled shafts with rock sockets, where NX refers to the nominal diameter of rock core, and the NX core barrel has a 2 1/8-inch inside diameter. At least 15 days prior to drilled shaft construction the contractor shall drill one NX size core at the center of each rock socket to a depth of 10 feet or twice the diameter of the rock socket, whichever is greater, below the bottom of the rock socket. The contractor shall use the foundation inspection hole to determine the amount of casing needed and casing ordered prior to foundation inspections holes is at the contractor's risk. The contractor may be directed to extend the rock socket to a lower elevation, resulting from the engineer's evaluation of the foundation inspection cores.

701.4.11.1 Log of Excavated Material. The contractor shall maintain a log of excavated material for each foundation inspection hole, and a rough draft of the logs shall be delivered to the engineer within 24 hours of completion of the boring. A typed log prepared by a geologist or engineer along with recommendations for the tip of casing shall be delivered to the engineer within 5 days. The log shall include the following:

(a) The amount of NX cored per run and the amount recovered. All core loss shall be noted and explained. Clay layers shall be noted and located on the log by depth.

(b) The Rock Quality Designation (RQD) for the NX core. The bedding thickness and degree of weathering shall also be noted.

(c) One unconfined compression test per 5 feet of NX core, unless otherwise specified by the contract documents or directed by the engineer, shall be run on samples of NX core from the rock socket. The results of these tests shall be delivered to the engineer. The results of the unconfined compression tests shall be reported in units of kips per square foot (ksf). Any effect on time of performance resulting from delays in delivery of the above test results to the engineer will be nonexcusable.

(d) Color photographs of the core.

701.4.11.2 Storage and Labeling of Rock Cores. Rock cores shall be stored in structurally sound core boxes and shall be protected from the elements. The core boxes shall be properly labeled to indicate location, depth, beginning elevation, contractor and date, and shall be delivered to the engineer.

701.4.12 Reinforcing Steel Cage Fabrication and Placement. The reinforcing steel cage, consisting of the longitudinal bars, ties, spirals, cage stiffener bars, spacers, centering devices, and other necessary appurtenances, shall be completely assembled as a unit, and shall be placed immediately after the shaft excavation is inspected and accepted, and just prior to shaft concrete placement. Temporary internal cage stiffeners shall be removed as the cage is placed in the shaft such that interference with the placement of concrete does not occur.

701.4.12.1 Reinforcing Ties, Splices and Clearances. All reinforcing steel in the shaft shall be double-wire tied and supported such that the steel remains within the allowable tolerances specified herein during placement of concrete or casing removal. Splices shall be located as shown on the plans and in accordance with plan

details. With approval from the engineer, mechanical bar splices meeting the requirements specified in the contract documents may be used. Mechanical bar splices in adjacent bars shall be staggered not less than 30 inches apart. Welding of reinforcing steel will not be permitted. The reinforcing steel cage shall have sufficient rigidity to prevent racking or permanent deformations during delivery or installation.

Concrete Cover			
Shaft Diameter	**Uncased**	**Casing Remains**	**Casing Withdrawn**
2'-0" or less	3"	3"	4"
3'-0"	3"	3"	4"
4'-0"	4"	4"	4"
5'-0" or larger	6"	6"	6"

701.4.12.2 Spacers. Rolling spacers for reinforcing steel shall be used to minimize disturbance of the shaft sidewalls and to facilitate removal of the casing during concrete placement. Concrete spacers or other approved non-corrosive spacing devices shall be used at sufficient intervals, near the bottom and along the shaft at intervals not exceeding 5 feet , to ensure concentric location of the cage within the shaft excavation. When the vertical steel is greater than one inch in diameter, the maximum spacing may be increased to 10 feet. As a minimum, a set of spacers shall be provided within 2 feet of both the top and bottom of the shaft. In addition, one set of spacers shall be provided at both 2 feet above and below each change in shaft diameter. Non-corrosive spacers shall be provided at a minimum of one spacer per 30 inches of circumference of cage with a minimum of three at each level to maintain the required reinforcement clearances. The spacers shall be of adequate dimension to maintain the specified clearance between the outside of the reinforcing cage and the side of the excavated hole or casing.

701.4.12.3 Bottom Supports. Approved non-corrosive bottom supports shall be provided for the reinforcing cage to ensure that the reinforcing is the correct distance above the bottom of shaft. The bottom supports shall not be used to support the weight of the cage. In the event that the shaft has been excavated below the anticipated tip elevation, the reinforcing cage shall be extended at the lower tip end by lap lengths for No. 11 bars or smaller or by use of mechanical connectors. Splices of adjacent bars will not need to be staggered in this situation and all of the reinforcing bars may be spliced at a given location. Reinforcement will not be required for the bottom 12 inches.

701.4.12.4 Durability of Spacers. Concrete spacers and bottom supports shall be constructed of concrete equal in quality and durability to the concrete specified for the shaft. Spacers fabricated from reinforcing steel shall be epoxy coated.

701.4.12.5 Protection of Reinforcing Cage. The reinforcing cage bottom supports shall be positioned such that the reinforcing steel is not allowed to come into contact with the soil or rock and to ensure that the bottom of the cage is maintained at the proper distance above the base as identified in the contract documents or directed by the engineer.

701.4.12.6 Check of Tolerances for Placement of Reinforcing Cage. The elevation of the top of the reinforcing cage shall be checked before and after the concrete is placed. The reinforcing cage shall be maintained within the specified tolerances, and the contractor shall make corrections to those tolerances, as required, to the satisfaction of the engineer. No additional shafts shall be constructed until the contractor has modified the reinforcing cage support to obtain the required tolerances.

701.4.13 Concrete Placement.

701.4.13.1 General Considerations. Accumulations of water in casings and excess sediment at the base shall be removed as described herein before the concrete is placed. No concrete shall be placed until all casings, if used, within a 15-foot radius have been installed. Within the 15-foot radius, all driving or vibratory installation methods shall be discontinued until the concrete in the last shaft has set at least five days. Concrete placement shall begin as soon as possible after completion of the excavation, inspection and setting of the reinforcing cage, and shall proceed in a continuous operation from the bottom of the shaft to the plan construction joint or above as specified herein. An unplanned stoppage of work may require an emergency construction joint during the shaft construction.

701.4.13.1.1 Placement of Concrete in the Shaft. Concrete shall be placed for each shaft with the flow of concrete directed down the center of the shaft. Concrete shall be placed by free fall or through a tremie or

concrete pump. The free fall placement method will only be permitted in dry holes when approved by the engineer. The maximum height of free fall placement shall be 80 feet. Concrete placed by free fall shall fall directly to the base without contacting either the reinforcing cage or hole sidewall. Drop chutes may be used to direct concrete to the base during free fall placement.

701.4.13.1.2 Extent of Concrete Placement. Concrete placement shall continue after the shaft is filled until good quality concrete, as determined by the engineer, is evident at the plan construction joint at the top of the shaft and until a minimum of 18 inches of concrete, measured vertically, has been expelled. Immediately after concrete placement has been completed, all contaminated concrete and deleterious material accumulated above the top of shaft shall be removed to within one foot of plan top of shaft. Any concrete remaining above the top of shaft shall be carefully removed to the plan construction joint after curing and excess casing removal.

701.4.13.1.3 Time Limitations. The elapsed time from the beginning of concrete placement in the shaft to the completion of the placement shall not exceed two hours. All admixtures shall be adjusted for the conditions encountered on the job so the concrete remains in a workable plastic state throughout the two-hour placement limit. Prior to concrete placement, the contractor shall provide test results of both a trial mix and a slump loss test conducted by an approved testing laboratory using approved methods to demonstrate that the concrete meets the two-hour requirement. The contractor may request a longer placement time if a concrete mix is provided that will maintain a slump of 6 inches or greater over the longer placement time in the entire shaft as demonstrated by trial mix and slump loss tests. The trial mix and slump loss tests shall be conducted using concrete and ambient temperatures approved for site conditions.

701.4.13.1.4 Adequacy of Concrete Placement Method. Failure to demonstrate the adequacy of concrete placement methods or equipment during construction of any technique or production shafts will be cause for the engineer to require appropriate alterations in equipment or methods by the contractor to eliminate unsatisfactory results. Drilled shafts that are completed, but do not meet the concrete placement requirements, will be unacceptable. The contractor shall correct all unacceptable completed shafts to the satisfaction of the engineer at the contractor's expense.

701.4.13.2 Concrete Placement by Tremie. Tremies used to place concrete shall consist of a tube of sufficient length to discharge concrete at the shaft base elevation. The tremie shall have sufficient weight to rest on the shaft bottom before the start of concrete placement and to prevent curling of the tremie line during placement of the concrete. The tremie shall not contain aluminum parts that may come in contact with the concrete. A tremie shall consist of a watertight tube having an inside diameter of no less than 10 inches and fitted with a hopper at the top. The inside and outside surfaces of the tremie shall be clean and smooth to permit both flow of concrete and unimpeded withdrawal during concrete placement. The tremie wall thickness shall be adequate to prevent crimping or sharp bends that restrict concrete placement. Tremies used for depositing concrete in a dry drilled shaft excavation shall be supported such that the free fall of the concrete is less than 80 feet at all times.

701.4.13.2.1 Adjustment of Concrete Free Fall or Rate of Concrete Flow. If the free fall concrete causes the shaft excavation to cave or slough, the contractor shall control the movement of concrete by reducing the free fall of the concrete or the rate of flow of concrete into the excavation. The contractor shall be responsible for proposing, developing, and after approval from the engineer, implementing corrective work.

701.4.13.2.2 Tremie Operation. Underwater placement of concrete shall not begin until the tremie is at the shaft base elevation. The discharge end of the tremie shall be constructed to permit the free radial flow of concrete during placement operations. The tremie discharge end shall remain immersed as deep as practical in the concrete, but shall be no less than 5 feet at all times. The tremie shall be supported such as to permit free movement of the discharge end over the entire top surface of the work and to permit rapid lowering when necessary to retard or stop the flow of concrete. The discharge end shall be sealed closed at the start of work to prevent water from entering the tube before the tube is filled with concrete. After placement has started, the level of the concrete in the tremie shall be maintained above the level of slurry or water in the borehole at all times to prevent water or slurry intrusion into the shaft concrete. If water enters the tube after placement is started, the tremie shall be withdrawn, the discharge end resealed, and the placement restarted. The flow of concrete shall be continuous until the work is completed.

701.4.13.2.3 Removal of Tremie Orifice From Concrete. If at any time during the concrete pour, when using the wet construction method, the tremie line orifice is removed from the fluid concrete column and discharges concrete above the rising concrete surface, the entire drilled shaft will be considered defective. In such a case, the contractor shall remove the reinforcing cage and concrete, complete any necessary sidewall cleaning or

overreaming as directed by the engineer, and repour the shaft. Corrections made by the contractor will be noncompensable and any effect on time of performance nonexcusable.

701.4.13.3 Concrete Placement by Pump. Concrete pumps and lines may be used for concrete placement by either the wet or dry construction method. All pump lines shall have a minimum diameter of 5 inches and shall be constructed with watertight joints. Concrete placement shall not begin until the pump line discharge orifice is at the shaft base elevation. For the wet construction method, a plug or similar device shall be used to separate the concrete from the fluid in the hole until pumping begins. The plug shall either be removed from the excavation or shall be of a material that does not cause a defect in the shaft if the plug is not removed. The discharge orifice shall remain at least 5 feet below the surface of the fluid concrete. If at any time during the concrete pour the pump line orifice is removed from the fluid concrete column and discharges concrete above the rising concrete level, the shaft will be considered defective. In such a case, the contractor shall remove the reinforcing cage and concrete, complete any necessary sidewall cleaning or overreaming as directed by the engineer, and repour the shaft. Corrections made by the contractor will be noncompensable and any effect on time of performance nonexcusable.

701.4.13.4 Drop Chutes. Drop chutes may be used to direct placement of free fall concrete down the center of the shaft excavations where the maximum depth of water does not exceed one inch. The free fall method of placement shall not be used in wet excavations. Drop chutes shall be a smooth tube constructed either as a continuous one-piece unit or as removable sections. Aluminum drop chutes will not be permitted. Concrete may be placed through either a hopper at the top of the tube or side openings as the drop chute is retrieved during concrete placement. The drop chute shall be supported such that the free fall of the concrete measured from the bottom of the chute is less than 80 feet at all times.

701.4.14 Construction Joints. Unless otherwise approved by the engineer, construction joints shall be made only where shown on the plans. All planned reinforcing steel shall extend uninterrupted through joints. Unless otherwise shown on the plans, horizontal joints may be constructed without keys. Surfaces of fresh concrete at horizontal construction joints shall be rough floated sufficiently to thoroughly consolidate the surface and to intentionally leave the surface in a roughened condition. Shear keys, if required, shall consist of formed depressions in the surface covering approximately one-third of the contact surface.

701.4.15 Concrete Protection and Curing. For at least 48 hours after shaft concrete has been placed, no construction operations that will cause soil movement adjacent to the shaft shall be conducted, except for movement of light construction equipment. Portions of drilled shafts exposed to a body of water shall be protected from the action of water by leaving the forms in place for at least seven days after concrete placement or until the shaft concrete reaches a minimum strength of 2,500 psi. After placement, the temporarily exposed surfaces of the shaft concrete shall be cured to prevent loss of water by use of one or more of the approved methods. Curing shall be in accordance with Sec 502.

701.4.16 Construction Tolerances. During excavation of the shaft, the contractor shall make frequent checks on the plumbness, alignment and dimensions of the shaft. Any deviation exceeding the allowable construction tolerances specified herein shall be corrected with a procedure approved by the engineer. Drilled shaft excavations constructed in such a manner that the concrete shaft cannot be completed within the required tolerances will not be accepted. Correction methods shall be submitted by the contractor for the engineer's approval. Drilled shaft construction shall not begin until approval has been obtained. When a shaft excavation is completed with unacceptable tolerances, the contractor shall propose, develop and, after approval from the engineer, implement corrective work. Redesign drawings and computations submitted by the contractor shall be signed by a professional engineer registered to practice in the State of Missouri. The following construction tolerances will apply to drilled shafts unless stated otherwise in the contract documents:

(a) Temporary casing diameters shall provide a final shaft diameter as shown on the plans. When approved by the engineer, the contractor may provide a larger casing at the contractor's expense.

(b) Shafts shall be constructed such that the center of the top of the shaft is within 3 inches of plan position in the horizontal plane at the plan elevation for the top of the shaft.

(c) The vertical alignment of a vertical shaft excavation shall not vary from the plan alignment by more than 1/4 inch per foot of depth. The alignment of a battered shaft excavation shall not vary by more than 1/2 inch per foot of the distance along the axis of the shaft from the prescribed batter.

(d) After all the shaft concrete is placed, the top of the reinforcing steel cage shall be no more than 6 inches above and no more than 3 inches below plan position.

(e) The top elevation of the shaft shall be no more than one inch above or 3 inches below the plan top of shaft elevation.

(f) The bottom of the shaft excavation shall be normal to the axis of the shaft within a tolerance of 3/8 inch per foot of shaft diameter.

701.4.17 Integrity Testing. The completed shaft shall be subjected to the specified testing methods, such as concrete coring or sonic logging testing, to determine the extent of any defects that may be present. Work and material required for testing shall be furnished by the contractor and will be paid for in accordance with the contract documents. If testing reveals voids or discontinuities in the concrete that, as determined by the engineer, indicate that the shaft is not structurally adequate, the shaft will be rejected. The contractor shall then repair, replace or supplement the defective shaft in a method approved by the engineer. The construction of additional drilled shafts shall be discontinued until the contractor demonstrates the adequacy of the shaft construction method to the satisfaction of the engineer. Any additional work required by the contractor as a result of shaft defects will be noncompensable and any effect on time of performance nonexcusable.

701.4.17.1 Concrete Coring. At locations where concrete coring is to be provided, as indicated in the contract documents or as directed by the engineer, the following will apply. Upon completion of placing concrete and after waiting a minimum of 48 hours, the top surface of concrete shall be cleaned of laitance and any unsound concrete, and then one core hole shall be drilled completely through the shaft concrete and the rock socket to approximately one foot below the bottom of the rock socket of each shaft. Provisions for the inspection of the concrete surface shall be in accordance with the applicable requirements described herein. Core holes shall be drilled at locations specified by the engineer. The holes shall be drilled to recover NX size cores. The core samples recovered shall be labeled as to the location from which the samples were taken. The samples shall be delivered to the engineer for examination. If the cores indicate defective concrete in the shaft, which in the judgment of the engineer impairs the strength of the completed shaft, the contractor shall drill additional cores as directed by the engineer. If the concrete is found to be defective, the contractor shall submit to the engineer in writing a proposal for correction, and those corrective procedures shall be approved by the engineer before such corrective work is undertaken. The cored holes in non-defective concrete shall be filled with grout such that all voids are filled. All grout used for core holes shall be in accordance with Sec 1066. No direct payment will be made for grout and grouting.

701.4.17.2 Sonic Logging Testing. The contractor shall perform non-destructive integrity testing on completed drilled shafts and rock sockets using the crosshole sonic logging (CSL) method for concrete drilled shafts. The tests shall be conducted as indicated on the plans or other contract documents, or as directed by the engineer. Sonic logging measurements and data interpretation shall be performed by a CSL consultant with at least two years of experience in CSL drilled shaft testing. The contractor shall submit the testing organization experience record to the engineer, along with a written description of the testing procedures, operation manuals for the testing equipment, and samples of previous test results indicating both sound and defective concrete. The contractor shall inform the engineer of scheduled test dates at least seven days prior to CSL testing. The contractor shall provide reasonable access to the shaft top for performance of the sonic logging testing.

701.4.17.2.1 Installation of Pipes. The contractor shall furnish and install 2-inch nominal inside diameter steel pipes, ASTM A 53, Standard Weight, for use in sonic testing of each drilled shaft. Pipes shall be installed in each drilled shaft at the locations shown on the plans, as required by the testing agency or as directed by the engineer. The pipes shall be sufficiently regular and free from defects to permit the free and unobstructed passage of the probes. The pipe shall be installed such that all internal joints are flush. Stiffening devices such as mandrels, tape or similar material to seal the joints shall not be used. Pipe shall be watertight with clean internal and external faces, the latter to ensure a good bond between the concrete and the pipes. The pipes shall be fitted with a screw-on watertight shoe and cap and shall be securely fixed to the interior of the reinforcement cage with a minimum cover of 3 inches from the shaft periphery. The pipes shall be as near to parallel as possible, equally spaced and vertical. Where several sections of pipe are required to reach the full length, joints shall be made watertight. The pipes shall be filled with water and plugged or capped before shaft concrete is poured. The upper end of the pipe shall not be left open after the pour. The pipes shall extend at least 3 feet above the top of the concrete in the shaft to compensate for water displaced by insertion and removal of the transmitter, receiver, and cable. For shafts with a rock socket, the lower end of the pipes shall extend to the bottom of the rock socket. Care shall be taken during the drilled shaft concrete pour to not damage the pipes. If a tremie is used, the tremie

shall not be permitted to rest on top of the pipes during the pour. After completion of the sonic logging and final acceptance of the drilled shaft, the contractor shall fill the access pipes with grout.

701.4.17.2.2 Sonic Logging Equipment. The sonic logging equipment furnished by the CSL consultant shall consist of all necessary supplies, support equipment and power to perform the sonic logging testing requirements as described herein.

701.4.17.2.3 Sonic Logging Test Procedure. The drilled shaft shall be tested between 2 and 40 days after concrete placement. The following procedures shall apply:

(a) Pipes shall be checked to ensure the pipes are free from blockages and are filled with water any addition of water shall be noted and reported.

(b) Levels shall be taken on top of each pipe, each pipe shall be plumbed and the length shall be recorded.

(c) Testing shall be performed between each pair of adjacent pipes around the shaft perimeter and also in pairing combinations between each pipe with all other pipes in the shaft. If concrete coring is performed to confirm the nature of an anomaly identified during CSL testing, a subsequent CSL survey shall be performed using the concrete core hole(s) and the CSL access pipes.

(d) All tests shall be carried out with the probes in the same horizontal plane unless the engineer directs that defects be further evaluated with the probes on different horizontal planes.

(e) The probes shall be raised simultaneously from the bottom of the pipes ensuring that all slack is taken out of the cables before the analyzer is switched on, and that the distance between transducers remains constant during the course of the test. The speed of ascent shall be less than 12 inches per second. Measurements shall be taken at 3-inch intervals or less. Anomalies indicated by reduced velocity in the drilled shaft concrete and significantly lower energy shall be reported. If anomalies are detected, additional tests with two or more sources per receiver with vertical offsets of greater than or equal to 20 inches may be conducted at the request of the engineer between the same tubes unless the anomaly is within 20 inches of the bottom of the shaft.

(f) The contractor shall provide accurate measurements of probe depths on the logs.

701.4.17.2.4 Record of Testing. Preliminary results of the testing shall be provided on site prior to the CSL consultant leaving the site. A detailed CSL report and test data shall be submitted to the engineer within seven days. The CSL report shall be signed and sealed by a Professional Engineer. The CSL report shall include, but is not limited to, the following: project identification and dates of testing, a table and schematic showing shafts tested with accurate identification of tube coordinates and collar elevation, name of personnel that performed the tests and interpretation and those personnel's affiliation, equipment used, data logs, interpretation, analysis, and results. The data logs shall include XY plots of velocity and energy versus depth. CSL data shall be processed to provide easy to understand 2D cross-sections between tubes for all tube pair combinations. These plots shall be annotated by the CSL consultant as appropriate to delineate anomalous results. If offset surveys are performed as part of 3D tomography, data plots shall include 3D volumetric images for the entire shaft, color-coded, to indicate velocity or energy variations along the shaft. Locations and geometry of anomalies or unconsolidated zones shall be identified in 3D color images with detailed discussion. The results for CSL and 3D surveys shall be based on the percentage decrease in velocity as correlated to the following Concrete Condition Rating Criteria (CCRC). The velocity of good concrete shall be established from a nearby zone of good concrete. Deviations from the velocity shall be used for determining the Concrete Condition Rating.

Concrete Condition Rating Criteria			
Concrete Condition Rating	**Rating Symbol**	**Velocity Reduction**	**Indicative Results**
Good	G	0 to 10%	Acceptable concrete
Questionable	Q	10% to 25%	Minor concrete contamination or intrusion. Questionable quality concrete.
Poor	P/D	> 25%	Possible defects exist, possible water slurry contamination, soil intrusion,

			and or poor quality concrete.
Water	W	V= 4760 to 5005 ft/sec	Water intrusion, or water filled gravel intrusion with few or no fines present.
No Signal	NS	No signal received	Soil intrusion or other severe defect absorbed the signal, tube debonding if near top.

701.4.17.2.5 Correction of Unacceptable Results. The contractor shall immediately inform the engineer of any suspected anomalies, honeycombing or poor concrete quality detected by testing. The contractor and CSL consultant shall duly perform further tests as directed by the engineer to evaluate the extent of any detected anomalies. Core drilling, or other investigative methods as approved by the engineer, shall be performed to further investigate the anomaly. If a defect is confirmed, the contractor shall bear all costs involved with the shaft coring, grouting and remediation. If no defect is found the length of the core will be eligible for payment. Within 14 days of the completion of testing, the contractor shall provide a report signed and sealed by a Professional Engineer registered in the State of Missouri providing the results of the additional investigations and recommendations to accept or repair the shaft. The report shall also contain recommendations for modification of construction procedures to prevent defects for subsequent shaft installations. The dates of the completion of drilling, cleaning, steel placement and concrete pour shall also be provided. Construction above the top of shaft shall not be performed until the shaft has been accepted by the engineer.

701.5 Drilled Shaft Load Tests. All load tests, when required by the contract documents, shall be completed and submitted to the engineer for review and approval before construction of any production drilled shafts. The locations of load test shafts, the maximum loads to be applied, the test equipment to be furnished by the contractor, and the actual sequence of the load testing shall be as shown on the plans or as specified in the contract documents. After completion of testing, test shafts not used as production shafts shall be cut off at an elevation 3 feet below the finished ground line. The portion of shafts cut off shall be disposed of by the contractor, at the contractor's expense, in a manner approved by the engineer.

701.6 Method of Measurement.

701.6.1 Drilled Shaft. Accepted drilled shafts will be measured for payment to the nearest 0.10 linear foot of length along the axis of each shaft complete-in-place. For shafts without a rock socket, measurement will be from the plan top of the shaft elevation to the bottom of the shaft. For shafts with a rock socket, measurement will be from the plan top of the shaft to the top of the rock socket. "Top of the rock socket" will be defined as the upper elevation at which rock occurs across the entire width of the shaft, as determined by the engineer. Reinforcing steel will be measured for payment in accordance with Sec 706.

701.6.2 Rock Socket. The accepted rock sockets, if required, will be measured for payment to the nearest 0.10 linear foot of length along the axis of each rock socket in-place from the top elevation of the rock, as determined by the engineer and in accordance with Sec 701.6.1, to the bottom of the rock socket as built. In the event that additional rock socket construction is directed by the engineer, the additional length will be measured to the nearest 0.10 linear foot. Reinforcing steel will be measured for payment in accordance with Sec 706.

701.6.3 Technique Shafts. Accepted technique shafts, if required, will be measured for payment to the nearest 0.10 linear foot of length along the axis of each shaft in-place from the plan top of the shaft elevation to the bottom of the rock socket or shaft as built for each size of acceptable technique shaft drilled, including rock socket. Reinforcing steel will be measured for payment in accordance with Sec 706.

701.6.4 Video Camera Inspection. Video camera inspection, as required, will be measured for payment per each.

701.6.5 Foundation Inspection Holes. Measurement for payment for foundation inspection holes will be to the nearest 0.10 linear foot of length along the axis of each hole by the linear foot. Measurement will be from the top of the rock socket to the bottom of the foundation inspection hole. If the engineer directs foundation inspection borings more than 10 feet or twice the diameter of the rock socket, whichever is greater, below the anticipated bottom of the rock socket elevation as shown on the plans, measurement for payment for that portion of the boring in excess of 10 feet below or twice the diameter anticipated bottom of the rock socket elevation as shown on the plans will be to the nearest 0.10 linear foot of excess.

701.6.6 Concrete Coring. Measurement for payment for concrete cores will be to the nearest 0.10 linear foot of

length along the axis of the shaft from the top of concrete to a point as determined by the engineer, and may extend the entire length of the shaft plus one foot below the bottom of the rock socket.

701.6.7 Sonic Logging Testing. Sonic logging testing of drilled shafts, as required, will be measured for payment per each.

701.6.8 Drilled Shaft Load Tests. Load tests will be measured for payment per each load test performed.

701.7 Basis of Payment.

701.7.1 Drilled Shaft. Payment will be considered full compensation for all steel casing required, costs of drilling, excavation, slurry, cleaning, an acceptable method of inspection as required, furnishing and placing concrete, grouting and incidental work and material required by the contract documents. Payment for any drilled shaft installed and accepted will be at the contract unit price per linear foot for the diameter of the drilled shafts specified, irrespective of the character of the material actually encountered during excavation. No additional compensation will be made for concrete required to fill an oversized casing or for oversized excavation. If the method of construction requires that drilled shaft casing be seated into the sound rock such that the bottom of the casing is below the determined top of sound rock elevation, payment for excavation below the top of the sound rock layer (top of the rock socket) will be included in the payment for the rock socket. If sound rock is encountered within the excavation at which point a rock auger, core barrel or other rock-removing specialty tool must be used by the contractor before the top of the sound rock elevation to be used as "top of the rock socket" is confirmed by the engineer, that work will be paid for as rock socket excavation. Payment for reinforcing steel will be in accordance with Sec 706.

701.7.2 Rock Socket. Payment will be considered full compensation for drilling, excavation, slurry, cleaning, dewatering, an acceptable method of inspection as required, furnishing and placing concrete, and incidental work and material according to the contract documents. For payment purposes the length of any rock socket installed and accepted shall be paid for at the contract unit price per linear foot for the diameter of the rock socket specified, irrespective of the character of the material actually encountered during excavation. In the event that the engineer orders additional rock socket construction, payment for the additional length will be at the rate of 150 percent of the contract unit price per linear foot of rock socket up to a maximum additional length of 8 feet. Any work necessary to extend the length of the rock socket more than the additional 8 feet will be paid for as changes in the work in accordance with Sec 104.3. Payment at the adjusted rate will be considered full compensation for the additional excavation into rock, all additional concrete, except reinforcing steel, including any and all splices, and all incidentals necessary to complete the work down to the elevation designated by the engineer. Reinforcing steel will be paid for in accordance with Sec 706.

701.7.3 Technique Shafts. Payment for technique shafts will be in accordance with the contract unit prices for the appropriate drilled shaft and rock socket diameters. Payment will be considered full compensation for any steel casing required, all costs of drilling, excavation, an acceptable method of inspection as required, furnishing and placing concrete, grouting and incidental work, and material necessary to satisfactorily construct the technique shafts according to the contract documents. Reinforcing steel will be paid for in accordance with Sec 706.

701.7.4 Unexpected Obstructions. Contract adjustment, in time or amount, resulting from encountering any obstructions in the work covered by Sec 701 will be made only if the obstruction constitutes a differing site condition, as defined by the contract. Contract adjustments will be determined only under the terms of the contract for adjustments in time or compensation due to encountering a differing site condition. Contract adjustments will be allowed only to the extent, in type and amount of contract adjustment, that such adjustment is expressly allowed for or permitted by the contract documents, specifically: (1) Secs 109.4 through 109.4.3 for cost adjustment; (2) Sec 109.11 for any compensable delay to the work to deal with the obstruction, but not for any effect upon the unchanged work; and (3) Sec 108.14 to determine any adjustment in contract time.

701.7.5 Video Camera Inspection. Payment for one complete video camera inspection of each shaft, including the rock socket when applicable, will be paid at the contract unit price. Any additional video camera inspections required by the engineer due to extending the rock socket to a greater depth will be paid for at the contract unit price for video camera inspection. Payment for video camera inspection will be considered full compensation for moving in equipment, flushing turbid water from the shaft, conducting the actual scanning as specified, furnishing video recording, removing equipment, and all tools, labor and any incidentals necessary to complete the work.

701.7.6 Foundation Inspection Holes. Payment for foundation inspection holes will be at the contract unit price and will be considered full compensation for drilling or coring the holes, extracting and packaging the samples or cores, laboratory testing, delivering the samples or cores to the specified MoDOT location and for all other expenses necessary to complete the work. If the engineer directs foundation inspection borings more than 10 feet or twice the diameter of the rock socket, whichever is greater, below the anticipated bottom of rock socket elevation as shown on the plans, payment for that portion of the boring in excess of 10 feet or twice the diameter of the rock socket, whichever is greater, below the anticipated bottom of the rock socket elevation as shown on the plans will be at the rate of 150 percent of the contract price per linear foot of excess.

701.7.7 Concrete Coring. Payment for concrete coring will be considered full compensation for all material, labor, tools, equipment, grouting and incidentals necessary to complete the work. The number of feet of cored holes may vary from the estimated quantities, but the contract unit price shall prevail regardless of the variation. When concrete coring has not been setup as a contract item and is eligible for payment, payment for concrete coring will be made per foot at the fixed contract unit price specified in Sec 109.

701.7.8 Sonic Logging Testing. Payment for sonic logging testing of drilled shafts as required by the engineer will be made at the contract unit price per each for sonic logging testing. No payment will be made for supplementary sonic logging testing to evaluate defects. Payment for sonic logging testing will be considered full compensation for providing all equipment, access pipes, conducting the actual probing measurements as specified, furnishing reports, removing equipment, and all tools, labor and any incidentals necessary to complete the work. The number of sonic logging inspections may vary from the estimated quantities, but the contract unit price shall prevail regardless of the variation.

701.7.9 Drilled Shaft Load Tests. Payment will be at the contract unit price and will be considered full compensation for all costs related to the performance of the load tests as specified by the contract documents.

701.7.10 Welding Inspection. If evidence of poor welding is found, radiographing or other non-destructive testing of welds required by the engineer will be noncompensable and any effect on time of performance nonexcusable.

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SECTION 702
LOAD-BEARING PILES

702.1 Description. This work shall consist of furnishing and driving concrete and steel load-bearing piles to the minimum nominal axial compressive resistance and penetration required, at the location shown on the plans.

702.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section/Specification
Reinforcing Steel for Concrete	1036
Cast-In-Place Pile Shells (Thick Shell Type) Welded or Seamless Steel Pipe	ASTM A 252 Grade 3
Closure Plates	AASHTO M 270, Grade 50 (ASTM A 709 Grade 50)
Structural Steel (HP) Pile	AASHTO M 270, Grade 50S (ASTM A 709 Grade 50S)
Fluted Pipe	SAE-1010 or SAE-1015
Forged Steel Tips or Noses	SAE-1020
Pile Point Reinforcement	ASTM A 27, Grade 65-35 or ASTM A 148, Grade 90-60
Galvanizing	1081, ASTM A 123
Field Galvanizing and Galvanizing Repair	ASTM A 780*

*Zinc rich paints will not be allowed.

702.2.1 Cast-In-Place (CIP) Concrete Piles. Cast-in-place concrete piles shall consist of Class B-1 concrete cast in pre-driven steel shells. The steel shells shall be in accordance with the shape, size and minimum shell thickness shown on the plans, or to an approved equivalent section. All material, proportioning, air-entraining, mixing, slump and transporting of concrete shall be in accordance with Sec 501. Steel shells shall be free from water, soil and other deleterious matter when concrete is cast in the shells.

702.2.2 Structural Steel (HP) Piles. Structural steel piles shall be of the size, weight and structural shape shown on the plans. Piles shall not have a camber or sweep in excess of 1/8 inch multiplied by the length of pile in feet divided by five. Structural steel piles shall be stored such that damage to the piling does not occur.

702.2.3 Pile Point Reinforcement. Pile point reinforcement shall be furnished and installed on load-bearing piles at locations shown on the plans. Pile point reinforcement for steel piles shall be furnished and installed in accordance with Sec 1080, except as modified herein.

702.2.4 Pile Length. The contractor shall be fully responsible for the lengths the contractor furnishes for driving to obtain the specified minimum nominal axial compressive resistance and penetration. The pile lengths shown on the plans shall be considered approximate lengths.

702.2.5 Probe Piles. Probe piles shall be of the same material and size as the permanent piles. Probe piles shall be of such length as to permit driving the tips to an elevation 10 feet below that indicated by plan lengths. Probe piles used as permanent piles in place shall conform to Sec 702.4.8.

702.2.6 Certification. For structural steel piles and shells for cast-in-place piles, the contractor shall furnish two copies of a certification from the pile manufacturer or fabricator setting out the designated specification with which the material furnished complies.

702.3 Equipment.

702.3.1 Driving Equipment. Piles shall be driven with power-driven hammers, or by a combination of power-driven hammer and water jets. Power-driven hammers will be defined as hammers operated by steam, air or diesel power. For determining the energy per blow of diesel power hammers without a fully enclosed ram, the manufacturer's energy rating for the hammer will apply and may be assumed equal to the ram weight times the stroke. If the contractor desires to check a diesel power hammer against an approved steam hammer on a specified type of pile at a particular site, the contractor may do so at the contractor's expense, and the checked rating of the diesel powered hammer will be used in determination of pile nominal axial compressive resistances

at that site. Diesel hammers that have a fully enclosed ram shall be equipped with a gauge and accompanying charts which evaluate the equivalent manufacturer's rated energy being produced under any driving condition.

702.3.2 Leads. Pile driver leads shall be constructed in such a manner as to afford freedom of movement of the hammer, and leads shall be held in position by guys or stiffener braces to ensure support to the pile during driving. Inclined leads shall be used for the driving of battered piles.

702.3.3 Followers. Followers may be used in driving piles only if approved in writing by the engineer. If a follower is used, one pile of every group of ten shall be driven without a follower to determine the available nominal axial compressive resistance of the group.

702.3.4 Water Jets. Water jets used to aid in driving piles shall be sufficient in number to deliver a volume and pressure of water at the jet nozzles that will freely erode the material adjacent to the pile. The use of water jets shall be discontinued before the final penetration is reached, and piles shall be driven to secure a final penetration of no less than 2 feet if the nature of the soil permits.

702.3.5 Hammer Energy. The contractor is responsible for determining the hammer energy required to successfully drive the pile to the minimum tip elevation and to reach the minimum nominal axial compressive resistance specified on the plans. When specified in the contract documents, the contractor shall perform a drivability analysis to select an appropriate hammer size to ensure the pile can be driven without overstressing the pile and to prevent refusal of the pile prior to reaching the minimum tip elevation. The contractor shall plan pile driving activities and submit hammer size and hammer energy requirements to the engineer for approval before driving.

702.4 Construction Requirements.

702.4.1 Probe Piles. The contractor shall furnish and drive probe piles at locations specified. Where required, probe piles shall be driven to refusal or to a capacity 50 percent greater than that shown on the plans. In all cases, probe piles shall be driven to at least the minimum tip elevation shown on the plans for permanent piles. If no minimum tip elevation is shown on the plans, piles shall have a tip elevation at least 10 feet below the bottom of the supported footing or 10 feet below the natural ground line, whichever is lower, unless specifically authorized otherwise by the engineer. Probe piles shall be driven with the same type of equipment as will be used for driving the permanent piles. Before driving probe piles, the excavation shall be completed to an elevation no more than 2 feet above the proposed grade at the point where a probe pile is to be driven. Probe piles not driven in a permanent location shall be cut off, or pulled and backfilled as approved by the engineer.

702.4.2 Load-Bearing Piles. Load-bearing piles shall not be driven until after the excavation for the footing has been substantially completed. The heads of piles shall be protected against damage during driving. The procedure incident to the driving of piles shall not subject piles to excessive and undue abuse. Steel shells and structural steel piles shall hold the original form without distortion after being driven and after adjacent piles have been driven. Any load-bearing pile broken or damaged by reason of internal defects, by improper driving, or driven outside of the pile's proper location, shall be removed and replaced, or a second adjacent pile may be driven if this can be done without detriment to the structure, as determined by the engineer.

702.4.3 Preboring. Where piles are to be driven through more than 5 feet of compacted embankment that has been in place for less than five years, holes shall be prebored entirely through the embankment to the lowest elevation of the natural ground line adjacent to the embankment, or as shown on the plans. The holes shall have a diameter no less than that of the pile. After the pile is placed in the hole and before driving begins, the space remaining around the pile shall be filled with sand or other approved material before and maintained full during the driving of the pile.

702.4.3.1 Other locations where preboring for piles will be required will be shown on the plans. At such locations, holes shall be prebored to the elevation specified prior to pile placement. The holes shall have a diameter no less than that of the pile and shall be large enough to avoid damage to the pile being driven through the hole in hard material. The size of the hole shall be approved by the engineer before preboring is started. Pilot holes of lesser diameter than the pile shall not extend below the pile tip. For holes not prebored into hard rock, the hole shall be filled with sand or other approved materials prior to or after placement of the pile. For holes prebored into hard rock, the hole shall be filled with sand or other approved materials prior to placement of the pile. At all locations, the hole shall be maintained full with sand or other approved material during the driving of the pile. The pile shall then be driven in accordance with Sec 702.4.11.

702.4.4 Pile Placement Tolerances. Final position of piles shall be no more than 1/4 inch per foot from the vertical or from the batter line shown on the plans. The maximum variation of the head of the pile from the position shown on the plans shall be no more than 2 inches, except that piles in footings entirely below the finished ground line may not vary more than 6 inches. All piles forced upward by the driving of adjacent piles or by any other cause shall be redriven to the required minimum nominal axial compressive resistance and penetration.

702.4.5 Pile Point Reinforcement. Each point shall be manufactured in one piece of cast steel. Pile points furnished for cast-in-place concrete piles shall be attached to the pile as shown on the plans. Pile points for structural steel piles shall be furnished with the minimum point web and flange thickness at the location of attachment to the pile equal to the thickness of that portion of the pile being attached thereto multiplied by the factor (t) shown below with additional requirements as described herein.

Material	(t)
ASTM A 27 Grade 65-35	2.0
ASTM A 148 Grade 90-60	1.6

702.4.5.1 The point shall extend onto the pile a minimum of 1/2 inch for both faces of the web and for the end one-fourth of the inside face of each flange.

702.4.5.2 The web portion of the point shall protrude a minimum of 0.2 times the flange width below the pile with the flange portion of the pile point transitioning to a protrusion depth of no less than the pile point flange thickness at the extreme ends.

702.4.5.3 The point shall be attached to the pile with a full penetration weld along each flange. Weld backing shall be furnished for the total width of each flange.

702.4.5.4 The point extension onto the web of the pile may be omitted if alternating 1 1/2-inch x 1/4-inch fillet welds are placed on each side of the web.

702.4.5.5 Welding of the point to the pile shall be by a MoDOT-certified welder. Properly dried low hydrogen electrodes of the E70XX series shall be used with adequate protection from the elements in accordance with Sec 1080. The contractor shall be fully responsible for the adequacy of welds during driving.

702.4.6 Splices. Full length piles shall be driven wherever possible and practical. If extensions and splices are permitted or required by the engineer, all welding, including splicing of steel shells and structural steel piles, and support or reinforcing angles welded to steel piles, shall be in accordance with Sec 1080 and performed by a MoDOT-certified field welder using properly dried low-hydrogen E7018 electrodes that have been protected from the elements to maintain the dry condition. Steel shells for cast-in-place concrete piles shall be spliced as shown on the plans. Structural steel piles shall be spliced with a butt joint as shown on the plans. The contractor may furnish lengths of steel shells that incorporate no more than one splice per pile or structural steel piles that incorporate no more than one splice per pile for lengths up to and including 40 feet. No more than two splices will be permitted in each structural steel pile furnished for lengths exceeding 40 feet. In preparation of piles prior to driving, the use of individual sections less than 8 feet long will not be permitted. Additional field splices necessary to extend structural steel piles or steel shells to reach adequate bearing material shall be limited to one per pile, unless authorized by the engineer.

702.4.7 Cut-Offs. The tops of all piles shall be cut off square at cut-off elevations.

702.4.8 Protective Coatings.

702.4.8.1 Bitumen and Paint. Before the coatings are applied, steel shall be thoroughly cleaned. A commercially available bituminous coating, as approved by the engineer, shall be applied heavily to steel shells and structural steel piles in end bents for a length of 3 feet below the bottom of the concrete cap. All exposed steel piles shall have a bituminous coating 3 feet below and one foot above the finished ground line. Unless otherwise specified in the contract documents, all other exposed surfaces of steel shells and structural steel piles, including bracing, shall be coated with one 6-mil thickness of an approved gray epoxy mastic in accordance with the epoxy mastic manufacturer's recommendations. Protective coatings will not be required below the normal low water line or for galvanized piles and bracing.

702.4.8.2 Galvanizing. Steel shells for cast-in-place piles, structural steel piles, and structural steel bracing shall be galvanized as shown on the plans and in accordance with this specification. All pile below the pile concrete encasement shall be galvanized down to an elevation as shown on the plans. At the contractor's option, the entire pile length may be galvanized. Repairs to the galvanized coating and field galvanizing shall be in accordance with this specification. Repairs and field galvanizing will not be required where the pile will be encased in concrete or below the limits specified herein. Galvanizing material shall be omitted or removed one inch clear of weld locations. The method used to omit or remove the galvanizing material shall be masking, grinding or other methods as approved by the engineer. If a weld location falls within an area where galvanizing is required, clean the weld area making sure to remove all welding slag. Then field galvanize the weld area in accordance with this specification.

702.4.8.3 Bitumen and paint protective coatings will not be required for galvanized piles and bracing.

702.4.9 Time Restrictions. Concrete footings shall not be placed on cast-in-place piles until at least 12 hours after the last pile in the footing has been cast. No piling shall be driven within a radius of 20 feet of concrete that has not attained a minimum compressive strength of 1,500 psi. Compressive strength will be determined by tests performed in accordance with approved methods.

702.4.10 FHWA-modified Gates Dynamic Pile Formula. The following formula shall be used to determine the nominal axial compressive resistance, P, of piles when other methods of determination are not specified in the contract documents:

$$\boxed{P = 1.75(E)^{0.5}\log_{10}(10N) - 100}$$

P = Nominal Axial Compressive Resistance measured during pile driving in kips

E = Developed hammer energy in foot-pounds (Joules). This is the kinetic energy in the ram at impact for a given blow and may be assumed equal to the ram weight times the stroke.

N = Number of hammer blows for 1.0 inch of pile permanent set in blows/inch.

702.4.10.1 The above formulas will be applicable only if:

(a) The hammer has an unrestricted fall.

(b) The pile head is not broomed, crushed or splintered.

(c) There is no appreciable bounce of the hammer after striking the pile.

(d) The penetration is at a uniform or uniformly decreasing rate.

702.4.10.2 For piles driven to a batter, the nominal axial compressive resistance, P, in the equations provided in Sec 702.4.10 shall be divided by the pile batter factor, B, in order to calculate the value of N, the number of hammer blows for 1.0 inch of pile permanent set.

$$B = \frac{0.1\,(10 - m)}{(1 + m^2)}$$, pile batter factor

m = the tangent of the angle of batter to a vertical line

702.4.11 Minimum and Maximum Limits of Pile Driving. Piles shall be driven to at least the minimum tip elevation indicated on the plans. If no minimum tip elevation is shown on the plans, piles shall have a tip elevation at least 10 feet below the bottom of the supported footing or 10 feet below the natural ground line, whichever is lower, unless specifically authorized otherwise by the engineer. Piles shall be driven to attain a nominal axial compressive resistance determined in accordance with Sec 702.4.10 and no less than that shown on the plans as the minimum nominal axial compressive resistance.

702.4.11.1 Pile Driving to Hard Rock. Prior to driving structural steel piles, the contractor shall review the

boring logs to determine the depth at which rock may be anticipated. The contractor shall be attentive to the physical conditions associated with pile refusal on hard rock. When indication of hard rock occurs, in no case shall the pile be driven more than 3 blows when the hammer is operating at maximum rated energy and the penetration per blow is equivalent to or less than 10 blows per 0.5 inch. Driving shall cease immediately to avoid damage to the pile and to reduce the risk of injury.

702.5 Method of Measurement.

702.5.1 Probe Piles. Probe piles will be measured to the nearest linear foot of pile authorized and driven. For galvanized pile, no separate measurement will be made for the part of the pile that is not galvanized.

702.5.2 Load-Bearing Piles. Piles in place will be the actual length of all piles, except probe piles, measured to the nearest foot for that portion of each pile that remains permanently in the structure. For galvanized pile, no separate measurement will be made for the part of the pile that is not galvanized.

702.5.3 Preboring. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, measurement of prebored holes required under the provisions of Sec 702.4.3 will be made to the nearest linear foot of each hole specified or directed by the engineer. The revision or correction will be computed and added to or deducted from the contract quantity.

702.5.4 Pile Point Reinforcement. Pile point reinforcement will be measured per each.

702.6 Basis of Payment.

702.6.1 Probe Piles. Probe piles will be paid for at the contract unit price. Probe piles, if driven and used as permanent piles in place, will be paid for as probe piles, and not as load-bearing piles in place.

702.6.2 Load-Bearing Pile. The accepted quantity of load-bearing pile in place will be paid for at the contract unit price for each of the items included in the contract. No direct payment will be made for incidental items necessary to complete the work unless specifically provided as a pay item in the contract.

702.6.3 Pile Cut-Offs. No direct payment will be made for pile cut-offs.

702.6.4 Preboring. Preboring will be paid for at the contract unit price. No direct payment will be made for backfilling.

702.6.5 Pile Point Reinforcement. Pile point reinforcement, where specified, will be paid for at the contract unit price per each.

702.6.6 Splices. Splices may be required to extend a structural steel or steel shell pile to reach the minimum nominal axial compressive resistance. Any additional splices authorized to achieve the minimum nominal axial compressive resistance will be paid for as an additional 8 feet of pile in place at the contract unit price.

702.6.7 Protective Coatings. No direct payment will be made for coating exposed surfaces of steel shells and structural steel piles. Galvanized bracing in place will be paid for at the contract unit price for miscellaneous fabricated structural steel. Payment for coating the structural steel piles as described herein, and all material, excavation, labor, tools, equipment and incidentals necessary to complete the protective coating items will be considered completely covered under the contract unit price for other items.

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SECTION 703
CONCRETE MASONRY CONSTRUCTION

703.1 Description. This work shall consist of constructing culverts, bridges and other concrete structures as shown on the plans or as directed by the engineer.

703.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Bearing Pads for Structures	1038
Concrete Sealer	1053
Concrete Curing Material	1055
Concrete Tinting and Staining Material	1056
Material for Joints	1057

703.2.1 Concrete Requirements. All material, proportioning, air-entraining, mixing, slump and transporting of Portland cement concrete shall be in accordance with Sec 501.

703.2.2 Material Source Changes. Changes in sources of cement and aggregate will be permitted only with written approval from the engineer. Aggregate of essentially the same characteristics, except as noted in Sec 1005, and cements resulting in concrete of the same color, shall be used in any individual unit of the structure. The superstructure will be considered an individual unit of the structure unless otherwise shown on the plans.

703.3 Construction Requirements.

703.3.1 Falsework. Falsework for concrete masonry construction shall be adequate to support and hold the forms true to lines, camber and grades shown on the plans. If requested by the engineer, the contractor shall submit detailed plans for falsework, including the supporting design computations. The engineer's acceptance of the plans will not relieve the contractor of the responsibility for obtaining satisfactory results. The falsework shall be constructed in general accordance with the submitted plans. Falsework and forms for single and multi-span concrete frames and for continuous concrete slab and girder-type bridges shall be provided for the full length of each continuous or monolithic unit and for the full width of the structure before starting concrete placement in that unit. The use of shims or blocking shall be held to a minimum. Jacks shall be placed at approved locations to secure and maintain the required camber. Means shall be provided by the contractor for accurately determining settlement of the falsework while the falsework is being loaded. The contractor shall correct for any settlement of forms or falsework during the concrete placing process.

703.3.2 Forms. Forms for concrete shall be built true to the lines and grades specified, and shall be mortar-tight and of sound material adequate to prevent distortion during the placing and curing of concrete. All concrete shall be formed unless otherwise specified. A concrete pad of approved thickness may be used as a form for the unexposed bottom of end bent beams on piles. If required by the engineer, formwork plans shall be submitted by the contractor before formwork is started. If during or after placing the concrete the forms sag or bulge, the affected concrete shall be removed, the forms realigned and new concrete placed. Construction camber to accommodate shrinkage or settlement impairing the strength of the structure by the reduction of depth will not be permitted. The forms shall be designed for following minimum criteria: a fluid pressure of 150 pounds per cubic foot, and for a live load of 50 pounds per square foot on horizontal surfaces and 30 pounds per square foot on vertical surfaces for impact and vibration.

703.3.2.1 Face lumber of forms for exposed surfaces of concrete shall have a smooth dressed surface free of loose knots, knotholes and other defects. The spacing of supports and the thickness of face lumber shall be adequate to prevent distortion due to the pressure of the concrete. Form material shall be placed with horizontal joints. Triangular moulding, smooth on three sides and having a 3/4-inch width on each of the two form sides, shall be used to bevel all exposed edges of the structure, except where special bevels are shown on the plans.

703.3.2.2 Forms reused shall be in good condition.

703.3.2.3 Design and construction of forms shall permit the removal of the forms without damage to the concrete. Cofferdam braces or struts that will extend through any exposed concrete section will not be permitted. Forms under copings and around offsets may be given a draft of no more than one inch per foot to

permit removal without damage to the concrete. For narrow walls where access to the bottoms of the forms is not otherwise obtainable, an opening shall be provided to allow chips, dirt, sawdust or other foreign material to be removed immediately prior to placing concrete.

703.3.2.4 Form lining will be permitted, and will be required for exposed curved surfaces. Liners other than plywood may be used with approval from the engineer.

703.3.2.5 Fiber tubes for column forms above the ground line shall have a finish free of gaps or overlaps in the inside ply and shall be coated inside with a waterproofing material that will not stick or bond to, or discolor the concrete surface of the column. Fiber tubes for column forms from 6 inches below the finished ground line down may show seams, shall be waterproofed and need not be removed.

703.3.2.6 If wood forms are to be used in combination with metal forms, form details shall be submitted for approval if requested by the engineer. Steel panels, or panels with metal frames and wood that leaves permanent impressions or ridges shall not be used, except for concrete box culvert-type structures and other non-exposed areas.

703.3.2.7 The inside of all forms shall be oiled, except for forms having composition linings. The oil used shall be a light, clear paraffin-based oil or other approved material that will not discolor or damage the exposed concrete surface. The coating shall be applied before placing reinforcing steel.

703.3.2.8 Ties, spreaders and all metal appliances used inside of forms to hold the forms in correct alignment and location shall be constructed such that after removal of the forms, the metal may be removed to a depth of at least one inch below the surface of the concrete. Metal tie rods used inside the forms where concrete will have an exposed surface shall be of a type that will not produce a cavity at the surface of the concrete greater than 1 1/2 inches in diameter. Bolts and rods used as ties shall not be removed by pulling the bolts and rods through the concrete. Wire ties and pipe spreaders will not be permitted, and metal or wood spreaders, which are separate from form ties, shall be removed as concrete is being placed. A bolt-through method of supporting forms for massive substructure units may be used with approval from the engineer. No form ties shall be embedded in concrete above the roadway surface on bridges, except that coil ties and threaded rods may be permitted through the vertical face of the base and vertically through the top of barrier curbs. Coil ties, and all metal to be embedded in barrier curbs shall be epoxy-coated or galvanized.

703.3.2.9 Cavities produced by the removal of metal tie rods shall be filled with mortar composed of approximately one part Portland cement to two parts sand or a non-shrinking, non-staining type of mortar. After the cavities are filled, the finished surface shall be left smooth, even and uniform in color and texture with minimal evidence of shrinkage. White cement may be added to the mortar if necessary to obtain the required color. Tie rod cavities in surfaces against which backfill is to be placed shall be filled with mortar or an approved plastic compound in accordance with Sec 1057. Patching of tie rod cavities in the interior surfaces of box girders will not be required.

703.3.2.10 Fiber tubes for voids shall be properly designed for the use indicated. The outside surface shall be waterproof. Distortion of the tubes shall be prevented. The ends shall be covered with suitably designed mortar-tight caps. If material used for capping tubes expands when moist, preformed joint filler 5/16 inch thick shall be used around the perimeter of the caps to prevent distortion, or another method approved by the engineer.

703.3.2.11 Steel tubes for voids shall be properly designed for the use indicated. Excessive distortion shall be prevented in handling, storage and placing. The diameter of the tube shall be as shown on the plans with a tolerance of plus zero and minus 3/4 inch. The ends of tubes shall be covered with suitably designed mortar-tight metal end caps.

703.3.2.12 Tubes for producing voids in concrete slab superstructures shall be accurately located in positions shown on the plans and shall be positively anchored to the joists carrying the floor forms. Anchors and ties shall be designed to leave a minimum of supporting material exposed in the bottom of the finished slab of the completed structure. Details of proposed anchorage and ties for the tubes shall be submitted for approval before work is started on the bridge superstructure. One 3/4-inch diameter weephole shall be provided near each end of each tube. Weepholes shall be placed in straight lines parallel to bents, and shall extend through the forms and be kept open at all times. Tubes shall be protected from moisture and heat until concrete is placed. Distortion of tubes after placing of concrete shall not increase the tubes' vertical axis by more than 1/2 inch.

703.3.2.13 Falsework and form removal from under any structural concrete unit shall not be started until the concrete has attained at least the required compressive strength shown. The falsework support of all concrete spans of a continuous or monolithic series shall be first released from the center of all spans, and shall proceed simultaneously from all span centers each way toward adjacent bents. Release shall be in such a manner as to permit the concrete to gradually and uniformly take stresses due to the self weight of the concrete. Compressive strength will be determined by tests conducted in accordance with AASHTO T 22.

Class of Concrete	Compressive Strength, psi, min.
B	2750
B-1	3000
B-2	3000

703.3.2.14 Except in accordance with Sec 703.3.6, forms for vertical surfaces of bridge superstructures shall be removed as soon as the concrete is self-supporting to permit prompt patching of tie holes.

703.3.2.15 Girders and beams shall not be set on bent cap until the concrete in the bent cap has attained at least the required compressive strength shown in Sec 703.3.2.13.

703.3.3 Placing Concrete. Placing concrete in any unit of a structure shall not begin until preparations for placing and finishing are satisfactory to the engineer. Concrete shall be placed in the form in layers as near final position as practical with minimum handling. Each placement shall be completed in a continuous operation with no interruption in excess of 45 minutes between the placing of contiguous portions of concrete. Where a finishing machine is to be used, the machine shall be moved over the area to be finished immediately prior to placing concrete in any bridge deck pour to facilitate checking reinforcement cover and slab thickness. This checking shall be done in the presence of the engineer and with the screeds in the finishing position. Placing of concrete for bridge decks shall proceed uniformly for the full width of the placement. Once begun, placing of concrete in the superstructure of a continuous or monolithic series of spans shall proceed as rapidly as good construction practice will permit until all concrete in that series is placed. Vibrators having a minimum frequency of 4,500 impulses per minute shall be used to thoroughly consolidate the concrete in the forms and around the reinforcing steel. Sufficient vibrators shall be on hand to ensure continuous placement of the concrete without delay. The vibrators shall not be used for moving concrete nor shall vibrators penetrate or disturb previously placed layers of concrete after initial set. Vibration shall not cause segregation of the material. Reinforcing steel protruding through transverse or longitudinal headers shall not be disturbed until the concrete is at least 24 hours old.

703.3.3.1 Where placing operations involve dropping the concrete more than 5 feet, the concrete shall be deposited as approved by the engineer to avoid segregation and contamination. Where concrete is placed in the interior of pneumatic caissons, the concrete may be deposited through air locks or other approved devices, and the requirement of dropping the mixture no more than 5 feet may be waived.

703.3.3.2 Concrete shall be worked under and around the reinforcing steel without displacing the steel. Forms and reinforcing steel above concrete being placed, and placing equipment shall be kept clean and free from coatings of hardened concrete. Water used for flushing the equipment shall be discharged clear of the concrete and forms.

703.3.3.3 Concrete shall be placed around the tubes forming voids in slab spans using methods to prevent the displacement of the tubes. For tubes having an inside diameter greater than 14 inches, the concrete shall be placed in three layers. The first layer shall extend from the floor forms up to a plane 1/4- tube diameter above the bottom of the tubes and the second layer to 3/4-tube diameter. For tubes 14 inches or smaller, the concrete shall be placed in two layers, with the lower layer extending to the middle of the tube. Each layer shall be vibrated and allowed to settle after placing, before the next succeeding layer is placed. The succeeding layer shall be deposited while the concrete in the layer below is still plastic enough to permit intermixing the two layers by use of a vibrator.

703.3.3.4 The sequence of placement of concrete for roadway slabs on a continuous series of spans will be shown on the plans, along with the minimum rates of placement required for the basic sequence and for combinations thereof. The basic sequence of placement shall be observed unless it can be demonstrated that the contractor can place and satisfactorily finish combined placements at the required rate. If the contractor wishes to alter the placing sequence or to combine units, the contractor shall submit a written request subject to approval from the engineer.

703.3.3.5 Concrete for substructure units shall be placed in the dry unless otherwise approved by the engineer. If the supporting material at plan elevation of the bottom of a pile footing is not sufficiently stable to support the concrete, the material shall be stabilized, or the bottom of the footing shall be formed to adequately support the concrete. The stabilizing of material or forming under pile footings will be at the contractor's expense.

703.3.3.6 Depositing concrete under water will be permitted if provided for in the contract documents or upon written approval from the engineer. The concrete shall be placed by tremie bottom dump bucket or mechanically applied pressure. The concrete shall be placed in the final position in still water and shall not be vibrated or disturbed after being deposited. Concrete placed under water for seal courses shall be Seal Concrete in accordance with
Sec 501.

703.3.3.7 Conveying, placing and pumping equipment shall have adequate capacity, be suitable for the intended work and shall be operated to produce a continuous stream of uniform concrete. Equipment shall be arranged to prevent transmission of vibration to freshly placed concrete. The system through which the concrete is pumped shall be manufactured such that no aluminum parts will come into contact with the concrete.

703.3.3.8 At the completion of concrete placement, the last concrete in the pipeline shall not be used.

703.3.3.9 Concrete used for filling cavities or crevices as directed by the engineer and as required in Sec 206 shall be Class B concrete. This concrete shall be unformed mass concrete placed separately from and prior to the placing of footing concrete.

703.3.3.10 When a closure pour is specified on the bridge plans, or is necessary for other requirements, the closure pour between slabs poured independently shall be expansive Class B-2 concrete. Unpolished aluminum powder shall be added to the Class B-2 concrete as recommended by the powder manufacturer or as approved by the engineer for controlled expansion. A shrinkage compensating cement may be substituted for the unpolished aluminum powder and cement. If a shrinkage compensating cement is substituted, the type and amount shall be approved by the engineer.

703.3.3.10.1 Prior to placing the closure pour, the contractor shall release the falsework to allow the initial deflection in the slab extension. The contractor shall obtain approval from the engineer prior to placing the closure pour.

703.3.3.10.2 The slab area to be in contact with the closure pour shall be sandblasted to remove all foreign matter and shall be cleaned to remove all dirt and loose material. Containment and disposal of material shall be in accordance with Sec 202.2. After the slab area has been cleaned and any damaged epoxy coating on the reinforcing bars repaired, an epoxy-bonding compound shall be applied to the slab area to be in contact with the closure pour. The concrete bonding compound and application shall be in accordance with Sec 623.

703.3.3.10.3 Immediately following application and before the concrete bonding compound has set, the closure pour shall be placed.

703.3.4 Joints in Concrete Masonry. Construction and expansion joints in concrete masonry shall be located where shown on the plans, except that in case of an unforeseen contingency, an emergency construction joint may be permitted.

703.3.4.1 Surfaces of construction joints shall be roughened or scored unless shear keys are shown on the plans. The face edges of all joints shall be carefully finished, and feathered edges shall be avoided. When the placing of concrete is temporarily discontinued, the concrete shall be cleaned of laitance and other objectionable material after becoming firm enough to retain form, and shall be thoroughly wetted before placing new concrete. Contraction joints in floor slabs of truss bridges may be sawed. Waterstops and flashings as shown on the plans shall be continuous if practical. Splices shall be watertight.

703.3.4.2 Preformed sponge rubber expansion joint material shall be of the dimensions shown on the plans. Splices shall be held to a practical minimum and shall be made by lacing with copper wire or soft-drawn galvanized steel wire. All joint material shall be securely stitched to one face of the concrete with No. 10 gage copper wire or No. 12 gage soft-drawn galvanized steel wire. Unless joint sealing is specified, the sponge rubber material shall be left exposed for the material's full length with clean and true edges.

703.3.4.3 Geotextile filter cloth, three feet wide double in thickness, meeting the requirements of Sec 1011.3.4, shall be centered on transverse joints in top slab and sidewalls for both cast-in-place and precast box culverts.

703.3.5 Concrete Finishes. Riding surfaces shall be finished true to the alignment, grade, cross section and camber shown on the plans. These surfaces shall be finished by use of an approved mechanical finishing machine. On skewed structures the finishing machine shall be adjusted to finish the surface approximately parallel to the skew if the angle of skew exceeds 45 degrees, or if the angle of the skew exceeds 30 degrees and the placement width divided by the span length equals or exceeds 0.8. Vibratory screeds shall not be used, including those that are a part of the proposed finishing machine.

703.3.5.1 Machine finishing shall be with an approved self-propelled mechanical finishing machine. The engineer may waive the use of a finishing machine on isolated irregular shaped areas of the bridge surface. The finishing machine shall travel on adjustable rails or guides set to proper grade, and supported outside the limits of the finished riding surface. Where a longitudinal joint is shown on the plans, the finishing machine rails or guides shall be placed as close as practical to the longitudinal joint. The rails shall be supported to limit the full operating load deflection between supports to 1/8 inch or less. The rails shall be placed parallel with the centerline of roadway or the longitudinal axis of the area to be finished. Where supports are located such that fresh concrete must be placed around the supports, the rails or guides shall be furnished in sections of 10 feet or less and placed above the concrete surface. The sections and supports shall be removed and the holes filled with concrete immediately after the final straightedging. The finishing machine shall make sufficient passes to obtain the specified cross section and surface finish. The final pass of the machine shall be of the maximum practical length, and shall be coordinated with the rate of placement. Finishing machine loads will not be permitted on concrete that has not reached a compressive strength of 3200 psi.

703.3.5.2 Where hand finishing of riding surfaces is permitted, the surface shall be finished to the specified cross section and surface texture .

703.3.5.3 Sufficient work bridges shall be provided to complete the work in an orderly and continuous manner. Work bridges shall be supported outside the limits of concrete placement.

703.3.5.4 The riding surface shall be checked with a 10-foot straightedge immediately after the final finishing operation. The straightedge shall be pulled lightly across the surface from one edge of the finished area to the other without interruption. Reaching from outer edges to the center of the finished area will not be permitted. Each transverse pass shall overlap the previously straightedged portion by approximately one-half the length of the straightedge. The straightedge shall not be used to cut or move concrete from its finished position. Any irregularities, bumps or improperly finished areas shall be refinished and the surface again checked by repeating the straightedging operation.

703.3.5.5 The roadway surface, except within 12 inches of the inside face of the curb, shall be textured as soon as the condition of the concrete will permit. The roadway finishing shall otherwise be in accordance with Sec 502.4. Hand-operated devices producing a satisfactory texture will be permitted. At the contractor's option, a finned float with a single row of fins may be used. The grooves produced by the finned float shall be approximately 1/8 inch wide at 5/8 to 3/4-inch centers and shall be approximately 1/8 inch deep. This operation shall be performed at such a time and in such a manner that the desired texture will be achieved while minimizing displacement of the layer aggregate particles.

703.3.5.6 As soon as curing has been completed, the riding surface will be thoroughly straightedged by the engineer, and all variations exceeding 1/8 inch in 10 feet will be plainly marked. Areas more than 1/8 inch high shall be removed by an approved device consisting of multiple cutting edges leaving a grooved surface finish comparable to that produced by the broom. The use of a bush hammer or other impact device will not be permitted.

703.3.5.7 Unless an armored joint is shown on the plans, construction and expansion joints in the roadway surface shall be carefully edged and left free of all mortar and concrete. If shown on the plans, these joints shall be sealed with joint sealing material. Joints shall be dry and cleaned immediately before the joints are sealed. Required joint sealing shall be done prior to surface sealing the bridge deck.

703.3.5.8 Surface finish for concrete masonry units, other than those specified in Sec 703.3.5, shall begin immediately following removal of the forms. Fins and irregular projections shall be removed. Form tie cavities,

holes, honeycomb spots in other than exposed surfaces, and other defects shall be thoroughly cleaned, saturated with water and carefully pointed with a mortar in accordance with Sec 703.3.2.9. Repaired surfaces shall be satisfactorily cured.

703.3.5.9 Bridge seats shall be finished to a smooth even surface. Where lead plates or fabric pads are used to seat steel bearing plates, the area under the lead plates or fabric pads shall be finished to within 1/8 inch above plan elevation and shall be dressed to a uniform, level bearing with a Carborundum brick or power grinder after the concrete has set sufficiently to fix the larger particles of sand. The deviation of the bearing seat from a true level surface shall not exceed 1/16 inch. Where elastomeric bearing pads are used, the finishing of 1/8 inch above plan elevation and grinding of the bridge seat area will not be required. Wells for anchor bolts shall be completely filled with an expansive-type mortar in accordance with Sec 1066 after the steel has been erected and adjusted. In lieu of wells, anchor bolt holes may be drilled in accordance with Sec 712. Keyways, anchor bolt wells, holes and other depressions that might collect water and freeze shall be sealed.

703.3.6 Curing Concrete.

703.3.6.1 Bridge Decks. Curing compound for bridge decks shall be Type 1-D liquid membrane-forming curing compound in accordance with Sec 1055 Bridge Curing Compounds, except that if diamond grinding is specified, either Type 1-D or Type 2 liquid membrane-forming curing compound in accordance with Sec 1055 may be used for the surfaces to be textured by diamond grinding. Wet curing is required and shall be performed in accordance with Sec 703.3.6.1.4.

703.3.6.1.1 Application Rate. The material shall be approved by the engineer prior to use and shall be applied at the manufacturer's recommended rate, but at a rate of no less than one gallon per 150 square feet.

703.3.6.1.2 Conventional Texturing. When conventional texturing is specified, fresh concrete shall be sprayed immediately with a curing compound following texturing as specified in Sec 703.3.5.5. The application of the curing compound shall progress such that no more than 10 linear feet of the textured concrete surface is exposed without curing compound at any time.

703.3.6.1.3 Diamond Grinding. When diamond grinding is specified in lieu of conventional deck texturing, fresh concrete shall be sprayed immediately after surface floating to smooth surface with curing compound as specified in Sec 703.3.6.1.

703.3.6.1.4 Wet Curing. The contractor shall submit to the engineer a plan to monitor the free moisture and maintain continuous free moisture for the 7 day period. The concrete shall be covered with clean mats as soon as the curing compound has dried sufficiently to prevent adhesion, and the concrete surface will support the curing mat without marring or distorting the finish, but no more than 90 minutes after the concrete is floated or textured. If the concrete mix contains more than 15 percent fly ash or slag or combination thereof and remains plastic after 90 minutes, coverage with mats may be delayed, as directed by the engineer, until the surface will support the curing mat without marring or distorting the finish. The mats shall be sufficiently wet at the time of placement to prevent moisture absorption from the finished surface. The contractor shall control the run-off so as not to cause a traffic hazard or soil erosion. The continuous wet cure shall be maintained a minimum of seven days and until the concrete has attained a minimum compressive strength of 3,000 psi.

703.3.6.1.5 Opening to Construction Activities. Light material and equipment weighing less than 1,000 pounds may be carried onto the bridge deck after the deck concrete has been in place at least 24 hours, provided curing is not interfered with and the surface texture is not damaged. Vehicles, material and equipment needed for construction activities and weighing less than 4,000 pounds shall not be moved onto any span until after the last placed deck concrete has attained a compressive strength of at least 3,200 psi. Loads in excess of the above shall not be moved onto the bridge deck until the deck concrete has reached the compressive strength specified on the plans. Placement of barrier walls on bridge decks shall not begin until the 7 day wet cure is complete and the deck has reached the minimum compressive strength shown on the plans.

703.3.6.1.6 Open To Traffic. Structures shall not be opened to any public vehicular traffic until at least 10 days after the last placement of deck concrete and until such time that the concrete has attained the compressive strength specified on the plans.

703.3.6.1.7 Railroad Bridge. Railroad bridge decks to be waterproofed shall not be cured with liquid membrane-forming compound.

703.3.6.2 Concrete Masonry Not to be Sealed. Curing of exposed concrete masonry surfaces not to be sealed shall be initiated after finishing operations are completed and as soon as marring of the concrete will not occur by application of the curing process. The surface of exposed concrete shall be covered and cured in accordance with one of the following methods. Concrete adjacent to construction joints shall be wet cured, and other locations shall be either wet cured or cured by application of Type 1-D liquid membrane-forming curing compound in accordance with Sec 1055. Curing mats for curing exposed surfaces shall be kept wet for 72 hours. The mats shall remain in place until the mats are dry, or if not dry, at least 24 hours after the wet curing period. Concrete shall not be left exposed for more than 30 minutes between stages of curing and during the curing period.

703.3.6.2.1 Damp Proofed. Surfaces to be damp proofed shall not be cured with liquid membrane-forming compound.

703.3.6.2.2 Footings. Footings may be cured by submersion with approval from the engineer.

703.3.6.2.3 Precast Members. Steam curing or curing by complete submersion in water will be permitted for precast members. If steam curing is applied, the jets shall not impinge directly on the concrete or on the forms, free circulation around the units shall be maintained, the steam shall be thoroughly saturated at all times, and the temperature around the concrete shall be raised no more than 40ºF per hour and shall not exceed 160ºF at any time. After the steam curing period, the temperature inside the chamber shall be reduced at a rate of no more than 40ºF per hour until the temperature has reached about 20ºF above the temperature of the air to which the concrete will be exposed.

703.3.6.3 Concrete Masonry to be Sealed. Curing of exposed concrete masonry surfaces to be sealed shall be initiated after finishing operations are completed and as soon as marring of the concrete will not occur by application of the curing process.

703.3.6.3.1 Curing. Concrete curing shall be performed in accordance with Sec 703.3.6.1, except for curbs, parapets, medians and bridge barriers.

703.3.6.3.2 Curbs, Parapets, Medians and Bridge Barrier.

703.3.6.3.2.1 Curing. Curing compounds for sealed concrete masonry shall be Type 1-D liquid membrane-forming curing compound in accordance with Sec 1055 Bridge Curing Compounds. Wet curing will not be required for curbs, parapets, medians and bridge barriers.

703.3.6.3.2.2 Application Rate. The material shall be approved by the engineer prior to use and shall be applied at the manufacturer's recommended rate, but no less than 150 square feet per gallon.

703.3.6.3.2.3 Application Time. The application of the curing compound shall progress such that no more than 10 linear feet of the textured concrete surface is exposed without curing compound at any time.

703.3.6.3.2.4 Open to Traffic. Structures shall not be opened to any public vehicular traffic adjacent to curbs, parapets, medians and bridge barrier until such time that the concrete has attained the compressive strength specified on the plans. The requirement for reaching compressive strength prior to adjacent traffic will be waived for curb blockouts placed on existing curbs.

703.3.7 Bridge Deck Surface Texturing. For conventional texturing, the roadway surface shall be textured in accordance with Sec 703.3.5.5 prior to the application of the curing compound.

703.3.7.1 When diamond grinding is specified, following the curing period and the attainment of design strength, the deck surface shall be diamond ground in accordance with the following.

703.3.7.1.1 The bridge deck shall be diamond ground in accordance with Sec 622.30, except traffic control and closure for grinding operations shall be as specified by other portions of the contract documents, except as noted herein. Grinding may proceed after design strengths are attained and shall be completed prior to opening to any traffic other than construction traffic.

703.3.7.1.2 Bumps and high areas shall be removed prior to the start of final grinding operations in accordance

with Sec 703.3.5.6. Typically 1/8 inch, and no more than 1/4 inch shall be removed from the plan profile of the deck. The final surface shall be textured to the satisfaction of the engineer.

703.3.7.1.3 The surface of the approach slabs and deck shall be ground simultaneously in a longitudinal manner to a distance 2 feet from the bridge barrier.

703.3.8 Surface Sealing for Concrete. Bridge decks shall be sealed with one application of an approved penetrating concrete sealer in accordance with Sec 1053. The penetrating concrete sealer shall also be applied to the top surface of the concrete bridge approach slabs, top and roadway faces of sidewalks, curbs, parapets, medians and barrier. The surfaces of deck patching shall not be sealed unless the surface of the rest of the deck is being sealed. The surface of a Latex Modified Concrete overlay shall not be sealed. The surface of all other concrete overlays shall be sealed.

703.3.8.1 Equipment. Application equipment shall be as recommended by the manufacturer except as mentioned below. A low pressure, high volume method of application shall be used that will not atomize the silane. Hand pump sprayer shall not be used. The spray equipment, tanks, hoses, brooms, rollers, coaters, squeegees, etc. shall be free of foreign matter, oil residue and water prior to applying the treatment.

703.3.8.2 Cleaning and Surface Preparation. Surfaces which are to be treated shall meet the approved product's requirements for surface condition. Sealing shall not be done until all concrete construction or repair has been completed and cured to the requirements of the manufacturer. The contractor shall furnish the engineer with written instructions for the surface preparation requirements.

703.3.8.2.1 Sealing shall be done after the bridge deck has been textured or diamond ground.

703.3.8.2.2 At a minimum, the surface shall be thoroughly cleaned to remove dust, dirt, oil, wax, curing components, efflorescence, laitance, coatings and other foreign materials. The manufacturer or manufacturer's representative shall approve the use of chemicals and other cleaning compounds to facilitate the removal of these foreign materials before use. The treatment shall be applied within 48 hours following surface preparation.

703.3.8.2.3 Cleaning equipment shall be fitted with suitable traps, filters, drip pans and other devices to prevent oil and other foreign material from being deposited on the surface.

703.3.8.3 Test Application. Prior to final application, the contractor shall treat a measured test coverage area on horizontal and vertical surfaces of the different components of the structure to be treated for the purpose of demonstrating the desired physical and visual effect on an application or of obtaining a visual illustration of the absorption necessary to achieve the specified coverage rate. In the latter case, the applicator shall use at least ½ gallon (1.9 liter) of treatment following the manufacturer's recommended method of application for the total of the test surfaces. Horizontal test surfaces shall be located on the deck and on the curb or sidewalk, and vertical test surfaces shall be located on a parapet or safety barrier curb so that the different textures are displayed.

703.3.8.4 Application. The sealer shall be applied by thoroughly saturating the concrete surfaces so that one gallon of material shall not be spread over more than 200 square feet.

703.3.8.4.1 The concrete surface temperature shall be between 35ºF and rising and 100ºF and falling.

703.3.8.4.2 At a minimum, the wet cure must be complete and the moisture content of the concrete must be at or below 8 percent as measured by a moisture meter.

703.3.8.4.3 Allow concrete to dry a minimum of 48 hours after any measurable precipitation.

703.3.8.4.4 The treatment shall be spread from puddles to dry areas.

703.3.8.4.5 If the applicator is unable to complete the entire application continuously, the location where the application was stopped shall be noted and clearly marked.

703.3.8.5 Protection of Adjoining Surfaces and the Public.

703.3.8.5.1 When applying the sealer, the contractor shall protect adjoining surfaces of the structure that are not to be sealed. The contractor shall also make provision to protect the public from overspray.

703.3.8.5.2 Asphalt and mastic type surfaces shall be protected from spillage and overspray. Any asphalt pavement damaged by the sealer will result in removal and replacement at the contractor's expense. Joint sealants, traffic paints and asphalt overlays may be applied to the treated surfaces 48 hours after the treatment has been applied. Adjoining and nearby surfaces of aluminum or glass shall be covered where there is possibility of the treatment being deposited on the surfaces. Plants and vegetation shall be protected from overspray by covering with drop cloths. Precautions shall be followed as indicated on the manufacturer's product and material safety data sheet.

703.3.8.6 Opening to Traffic. Traffic may be allowed on a deck when the material is tack free.

703.3.9 Hot Weather Concreting. The contractor shall schedule placing and finishing of bridge deck concrete during hours in which the ambient temperature will be lower than 85ºF. The mixed concrete when placed in the deck forms shall have a temperature no higher than 85ºF, however, if the contractor starts the concrete placement at least 30 minutes after sundown and covers the concrete with wet burlap when it will not mar the surface, but before morning solar radiation dries the surface and implements, to the extent possible, precautionary measures for hot weather concreting recommended in ACI 305R 'Hot Weather Concreting', then the concrete temperature can be increased to 90ºF.

703.3.10 Cold Weather Concreting. Concrete work shall proceed on all structures, except bridge superstructures, whether or not heating will be required, unless it can be definitely established that the overall progress of the project will not be affected. Placing of concrete in the superstructure of a continuous or monolithic series of spans once begun shall be continued within the provisions of cold weather concreting procedures until all the concrete in that series is placed. Concrete placed in cold weather shall be protected from freezing during the curing period. Concrete shall not be placed on frozen ground, or against steel or concrete surfaces with temperatures lower than 35ºF. Concrete shall not be placed where the ambient temperature is below 35ºF without prior approval from the engineer. Concrete in bridge superstructures shall not be placed where the ambient temperature is below 40ºF without prior approval from the engineer.

703.3.10.1 The aggregate, the water, or both, shall be heated during the season when the atmospheric temperature may drop below 40ºF. Aggregate shall not be heated higher than 150ºF. The temperature of the aggregate and water combined shall not be higher than 100ºF when the cement is added. Any method of heating during the mixing of concrete may be used, provided the heating apparatus will heat the mass uniformly and avoid hot spots that will burn the material. The temperature of the concrete at the time of placing in the forms shall be no lower than 45ºF for concrete in footings, massive piers and abutments, or less than 60ºF for all other concrete.

703.3.10.2 When the ambient temperature is below 40ºF, with the approval from the engineer, curing of superstructure concrete, substructure units above ground surface, retaining walls and box culverts of more than 15 square feet opening shall be accomplished by methods that will prevent concrete from freezing. The minimum compressive strength required for form removal and ending protection from freezing shall be in accordance with Sec 703.3.2.13. The contractor shall furnish temperature monitoring equipment and accessories that demonstrate to the engineer that concrete has been protected from freezing, with payment for such equipment and accessories included in the contract unit price for concrete. Exposed surfaces of the concrete shall be kept moist during the curing process. Substructure concrete below ground surface may be protected by submersion provided the temperature of the water is maintained between 40° and 80° F for seven days.

703.3.10.3 Concrete headwalls for pipe culverts, drop inlets and box culverts of 15 square feet or less openings, may be placed without air temperature limitations, but the contractor shall be responsible for proper protection from freezing during placing and curing of the concrete.

703.3.11 Extending and Widening Structures. Extending and widening of existing concrete structures shall be in accordance with the details shown on the plans. A continuous groove at least one inch deep shall be sawed in the faces of the existing concrete as a guide for the line of break to prevent spalling. Surfaces of existing concrete that are to come in contact with new concrete shall be thoroughly cleaned, saturated with water and painted with an epoxy mortar of paint consistency or other approved products. The new concrete shall be placed immediately after the cement grout has been applied. If new concrete is to be placed against the natural finish of existing concrete work, the surface shall be roughened by bushhammering or other approved methods before being cleaned and treated. Before applying a new concrete riding surface, any existing bituminous surfacing shall be removed, and the exposed concrete surface shall be roughened by bushhammering or other approved

methods before being cleaned and treated. Work incidental to joining new concrete to existing concrete will be at the contractor's expense.

703.3.12 Stenciling Structure Identification Numbers. Bridge numbers shall be stenciled in black paint on all concrete bridges. The letters shall be capitals and 2 to 3 inches high. The bridge numbers shall be stenciled on concrete surfaces at two locations as directed by the engineer.

703.3.13 Aesthetic Concrete Stain. This stain shall consist of a two coat acrylic resin system. The surface preparation and application shall be in accordance with the manufacturer's recommendations. Field approval of the proposed material will be in accordance with Sec 1056.

703.4 Method of Measurement. Final measurement will not be made unless changes from contract plans are authorized by the engineer during construction, or appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity. Where required, quantities for concrete masonry will be computed from dimensions shown on the plans, or as revised in writing by the engineer because of changes to the contract plans or due to appreciable errors, and will be computed to the nearest 1/10 cubic yard for each structure. No deduction will be made for the space occupied by reinforcing steel, conduit or piles. Deductions will be made for the space occupied by the tubes in voided slabs.

703.4.1 Measurement of concrete quantities in seal courses will be made for the actual quantity placed, except that this quantity will be limited to that included within vertical planes 18 inches outside the neat lines of the footings, and to the maximum depth shown on the plans or as authorized by the engineer.

703.4.2 Measurement of concrete quantities used to fill cavities or crevices will be made for the accepted quantity placed below the authorized elevation of the structure footing.

703.4.3 Final measurement for diamond grinding will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from contract quantity.

703.5 Basis of Payment. The accepted quantity of concrete masonry, complete in place, will be paid for at the contract unit price for each of the pay items included in the contract.

703.5.1 The accepted quantity of concrete used to fill cavities or crevices below final authorized bottom elevation of the footing structure will be paid for based on the accepted quantity per cubic yard at the fixed unit price specified in Sec 109.

703.5.2 No direct payment will be made for incidental items necessary to complete the work unless specifically provided as a pay item in the contract documents. No direct payment will be made for concrete required to fill overbreak where footings or walls are cast against vertical faces of rock or shale excavation.

703.5.3 Payment for diamond grinding will be made per square yard of surface.

703.5.4 No direct payment will be made for furnishing and applying the surface sealer and all incidental work. Payment shall be considered completely covered by the contract unit price for other items.

703.5.5 Payment for the work necessary to complete a closure pour, including all material, labor, tools, equipment and incidentals, will be made and considered completely covered under the contract unit price for the applicable pay item for the slab.

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SECTION 704
CONCRETE MASONRY REPAIR

704.1 Description. This work shall consist of removing deteriorated concrete, preparing the repair site, forming where required, placing and finishing new concrete or qualified special mortar, applying epoxy and applying concrete crack filler in the required areas.

704.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows. The qualified special mortar shall be from the qualified rapid set concrete patching material listing available from Construction and Materials or MoDOT's web site.

Item	Section
Concrete	501
Concrete Bonding Compound and Epoxy Mortar	623
Gradation E Coarse Aggregate	1005
Type III Cement	1019
Type III Epoxy & Epoxy Polymer Concrete Overlay	1039
Concrete Crack Filler	1053
Water	1070

704.3 Types of Repair.

704.3.1 Repairing Concrete Deck (Half-Soling). This work shall consist of partial removal and replacement of bridge deck concrete in the required areas.

704.3.2 Deck Repair With Void Tube Replacement. This work shall consist of partial removal and replacement of bridge deck concrete and removal and replacement of the deteriorated void tube in the required areas.

704.3.3 Full Depth Repair. This work shall consist of complete removal and replacement of the bridge deck concrete in the required areas and for voided slabs, the removal and replacement of the deteriorated void tube in the required areas.

704.3.4 Modified Deck Repair. This work shall consist of the removal and replacement of visibly loose or spalled bridge deck concrete and placement of concrete in the areas where the reinforcing steel is exposed. The repair concrete for these areas shall be Class B-1.

704.3.5 Superstructure Repair (Unformed). This work shall consist of repairing the deteriorated concrete on the bottom of the bridge deck in the required areas with a qualified special mortar.

704.3.6 Slab Edge Repair. This work shall consist of repairing the edge of the bridge deck by removing deteriorated concrete and patching the required areas with a qualified special mortar. All repairs made within 4 inches of the edge of the bridge deck, regardless of the repair thickness, will be considered slab edge repair. Portions of the bridge deck areas requiring repair that extend more than 4 inches from the edge of the bridge deck shall be repaired as superstructure repair (unformed) or full depth repair.

704.3.7 Substructure Repair (Formed). This work shall consist of formed substructure repair. The required areas shall be patched with Class B-1 concrete. Coarse aggregate shall be Gradation E in accordance with Sec 1005. The extent of a single formed repair area for measurement shall be the contiguous concrete surfaces that meet at a formed edge.

704.3.8 Substructure Repair (Unformed). This work shall consist of unformed substructure repair. The required areas shall be patched with a qualified special mortar.

704.3.9 Epoxy Sealing. This work shall consist of applying an epoxy material to the concrete in the required areas.

704.3.10 Concrete Crack Filler. This work shall consist of applying a concrete crack filler to the concrete in the required areas.

704.4 Construction Requirements.

704.4.1 Removal Requirements. The type of repair and areas to be repaired will be outlined by the engineer. All loose, deteriorated and unsound concrete in the required repair areas shall be removed by conventional hand/mechanical, hydro demolition or other approved equipment to a depth as specified herein and as directed by the engineer. Slight deck imperfections surrounded by sound concrete shall be cleaned of all dirt, loose material and deteriorated concrete. If reinforcing steel is not exposed, deck repair work will not be required.

704.4.1.1 Bridge Decks to be Covered with Asphalt or Concrete Wearing Surface. The existing bridge deck shall be scarified for the concrete wearing surface as specified in the contract documents and in accordance with Sec 505. Slight bridge deck imperfections of 0.5 inch or less in depth below the prepared deck surface that are surrounded by sound concrete, and the reinforcing steel is not exposed, shall not be half-soled. These areas shall be cleaned by hand tools, sand or hydro blasting to remove all dirt, loose material and deteriorated concrete before the application of the asphalt or concrete wearing surface. Asphalt or concrete for these areas shall be placed monolithic with the wearing surface in accordance with Sec 403 or Sec 505.

704.4.1.2 Bridge Decks to be covered with Epoxy Polymer Concrete Overlay. Preparing and cleaning the existing bridge deck shall be in accordance with Sec 623.

704.4.1.3 Conventional Hand/Mechanical Equipment. Conventional hand/mechanical equipment consisting of jackhammers no heavier than the 35-pound class shall be used for concrete removal. For bridge decks rated 5 or below, the jackhammers shall not be heavier than the 65-pound class. Chipping hammers from the 15-pound class shall be used to remove concrete from beneath any reinforcing bars, where required. The bits shall be sharp in order to reduce pounding. Jackhammers shall be operated to minimize damage to the sound concrete around the patch area. Other methods that would be less damaging to the concrete and reinforcement may be used with approval from the engineer.

704.4.1.4 Patch Repair Hydro Demolition Equipment. The hydro demolition equipment shall be capable of removing concrete to the specified depth and shall be capable of removing rust and concrete particles from exposed reinforcing bars. All water used in hydro demolition shall be potable in accordance with Sec 1070. Stream or lake water will not be permitted. The contractor shall take necessary precautions during hydro demolition to prevent damage to the remaining structure and adjacent property as a result of runoff. Slab drains receiving runoff from the contractor's operation shall be temporarily plugged. The discharge water shall not be released from the site until the broken concrete, aggregate and other settleable solids have been removed through filtration, sediment basins or other approved methods. The contractor shall control dust and run-off in accordance with applicable governmental regulations. Environmental protection shall be in accordance with Sec 107. Hydro demolition shall not impede or interfere with maintaining traffic. Heavy equipment, such as vacuum trucks for removal of concrete debris, will not be permitted to place wheel loads on the deck areas where deteriorated concrete has been removed.

704.4.1.5 Concrete Removal. A boundary perimeter with one-inch vertical sides shall be established outside the deteriorated area. The deteriorated concrete shall be removed as required to provide good sound concrete on which new concrete can be placed and satisfactorily bonded to the reinforcing bars. The areas of repair shall be made approximately rectangular with the sides generally perpendicular to the surface being repaired. These areas shall be carefully removed such that reinforcement is not disturbed or damaged. For full depth repair, a saw cut outside the deteriorated area shall also be made on the bottom of the bridge deck, except on voided slab, solid slab and box girder bridges without entry access. Other acceptable methods for saw cutting the bottom of the deck may be used with approval from the engineer. No more than one-fourth of the column perimeter shall be removed at any one time, and no more than one-eighth of the column perimeter if the repair is completed under live load. Once the one-quarter or one-eighth limit has been reached, the column shall be repaired before any further column removal is done.

704.4.1.6 Reinforcing Bar Exposed. All exposed reinforcing bars shall be thoroughly cleaned by sand or hydro blasting to the satisfaction of the engineer.

704.4.1.6.1 Superstructure and Substructure Repair. The concrete within the boundary area for superstructure repair (unformed), substructure repair (formed) and substructure repair (unformed) shall be removed a minimum of one inch beyond the inside edge of any exposed reinforcing bars, including the main reinforcement.

704.4.1.6.2 Deck Repairs. The minimum depth of repair for repairing concrete deck (half-soling) or modified deck repair shall expose the upper layer of the top mat of reinforcing steel. When the bond between existing concrete and a reinforcing bar has been destroyed, or more than half the diameter of a reinforcing bar is exposed, the concrete adjacent to the reinforcing bar shall be removed to a depth that will permit the concrete to bond to the entire periphery of the bar. A minimum of one-inch clearance shall be maintained.

704.4.1.6.3 If a reinforcing bar is exposed during slab edge repair, the concrete adjacent to the bar shall be removed to a depth that will permit a qualified special mortar to bond to the entire periphery of the bar. A minimum of one-inch clearance shall be maintained.

704.4.1.7 Reinforcement Repair. Particular care shall be taken not to disturb or damage reinforcing bars. All exposed reinforcing bars shall be thoroughly cleaned by sand or hydro blasting. Cut or broken bars or bars with 25 percent or more cross sectional area lost shall be spliced 24 diameters on each side of the damage with new bars of the same size in accordance with Sec 706. Damaged existing epoxy coated reinforcement shall be repaired in accordance with Sec 710.

704.4.1.8 Material Disposal. All material removed shall be disposed of in accordance with Sec 202.

704.4.2 Preparation of the Repair Area.

704.4.2.1 Patch Preparation Requirements. After removal of deteriorated concrete, the area to be repaired shall be sand or hydro blasted to remove all foreign matter, dirt, free standing water and loose material. Containment and disposal of material shall be in accordance with Sec 202.2. The hydro demolition process will not require sand or additional hydro blasting unless the bonding surface of the repair area becomes contaminated or unsatisfactory prior to placement of new concrete. The area to come in contact with new concrete shall be cleaned as stated above, saturated with water and painted with a concrete bonding compound or an epoxy mortar prior to the placement of new concrete. A concrete bonding compound shall be used for all structures with the following exception. An epoxy mortar shall be used on box girder, voided and solid slab structures and on structures where a cathodic protection system is to be installed.

704.4.2.2 Epoxy Sealing Preparation. The area to be sealed shall be cleaned by sand blasting. Containment and disposal of material shall be in accordance with Sec 202.2. Prior to sealing the concrete, all loose particles and foreign matter shall be removed using oil-free and water-free compressed air or a vacuum of at least 90 psi.

704.4.2.3 Concrete Crack Filler Preparation. The area to fill the cracks shall be cleaned by pressure washing with at least 2500 psi, 3 days minimum prior to the crack filler application and 2 days after any measurable precipitation.

704.4.3 Applying Epoxy. The area to be sealed shall be sealed with a qualified Type III epoxy or epoxy material for epoxy polymer concrete overlay. Sealing shall be completed before the application of any overlay. The cleaning, sealing and epoxy application shall proceed only as approved by the engineer, in accordance with the manufacturer's written recommendations. The epoxy application and rate of coverage shall be in accordance with manufacturer's recommendations, with a maximum coverage of 100 square feet per gallon.

704.4.3.1 Applying Concrete Crack Filler. The area to fill the cracks shall be filled with a low viscosity polymer crack filler. The concrete crack filler application and rate of coverage shall be in accordance with the manufacturer's recommendations, with a maximum coverage of 100 square feet per gallon. The broadcasting of dry blasting sand shall be applied only as approved by the engineer, in accordance with the manufacturer's written recommendations with a maximum coverage of 1 to 2 lbs/sq.yd. starting approximately 10 minutes after crack filling operation has started.

704.4.4 Placement of New Concrete.

704.4.4.1 Concrete Placement Requirements. Concrete shall be placed before the concrete bonding compound or epoxy mortar has begun to set. Deck repair concrete shall be placed in the repair area to match the top of the original deck surface. For bridges to be covered with concrete wearing surface, deck repair concrete shall be placed in the repair area up to the bottom of the proposed concrete wearing surface. The finished repair area shall have a light broom texture for bonding of the deck seal, except bridges to be covered with concrete wearing surface shall have a rough surface for bonding of the concrete wearing surface. All joints shall be formed to match any existing joint pattern.

704.4.4.2 Concrete Requirements. Concrete for concrete deck repair shall be Class B-2, except that solid slab, voided slab and box girder structures shall be the same class as the existing deck concrete and as specified in Secs 704.3.4 and 704.4.4.3. The repair area shall not be opened to any traffic until the concrete has reached a compressive strength of 3,200 psi. Type III cement may be used to accelerate the set. The coarse aggregate shall be Gradation E in accordance with Sec 1005. Accelerating additives containing chlorides will not be permitted.

704.4.4.3 Bridge Decks with Cathodic Protection System. Concrete for repairing the concrete deck shall be Class B-1. The repair area shall not be opened to any traffic until the concrete has reached a compressive strength of 3200 psi. Type III cement may be used to accelerate the set. The coarse aggregate shall be Gradation E in accordance with Sec 1005. Accelerating additives containing chlorides will not be permitted. All half-sole repairs made on the deck shall be Class B-1 concrete that has a maximum chloride ion content of 5 pounds per cubic yard. All full depth repairs made on the deck shall be chloride-free Class B-1 concrete from the bottom of the deck to within one inch of the lowest rebar of the top layer of reinforcing steel. The remainder of the repair shall be Class B-1 concrete with a maximum chloride ion content of 5 pounds per cubic yard.

704.4.4.4 Curing. The repaired areas shall be cured in accordance with Sec 703. The cleaning and application of the epoxy polymer concrete overlay to the deck shall proceed only as approved by the engineer in accordance with the manufacturer's written recommendations.

704.5 Method of Measurement. The extent of repair may vary from the estimated quantities, but the contract unit price shall prevail regardless of the variation. Final measurement will not be made for preparation of the existing deck. No duplication of measurement will be made for full depth repair, repairing concrete deck (half-soling), deck repair with void tube replacement, slab edge repair, superstructure repair (unformed) or modified deck repair. No duplication of measurement will be made for substructure repair, unformed and formed.

704.5.1 Repairing concrete deck (half-soling), deck repair with void tube replacement, full depth repair, modified deck repair, superstructure repair (unformed) and substructure repair (formed and unformed) will be measured to the nearest square foot.

704.5.2 Slab edge repair will be measured to the nearest linear foot.

704.5.3 No measurement will be made for epoxy sealing.

704.5.4 Measurement of reinforcing steel replaced due to excess section loss will be made to the nearest 10 pounds.

704.5.5 Filling concrete cracks will be measured to the nearest square foot.

704.6 Basis of Payment. Accepted quantities of concrete masonry repairs will be paid for at the contract unit price for each of the pay items included in the contract. No direct payment will be made for epoxy sealing. Payment for accepted quantities of reinforcing steel replaced due to excess section loss will be paid for at the fixed contract unit price specified in Sec 109.16. No payment will be made for replacement of reinforcing steel cut or broken by the contractor.

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SECTION 705
PRESTRESSED CONCRETE MEMBERS FOR BRIDGES

705.1 Description. This work shall consist of furnishing and placing prestressed concrete members, complete in place, in the superstructure of bridges. This work shall cover both prestressed and post-tensioned members.

705.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Prestressed Concrete Members for Bridges	1029
Reinforcing Steel for Concrete Structures	1036

705.3 Equipment. Prestressing equipment shall be in accordance with Sec 1029.

705.4 Construction Requirements.

705.4.1 Post-Tensioned Members. Post-tensioned members shall be in accordance with Sec 1029.

705.4.2 Erection. Erection of the structure shall be in accordance with the working drawings. Camber of beams, measured as the differential between adjacent beams in the final location, shall be no more than 1/8 inch per 10 feet of span, and in no case greater than 1 inch. The butt joints between precast panels shall be caulked to prevent excessive grout leakage between panels.

705.5 Method of Measurement. Measurement of prestressed concrete members, complete in place, in the finished structure will be based on contract plan quantities. Final measurement will not be made, prestressed concrete members will be computed to the nearest linear foot for each structure and each type of prestressed concrete member.

705.6 Basis of Payment. Accepted prestressed concrete members will be paid for at the contract unit price for each of the pay items included in the contract.

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SECTION 706
REINFORCING STEEL FOR CONCRETE STRUCTURES

706.1 Description. This work shall consist of furnishing and placing reinforcing steel of the designated shape, size and grade as shown on the plans.

706.2 Material.

706.2.1 All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Reinforcing Steel for Concrete	1036

706.2.2 Reinforcing steel shall be accurately cut and bent to the dimensions and shapes shown on the plans. Cutting and bending tolerances for reinforcing steel shall be in accordance with the Concrete Reinforcing Steel Institute's Manual of Standard Practice. Flame-cutting of uncoated reinforcing steel will be permitted.

706.3 Construction Requirements.

706.3.1 Reinforcing steel shall be protected from damage at all times. When placed in the work and before concrete is placed, reinforcing steel shall be free from dirt, oil, paint, grease, loose mill scale, thick rust, any dried mortar and other foreign substances. A thin layer of powdery rust may remain. All reinforcing steel required for superstructure concrete, such as slabs, girders and beams and top slabs of culverts with more than a 4-foot span, shall be held securely in correct position with approved metal or plastic bar supports and ties. Reinforcing bars shall be positively secured against displacement. For bridge decks and top slabs of culverts, bars in the top mat shall be tied at all intersections except where spacing is less than or equal to 12 inches in each direction, in which case alternate intersections shall be tied. At other locations, the bars shall be firmly tied at alternate crossings or closer. The steel shall be tied in the correct position with proper clearance maintained between the forms and the reinforcement. The contractor shall construct the unit as shown on the plans. Measurements to reinforcing steel will be made to the centerline of bar, except where the clear distance from face of concrete is shown on the plans.

706.3.2 Bars shall not be spliced, except as shown on the plans or as directed by the engineer.

706.3.3 Mechanical bar splice systems, as shown on the plans, shall be capable of developing 125 percent of the specified yield strength of the bar being spliced and shall be installed in accordance with the manufacturer's recommendations and as modified herein.

706.3.3.1 The contractor shall furnish to the engineer a manufacturer's certification stating that the mechanical bar splice systems are in accordance with this specification. The certification shall include or have attached specific results of tests showing yield and ultimate tensile load capacities.

706.3.3.2 The splicing system may attach directly to the bars being coupled or may be of a type that provides reinforcing bars of like size that lap with the bars being joined. A threaded-type splice system will be required where clearance considerations require the splicing device to be placed flush to the face of the construction joint for the initial concrete placement.

706.3.3.3 Regardless of the type of splicing system that will be used, the total bar lengths for bars indicated in the bill of reinforcing steel are determined based on the end of the bars being located flush to the face of the construction joint. No additional payment will be made for any additional bar lengths required for the mechanical bar splices. Reinforcing bar lengths shown in the bill of reinforcing steel may require modification to accommodate the specific mechanical bar splice system that will be used. The contractor shall determine the actual reinforcing bar lengths to accommodate the manufacturer's recommendations for installation of the mechanical bar splices.

706.3.3.4 For mechanical bar splice systems that require laps with the reinforcement, the minimum lap length in inches on each side of the joint shall be as shown in the tables below provided that the actual cover to the nearest concrete surface or actual bar spacing is no less than minimums shown.

Minimum Lap Lengths			

	Location 1 - Horizontal and Inclined Bars with more than 12 inches of fresh concrete cast below bars				Location 2 - Vertical Bars - Horizontal and Inclined Bars with 12 inches or less of fresh concrete cast below bars					
	f'c = 3 ksi		f'c = 4 ksi		f'c = 3 ksi		f'c = 4 ksi		Minimums (Inches)	
Bar Size	Plain	Epoxy Coated	Plain	Epoxy Coated	Plain	Epoxy Coated	Plain	Epoxy Coated	Cover	Spacing
4	29	37	25	32	22	33	19	29	1 ½	2 ½
5	36	46	31	40	28	41	24	36	1 ⅞	3 ⅛
6	43	56	37	48	33	49	29	43	2¼	3¾
7	50	65	43	56	38	57	33	50	2⅝	4⅜
8	57	74	49	64	44	65	38	57	3	5
9	64	83	55	72	49	74	43	64	3½	5¾
10	72	94	62	81	55	83	48	72	3⅞	6⅜
11	80	104	69	90	61	92	53	80	4¼	7⅛

Values are LRFD Class B splices based on the following modification factors:

$\lambda rl = 1.3$ (Location 1), $\lambda rl = 1.0$ (Location 2), $\lambda cf = 1.0$ (Plain), $\lambda cf = 1.5$ (Epoxy), $\lambda rc = 0.4$ (Minimum reinforcement confinement factor)

706.3.3.4.1 For reinforcement with cover or spacing less than required minimums shown in the table provided in Sec 706.3.3.4, the required minimum lap length in the table shall be multiplied by the reinforcement confinement adjustment ratio, B.

$$B = \frac{d_b}{0.4c_b}, \text{ if } B > 2.5, \text{ then } B = 2.5$$

Where:

d_b = diameter of bar (inches)

c_b = the smaller of the distance from center of bar to the nearest concrete surface and one half the center-to-center spacing of the bars (inches)

706.3.3.4.2 Mechanical bar splice systems that require laps with the reinforcement shall not be used for voided slab and solid slab bridges. Systems that require laps shall be Grade 60 deformed bars in accordance with Sec 1036. Epoxy-coated bars shall have epoxy-coated mechanical bar splices.

706.4 Method of Measurement. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, measurement of reinforcing steel will be made to the nearest 10 pounds for each structure. The weight will be the plan weight of uncoated bars, and will not include mechanical bar splice systems, clips, wire, supports, spacers or other fastening devices for holding the reinforcement in place. Allowances will not be made for an overrun in scale weights of bars. The revision or correction will be computed and added to or deducted from the contract quantity. Mechanical bar splice systems will be measured per each.

706.5 Basis of Payment. The accepted quantity of reinforcing steel including any approved mechanical bar splice systems, complete in place, will be paid for at the contract unit price.

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SECTION 707
CONDUIT SYSTEM ON STRUCTURE

707.1 Description. This work shall consist of furnishing and placing all material and equipment and performing all work necessary to create a complete conduit system as shown on the plans.

707.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Electrical Conduit	1060
Pull and Junction Boxes	1062

707.3 Construction Requirements.

707.3.1 Conduit systems shall be free from corrosion, restrictions, sharp edges and debris. The ends of conduit runs shall be protected by bushings and shall be temporarily capped if conductor cable is not installed immediately. Conduit shall be rigidly held in place to prevent misalignment during placement of concrete. Reinforcing bars shall not be cut, bent, displaced or otherwise altered unless authorized by the engineer. All joints shall be rigid and waterproof. A 1/2-inch diameter drain hole in all low points of conduits and junction boxes where exposed and a 1/2-inch rigid steel conduit drop from the low point if the conduit and junction boxes are encased in concrete, shall be provided for drainage of water. Exposed ends of such drains shall be covered with either a commercial bronze or a stainless steel insect screen having an open area between 60 percent and 70 percent, held in place with a conduit bushing.

707.3.2 After placing concrete, the conduit around which the concrete is placed shall be tested by the contractor, in the presence of the engineer, for continuity and freedom from obstruction by pulling a steel ball through the entire length. The steel ball shall have a diameter 1/2 inch smaller than the inside diameter of the conduit being tested. Galvanized pullwires shall be installed in conduit for pulling wiring by others.

707.3.3 Junction box covers shall have a waterproof seal securely fastened in place. Junction boxes shall be drilled and tapped for all conduit connections.

707.4 Method of Measurement. The work provided herein will not be measured for payment, but will be considered a lump sum unit.

707.5 Basis of Payment. The accepted conduit system on structure will be paid for at the contract lump sum price.

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SECTION 710
EPOXY COATED REINFORCING STEEL

710.1 Description. This work shall consist of furnishing and placing epoxy-coated reinforcing steel of the shape, size and grade shown on the plans, and in accordance with Sec 706, except as modified herein.

710.2 Material.

710.2.1 All material shall be in accordance with Division 1000 Material Details, and specifically as follows:

Item	Section
Epoxy Coated Reinforcing Steel	1036

710.2.2 Epoxy coated reinforcing steel shall not be flame-cut.

710.3 Construction Requirements.

710.3.1 Handling. All systems for handling epoxy-coated bars shall have padded contact areas. If, in the judgment of the engineer, the coating is damaged to the extent that the coating can no longer provide the intended protection and cannot be satisfactorily patched, the material shall be returned to the coating applicator for repair or shall be replaced.

710.3.2 Placement.

710.3.2.1 Epoxy-coated bars shall be held securely in the correct position with approved metal bar supports coated with plastic or epoxy or on plastic bar supports, and shall be held in place by use of plastic-coated tie wires or molded, plastic clips. When placing epoxy-coated bars, the bars shall be prevented from coming into contact with other steel items such as drains and shear connectors.

710.3.2.2 The contractor shall prevent damage to the epoxy coating when placing and vibrating concrete. In order to prevent damaging the coated bars, the vibrator head shall be covered with a sheet of rubber, and shall be equipped with a rubber tip with a maximum diameter of 2 1/2 inches. Another resilient material may be substituted for rubber as approved by the engineer.

710.3.2.3 After the reinforcing bars are secured to approved bar supports, a final visual inspection will be made, and all uncoated or damaged areas shall be coated or repaired in accordance with Sec 710.3.3 as directed by the engineer.

710.3.3 Repairing Bars. All damaged areas of epoxy coating shall be patched with the material specified in Sec 1036, and in accordance with the manufacturer's recommendations. All sheared or cut ends of bars, end areas left bare during the coating process, and any areas where the entire coating is removed shall be patched. All repairs shall be completed as soon as practical, and in the case of bare end areas and sheared ends, before visible oxidation of the surface occurs.

710.3.4 Mechanical Bar Splices. Requirements for mechanical bar splice systems shown on the plans shall be in accordance with Sec 706. Epoxy coated mechanical bar splices shall be used with epoxy-coated reinforcing steel, and if the epoxy coating is damaged, shall be repaired in accordance with Sec 710.3.3 as directed by the engineer.

710.4 Method of Measurement. Measurement of epoxy-coated reinforcing steel will be made for plan weight of uncoated bars in accordance with Sec 706.4.

710.5 Basis of Payment.

710.5.1 The accepted quantity of epoxy-coated reinforcing steel, including any approved mechanical bar splice systems, complete in place, will be paid for at the contract unit price.

710.5.2 Repair of damaged epoxy coating will be at the contractor’s expense.

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SECTION 711
PROTECTIVE COATINGS FOR EXPOSED CONCRETE SURFACES

711.1 Description. This work shall consist of the surface preparation and application of protective coatings for sealing and protecting exposed concrete elements. The locations and elevations of the protective coatings shall be as shown on the bridge plans. The work involving temporary coating on weathering steel bridges shall also include the removal of the temporary coating.

711.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Protective Coating Material	1059

711.3 Construction Requirements.

711.3.1 Protective Coating - Concrete Bents and Piers (Urethane). This protective coating shall consist of a modified urethane or polyurethane elastomer. New concrete shall cure a minimum of 28 days prior to application of the protective coating. The coating shall be applied to dry surfaces. The surface preparation and application shall be in accordance with the manufacturer's recommendations. The surface preparation shall include removal of all loose or delaminated concrete, as well as any other contaminants or latent materials. The coating shall be applied to obtain a minimum dry film thickness of 40 mils. Any unevenly applied film that causes ponding of water shall be given additional coats as directed by the engineer.

711.3.2 Protective Coating - Concrete Bents and Piers (Epoxy). This protective coating shall consist of a two-component, modified polyamide converted epoxy, clear or gray in color. New concrete shall cure a minimum of 28 days prior to application of the protective coating. The coating shall be applied to dry surfaces. The surface preparation and application shall be in accordance with the manufacturer's recommendations. The surface preparation shall include removal of all loose or delaminated concrete, as well as any other contaminants or latent materials. The coating shall be applied to obtain a minimum dry film thickness of 6 mils.

711.3.3 Concrete and Masonry Protection System. This protective coating shall consist of a clear penetrating siloxane or silane based sealer. The surface preparation and application shall be in accordance with the manufacturer's recommendations. Field approval of the proposed material will be in accordance with Sec 1059.

711.3.4 Sacrificial Graffiti Protection System. This system shall consist of a clear coating that can be removed with a hot water wash. The surface preparation and application shall be in accordance with the manufacturer's recommendations. Field approval of the proposed material will be in accordance with Sec 1059.

711.3.5 Temporary Coating - Concrete Bents and Piers (Weathering Steel). This protective coating shall consist of a clear temporary coating applied to the concrete substructure for protection against staining from weathering steel girders during initial weathering. The surface preparation and application shall be in accordance with the manufacturer's recommendations. The concrete substructure shall be cured a minimum of 14 days prior to application, unless otherwise specified by the manufacturer. The coating shall be applied to the concrete substructure before the erection of structural steel. The temporary coating shall be removed by the contractor after construction of the deck and curbs is complete, or as directed by the engineer.

711.4 Basis of Payment. The accepted quantity of protective coatings for exposed concrete surfaces will be paid for at the contract lump sum price.

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SECTION 712
STRUCTURAL STEEL CONSTRUCTION

712.1 Description. This work shall consist of the field construction of bridges and structures made of structural steel and miscellaneous metals.

712.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Shear Connectors	1037
Paint for Structural Steel	1045
Structural Steel Fabrication	1080
Coating of Structural Steel	1081

712.3 Handling, Transporting, Storing and Erecting. Fabricated material shall be properly braced and supported at all times to prevent damage from torsional, vertical and lateral deflections. Members or shipped material showing possible damage during handling, transporting, storing or erecting will be subjected to nondestructive tests as directed by the engineer. The costs of these tests will be at the contractor's expense. Fabricated structural steel shall be stored on suitable supports. Trough sections shall be stored in a manner to provide drainage. Any material that has become bent shall be straightened before being assembled or shall be replaced, if necessary. Material intended for use in the finished structure shall not be used by the contractor for erection or temporary purposes unless such use is provided for in the contract, or with written approval from the engineer.

712.4 Falsework. Staging and falsework necessary for the erection of the structure shall be furnished and placed and, upon completion of the erection, removed by the contractor. If required, plans for falsework shall be submitted to the engineer before starting the work, but the engineer's acceptance of the plans will not relieve the contractor of the responsibility for obtaining satisfactory results.

712.5 Erection. Erection of all parts of the structure shall be in accordance with the erection diagram or working drawings. Surfaces to be in permanent contact shall have all burrs and loose scale removed. Before erection, machine finished surfaces shall be cleaned of the protective coating, other than the primer permitted by the contract, and contact surfaces shall be given a heavy coat of graphite and oil. Connections match-marked in the shop shall be erected in accordance with those match marks. Interchange or reversal of match-marked connections will not be permitted. Any damage or distortion of members will not be permitted.

712.5.1 Fit-up and Drifting. Truss spans, plate girders and continuous I-beams shall be supported to maintain required camber during erection. High-strength bolted field splices and primary connections, except for trusses and structures carrying live load erection stresses, shall have no less than one-half of the holes filled with a combination of fitting-up bolts and cylindrical drift pins. No more than 50 percent of this combination shall be fitting-up bolts. Splices and primary connections carrying erection traffic during erection or truss connections shall have no less than three-fourths of the holes filled with drift pins and bolts with no more than 50 percent of being fitting-up bolts. The specified ratio of pins to bolts shall apply to each element of the splice, for example, top flange, web and bottom flange of girders. Fitting up bolts shall be the same diameter as the high-strength bolts. High strength bolts may be used for fitting-up bolts, and may be left in place, as long as they are not damaged during erection. High strength bolts will be considered damaged and shall be replaced if they are tensioned past snug tight, used to draw two members together, driven into place with a hammer, or have any deformation of the threads. Drift pins shall be sized to provide a driving, tight fit that maintains structure geometry during erection. Reaming of the holes to aid in drifting the connections will not be permitted. Fitting-up bolts shall be placed uniformly to draw the entire splice tight. All fitting-up bolts and drift pins shall be properly installed before beginning high strength bolt installation. Holes that do not match shall be reamed only with approval from the engineer. Drifting that would distort the metal will not be permitted.

712.5.2 Bearings. The lead plates or preformed rubber and fabric pads shall be approximately 1/8 inch thick and 1/2 inch greater in length and width than the bottom bearing plates under which the plates are to be placed. Lead plates shall weigh approximately 8 psf. Preformed rubber and fabric pads shall be in accordance with Sec 1038. Shop drawings will not be required for lead plates or preformed rubber and fabric pads. Lead plates or preformed rubber and fabric pads will be considered incidental to bearings, and payment will be considered as covered under the contract unit price for bearings.

712.5.3 Anchor Bolts. Anchor bolt wells for superstructures shall be formed in the substructure units in accordance with the details shown on the plans utilizing removable forming material which shall not be left in place. Where permitted or required, the anchor bolt wells may be omitted, and in lieu thereof, holes drilled into the substructure without cutting any reinforcements. The anchor bolt holes shall be drilled in the exact location shown, to the required depth and perpendicular to the plane of the bridge seat. The drilled holes shall be at least 1 inch larger than the bolt diameter. When the anchor bolts are set in wells or holes, the wells or holes shall be clean and dry prior to grouting with an expansive mortar in accordance with Sec 1066. Excess mortar forced out of the holes shall be removed. The location of anchor bolts in relation to the center of slotted holes provided in movable plates and shoes shall be varied to compensate for the movement of spans due temperatures above or below 60 F. Nuts on anchor bolts through moving parts of expansion bearings shall be adjusted to provide ample clearance for free movement of the span.

712.5.4 Grouting. Grouting under bearing plates and castings to build the bearing plates and castings to the proper grade will not be permitted. Steel shims the full size of the plate of the bearing device may be used for this purpose. Shims shall be placed between the bottom of the stringers and the top of bearing plates, if practical, and shall be straightened to a plane surface.

712.6 Field Welding. All field welding shall be performed in accordance with Sec 1080.

712.6.1 Certification. All field welders shall be certified to weld on all steel products incorporated in MoDOT projects.

712.6.2 Testing. Field welders shall be certified by a test facility with an established accredited American Welding Society (AWS) Certified Welder Program as defined in the current AWS Standard QC 4. Welders shall be certified per the current QC 7 Standard for AWS Certified Welders. The code of acceptance shall be AWS Bridge Welding Code D1.5 and qualifications range shall include the processes, positions, filler and base metal type as the work requires. Certification maintenance per applicable AWS Code of Acceptance shall be the responsibility of the certification holder. A copy of the current welder's certification from the AWS test facility shall be delivered to the engineer. The engineer may require recertification if there is specific reason to question the welder's ability.

712.6.3 Welding Procedures. Welding procedures shall be submitted for review prior to welding, at the engineer’s request. The engineer may verify the quality of a certified welder at any time.

712.7 High-Strength Bolt Installation.

712.7.1 Bolted Parts. The slope of surfaces of bolted parts in contact with the bolt head and nut shall not exceed one in 20 with respect to a plane normal to the bolt axis. All bolted parts, including underhead bearing areas and joint surfaces within the grip of the bolt, shall fit solidly together when assembled in the snug tight condition, and shall not be separated by gaskets or any other interposed compressible material. When assembled, all joint surfaces, including those adjacent to the bolt heads, nuts or washers, shall be free of scale, dirt, burrs, other foreign material and other defects that would prevent solid seating of the parts. Contact surfaces within friction-type joints shall be free of oil and paint, except in accordance with Sec 1081.10.3.10, lacquer, rust inhibitor and galvanizing. All bolts, nuts and washers shall be free of rust, burrs, dirt, other foreign material and other defects that would prevent proper tensioning. All nuts for coated high-strength bolts shall be properly lubricated with a visible water-soluble lubricant. All nuts for uncoated high-strength bolts shall be properly lubricated with a water-soluble lubricant that is oily to the touch.

712.7.2 Snug Tightness of Connections. Regardless of the method of final tightening used to install the fasteners, the joint and all fasteners shall first be brought to the snug tight condition. Snug tight will be defined as the tightness where all faying surfaces of the joint are in firm contact as attained by a few impacts of an impact wrench or the full effort of a person using an ordinary spud wrench. Following the initial snug tightening of the fitting-up bolts, the remaining holes shall be filled with high strength bolts and tightened to a snug tight condition. All final bolts completing the connection shall be high strength and required nominal diameter. Snug tightening shall progress systematically from the most rigid part of the connection to the free edges. Bolts shall be retightened in a similar manner as necessary until all bolts are simultaneously snug tight, and the section is fully compacted with the bolted parts of the joint in full contact. For Type 3 and Type 1 bolts that will be field coated, if a connection is not completely tightened within five days of snug tightening, the contractor shall remove five percent or five bolts (whichever is less) of a given connection and conduct rotational capacity

testing in accordance with Sec 1080 to verify nut lubrication. For bolted field splices, the amount of bolts specified for bolt removal shall apply to each element of the splice (top flange, web and bottom flange). If the rotational capacity test is unacceptable, all bolts shall be removed, inspected, relubricated and may then may be reinstalled. For galvanized bolts, the above condition shall be met as well as the threads of the bolts and nuts shall be inspected for galling prior to final tensioning. Any bolts or nuts with threads that are galled shall be removed and replaced.

712.7.3 Bolt Tension. Each fastener shall be tightened to provide, when all fasteners in the joint are tight, at least the minimum bolt tension shown below for the size and grade of fastener used. Threaded bolts shall be tightened by methods described in Secs 712.7.5, 712.7.6 or 712.7.7. If required because of bolt entering and wrench operation clearances, tightening may be done by turning the bolt while the nut is prevented from rotating. On non-parallel abutting surfaces where bevel washers will not be required, the nut shall be torqued against the non-sloping surface. Nuts shall be placed on the inside face of exterior girders, the top of girder flanges or in other situations the least exposed position, except if inaccessible for turning, on a sloping surface or otherwise approved by the engineer. Impact wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately 10 seconds. Bolts or nuts, once tensioned and subsequently loosened (turned), shall not be used as permanent bolts or nuts. Bolt tension calibration devices shall be calibrated and certified as to accuracy by a private testing lab within one year before usage, or at any time the tensioning process indicates that the calibration is in error.

Bolt Tension		
English		
Bolt Size (in.)	**Minimum Bolt Tension (lb x 1000)**	
	A 325	A 490
1/2	12	15
5/8	19	24
3/4	28	35
7/8	39	49
1	51	64
1 1/8	56	80
1 1/4	71	102
1 3/8	85	121
1 1/2	103	148

712.7.4 Washers. All fasteners shall have a hardened washer under the nut or bolt head, whichever is turned in tightening. All fasteners over all oversized or slotted holes shall also have a hardened washer under the non-turned element. Where an outer face of the bolted parts has a slope of more than one in 20 with respect to a plane normal to the bolt axis, a smooth beveled washer shall be used to compensate for the lack of parallelism.

712.7.5 Calibrated Wrench Method. When calibrated wrenches are used to provide the bolt tension specified in Sec 712.7.3, the wrench setting shall be such as to induce a bolt tension 5 to 10 percent in excess of the specified value. Wrenches shall be calibrated at least once each working day by tightening in a device capable of indicating actual bolt tension no less than three typical bolts of each diameter from the bolts to be installed. Power wrenches shall be adjusted to stall or cut out at the selected tension. If manual torque wrenches are used, the torque indication corresponding to the selected tension shall be noted and used in the installation of all bolts of the tested lot. Nuts shall be in tightening motion when torque is measured. After the joint has been brought to a snug tight condition, all bolts in the joint shall be tightened by progressing systematically from the most rigid part of the joint to the free edges. When using calibrated wrenches to install several bolts in a single joint, the wrench shall be returned to "touch up" bolts previously tightened, which may have been loosened by the tightening of subsequent bolts, until all are tightened to the selected tension. During tightening, there shall be no rotation of the part not turned by the wrench.

712.7.6 Turn-of-Nut Method. When the turn-of-nut method is used to provide the bolt tension, there shall first be enough bolts brought to a snug tight condition as defined in Sec 712.7.2 to ensure that the parts of the joint are brought into full contact with each other. Following this initial operation, bolts shall be placed in any remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally by the applicable nut rotation specified below, with tightening progressing systematically from the most rigid part of the joint to the free edges. During this operation, there shall be no rotation of the part not turned by the wrench.

Nut[a] Rotation from Snug Tight Condition			
Disposition of Outer Faces of Bolted Parts			
Bolt length measured from underside of head to extreme end of point	**Bolt faces normal to bolt axis**	**One face normal to bolt axis and other face sloped not more than 1:20 (bevel washer not used)**	**Both faces sloped not more than 1:20 from normal to bolt axis (bevel washers not used)**
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 diameters but not exceeding 8 diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 diameters but not exceeding 12 diameters	2/3 turn	5/6 turn	1 turn

[a]Nut rotation shall be relative to bolts, regardless of the element (nut or bolt) being turned. For bolts installed by one-half of a turn and less, the tolerance will be ± 30 degrees. For bolts installed by two-thirds of a turn and more, the tolerance will be ± 45 degrees.

712.7.7 Load Indicating Bolt Method. Tightening by this method will be permitted, provided it can be demonstrated by the following procedure that the bolt has been tightened, at a minimum, to the bolt tension indicated in Sec 712.7.3. Three bolts of a representative length and of the same grade, diameter and condition as those under inspection shall be placed individually in a calibration device capable of indicating bolt tension. There shall be a washer under the part turned in tightening each bolt. Each bolt specified shall be tightened in the calibration device until the spline drive has sheared off. When this method is used to provide the bolt tension, all bolts in the joint shall be tightened in stages to prevent or minimize slackening of the installed bolts. The first stage shall be to tighten all bolts to a snug tight condition at which point all of the faying surfaces of the joint shall be firmly in contact. The final stage of tightening to full tension shall be accomplished by progressing systematically from the most rigid part of the joint to the free edges.

712.7.8 Bolt Length. When snug tight, the beginning of the bolt threads shall be even with or project slightly beyond the nut. When properly tensioned, the bolt projections beyond the nut shall be as such to prevent the nut from engaging the thread runout.

712.7.9 Bolt Tension Calibration Device. A Skidmore-Wilhelm Calibrator or an acceptable equivalent tension measuring device will be required at each job site during erection. Periodic testing, at least once each working day when the calibrated wrench method is used, shall be performed to assure compliance with the installation test procedures required for the tightening method used, and to perform pre-installation job site rotational-capacity testing. Bolts too short for the Skidmore-Wilhelm Calibrator may be tested using direct tension indicators (DTI). The DTI shall be calibrated in the Skidmore-Wilhelm Calibrator using longer bolts. Bolt tension calibration devices shall be calibrated and certified as to accuracy by a private testing laboratory within one year before usage or at any time the accuracy is questionable.

712.7.10 Rotational-Capacity Testing. The rotational-capacity test shall be performed on each rotational-capacity lot prior to the start of bolt installation. Hardened steel washers shall be part of the test, regardless if washers will not be required as part of the installation procedure. Bolt, nut, and washer when required, combinations as installed shall be only from the established and tested rotational-capacity lot.

712.7.11 Weathered Bolts. Weathered or rusted bolts or nuts not in accordance with Secs 712.7.1, 712.7.3 and 712.7.10 shall be cleaned and relubricated prior to installation. Recleaned or relubricated bolt, nut and washer assemblies shall be retested in accordance with Sec 712.7.10 prior to installation.

712.7.12 Inspection. The engineer will observe the installation and tightening of bolt assemblies to determine that the selected tightening procedure is properly used, and will determine that all bolt assemblies are tightened. The following verification inspection will be used:

(a) Either the engineer, or the contractor in the presence of the engineer, will use an inspecting torque wrench and bolt tension calibration device furnished by the contractor.

(b) Five bolt assemblies of a representative length, and of the same grade, diameter and condition as those under inspection will be placed individually in a calibration device capable of indicating bolt

tension. There will be a washer under the part turned in tightening each bolt. Each bolt specified will be tightened in the device by any convenient means to the minimum tension specified in Sec 712.7.3. The inspecting torque wrench then will be applied to the tightened bolt, and the torque necessary to turn the nut or head 5 degrees, approximately one inch at 12-inch radius, in the tightening direction will be determined. Of the five values obtained, the highest and the lowest values will be disregarded, with the average of the remaining three being taken as the job inspecting torque to be used in the manner specified in Sec 712.7.12. The inspecting torque will be re-established at intervals of no more than 30 calendar days or at any time appreciable changes are encountered.

(c) Bolts represented by the sample prescribed in Sec 712.7.12 that have been tightened in the structure will be inspected by applying, in the tightening direction, the inspecting wrench and the wrench's job inspecting torque to 10 percent of the bolts, but no less than two bolts, selected at random in each connection. If no nut or bolt head is turned by this application of the job inspecting torque, the connection will be accepted as properly tightened. If any nut or bolt head is turned by the application of the job inspecting torque, this torque shall be applied to all bolts in the connection. All bolts whose nut or head was turned by the job inspecting torque shall be tightened and re-inspected.

(d) Calibrated wrench tightening will be verified during actual installation in the assembled steel work. The wrench adjustment selected by the calibration shall not produce a bolt or nut rotation from snug tight greater than permitted in Sec 712.7.6.

712.8 Field Coating. Field coating of structural steel shall be in accordance with Sec 1081.

712.9 Steel Bar Dams. Steel bar dams placed at expansion devices on existing bridges to serve as headers for surfacing material shall be installed in a manner that will not interfere with the movement of the expansion devices.

712.10 Method of Measurement.

712.10.1 Steel and Iron. Payment for structural steel and wrought iron weights will be based on contract plan quantities. The theoretical weight of the various sections will be used to compute the contract plan quantities of the material incorporated in the completed structure. No allowance will be made for overrun in scale weights or for erection bolts, excess field bolts or similar items, or the weight of any coating, galvanizing or weld material.

712.10.2 Bolts. The weight of steel bolts for steel-to-steel connections will be included in the contract plan quantities for fabricated structural steel on the basis of following weights per 100 bolts:

Bolt Weights[a]	
Bolt Size (in.)	**Weight (lb)**
5/8	40
3/4	65
7/8	95
1	135

[a]These specified weights will be considered to cover the head, nut, any required washers and only that part of the bolt extending outside the grip of steel.

712.10.3 Connection to Concrete or Timber. The weight of bolts connecting steel to concrete or timber will be included for payment as fabricated structural steel, and the full weight of the bolts will be computed.

712.10.4 Castings. Castings will be computed on the basis of the theoretical weight of the material in the completed structure, and no allowance will be made for overrun in scale weights or for the weight of any coating material, galvanizing material or other protective coatings.

712.10.5 Accuracy of Weights. Weights of structural steel, wrought iron and castings will be computed to the nearest 10 pounds of the total weight of each class of material in the completed structure.

712.10.6 Coatings. For recoating or overcoating, the contract documents will indicate the estimated number of tons to be coated for informational purposes.

712.10.6.1 Weight Measurement. If the contract specifies a unit of measurement of coating steel structures in tons, the weight of the steel to be cleaned and coated will be based on plan quantities to the nearest 1/10-ton. The weight will not vary with the number of coats applied.

712.10.6.2 Surface Area Measurement. If the contract specifies a unit of measurement of coating steel structures in square feet, the area of the girders or stringers to have surface preparation performed or to be coated will be computed to the nearest 100 square feet. The bearings, diaphragms, stiffeners and all other miscellaneous steel within the limits of surface preparation or of the field coatings will not have the area computed and will be considered completely covered by the area computations of the girders or stringers. The area will not vary with the number of coats applied. Final measurement will not be made.

712.10.6.3 Lump Sum Measurement. Measurement will not be made when the contract specifies units of measurement per lump sum.

712.10.7 Bar Dams. A steel bar dam shall consist of the complete assembly on both sides of the expansion joint and will be considered a unit.

712.10.8 Shear Connectors. The weight of shear connectors will be based on the theoretical weight and will be included for payment in the weight of material to which the connectors are attached.

712.11 Basis of Payment.

712.11.1 Fabricated Steel. Payment for fabricated structural steel, fabricated wrought iron, steel castings and gray iron castings will be based on the contract plan quantities. Any change in the contract plan quantities based on approved change orders will be paid for at the contract unit price. Payment for the shop prime coat, including inaccessible areas, will be included in the cost of fabricated structural steel, and no direct payment will be made. No direct payment will be made for coating bolted field connections, touch-up, galvanizing, applying protective coating to machined surfaces or for cleaning coatings and rust streaks from finished concrete.

712.11.2 Hardware. Bolts for attaching timber members to any part of a structure will be classified as hardware and no direct payment will be made.

712.11.3 Coatings. Payment for surface preparation and applying field coatings to the structural steel, if specified as a contract item, will be based on the contract plan quantities. Any change in the contract plan quantities, based on approved change orders, will be paid for at the contract unit price. If no contract item is specified for surface preparation or applying field coatings, no direct payment will be made. Payment for the shop applied coatings, including inaccessible areas, will be considered completely covered by the cost of the fabricated structural steel. No direct payment will be made for the surface preparation or applying field coatings to the bearings, diaphragms, stiffeners and all other miscellaneous steel within the limits of surface preparation or of the field coatings. No direct payment will be made for stencils, paint and painting specified in Sec 1081. No direct payment will be made for field touch-ups or repairs specified in Sec 1081.

712.11.4 Bar Dams. The accepted number of steel bar dams will be paid for at the contract unit price.

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SECTION 713
THRIE BEAM FOR BRIDGE GUARDRAIL

713.1 Description. This work shall consist of furnishing and erecting steel thrie beam guardrail, including beams, posts and all appurtenances, as shown on the plans or as directed by the engineer.

713.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Guardrail Material	1040

713.3 Construction Requirements. Anchor bolts for posts shall be set with suitable templates in position and securely fixed to prevent displacement during concreting operations. The areas upon which the bases of the posts are to bear shall be dressed smooth to a true plane. Posts shall be aligned by the use of shims such that the post deviates no more than 1/2 inch from true alignment after final adjustment.

713.4 Method of Measurement. Final measurement of the completed thrie beam for bridge guardrail will not be made except for authorized changes during construction or if appreciable errors are found in the contract quantity. Where required, measurement of thrie beam for bridge guardrail will be made to the nearest linear foot for each structure, measured along the face of the thrie beam and from center to center of end posts. The revision or correction will be computed and added to or deducted from the contract quantity.

713.5 Basis of Payment. The accepted quantity of thrie beam for bridge guardrail, complete in place, will be paid for at the contract unit price for each of the pay items included in the contract.

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SECTION 715
VERTICAL DRAIN AT END BENTS

715.1 Description. This work shall consist of furnishing and installing a vertical drain system consisting of drain core, geotextile fabric, perforated and unperforated drain pipe, couplers and a rodent screen as shown on the plans or as directed by the engineer.

715.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Geotextile	1011
Geocomposite Drainage Material	1012
Miscellaneous Drainage Material	1013
Corrugated Metallic-Coated Steel Pipe Underdrain	1022

715.3 Construction Requirements.

715.3.1 The contractor shall install the vertical drain system in accordance with the manufacturer's recommendations.

715.3.2 If the core of the drain is not perforated, modifications shall be made to the core to provide adequate drainage into the drain pipe as approved by the engineer.

715.3.3 Vertical and horizontal joints shall be constructed to form an uninterrupted drain face after compaction is completed. All joints shall have an overlap of geotextile to prevent any intrusion of fill material into the drain. Horizontal joints shall be designed to drain downward. Any cracks or openings in the drain adjacent to the fill will be cause for rejection of the drain, and the drain shall be replaced by the contractor, at the contractor's expense.

715.3.4 The backfill material shall be placed and compacted in accordance with Sec 206. The backfill shall be placed in such a manner as to prevent damage to the vertical drain system. The backfill material shall be as approved by the engineer.

715.4 Method of Measurement. The work provided herein will not be measured for payment, but will be considered completely paid for as a system, per each.

715.5 Basis of Payment. The accepted vertical drain system, complete in place, will be paid for at the contract unit price for vertical drain at end bents, per each. No direct payment will be made for excavation, backfilling, compaction, drain pipe or other material and work

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SECTION 716
NEOPRENE BEARINGS

SECTION 716.10 PLAIN AND LAMINATED NEOPRENE BEARING PADS.

716.10.1 Description. This work shall consist of furnishing and installing complete factory-produced plain or laminated neoprene bearing pads as shown on the plans or as directed by the engineer.

716.10.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Elastomeric Bearing Pads	1038

716.10.3 Construction Requirements. The neoprene pads shall be bonded to the bearing seat with an epoxy adhesive, in accordance with the bearing manufacturer's recommendations for bonding neoprene to concrete to prevent sliding.

716.10.4 Method of Measurement. Measurement will be made per each. The plain neoprene bearing pad, complete in place, shall include the plain neoprene bearing pad and any incidental materials needed to complete the work. The laminated neoprene bearing pad, complete in place, shall include the laminated neoprene bearing pad and any incidental material needed to complete the work.

716.10.5 Basis of Payment. The accepted quantity of plain neoprene bearing pads will be paid for at the contract unit price.

SECTION 716.20 LAMINATED NEOPRENE BEARING PAD ASSEMBLY.

716.20.1 Description. This item shall include furnishing and installing complete factory produced bearings as shown on the plans or as directed by the engineer.

716.20.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Elastomeric Bearing Pads	1038

716.20.3 Construction Requirements. All sole plates shall be furnished with the bearings as a complete unit and directly welded to the girder or stringer as shown on the plans. The neoprene pads shall be bonded to the bearing seat with an epoxy adhesive in accordance with the bearing manufacturer's recommendations for bonding neoprene to concrete to prevent sliding.

716.20.4 Method of Measurement. Measurement will be made per each. The laminated neoprene bearing pad assembly, complete in place, shall include the steel sole plate, laminated neoprene bearing pad, anchor bolts, heavy hexagon nuts, coating and any incidental material needed to complete the work.

716.20.5 Basis of Payment. The accepted quantity of laminated neoprene bearing pad assemblies will be paid for at the contract unit price.

SECTION 716.30 TYPE "N" POLYTETRAFLUOROETHYLENE (PTFE) BEARINGS.

716.30.1 Description. This work shall consist of furnishing and installing complete factory produced Type "N" PTFE bearings as shown on the plans or as directed by the engineer.

716.30.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Type "N" PTFE Bearings	1038

716.30.3 Construction Requirements. All sole plates shall be furnished with the bearings as a complete unit and directly welded to the girder or stringer as shown on the plans. At the time of installation, the stainless steel sliding face of the upper element and the PTFE sliding face of the lower element shall have the surface finish specified and shall be free of all dust, dirt, moisture or any other foreign matter. The neoprene pads shall be bonded to the bearing seat with an epoxy adhesive in accordance with the bearing manufacturer's recommendations for bonding neoprene to concrete to prevent sliding. The top and bottom plates shall be properly aligned before gluing pads.

716.30.4 Method of Measurement. Measurement will be made per each. The type "N" PTFE bearing, complete in place, shall include the steel sole plate, stainless steel plates, PTFE face on the stainless steel plates, laminated neoprene bearing pad, anchor bolts, heavy hexagon nuts, coating and any incidental material needed to complete the work.

716.30.5 Basis of Payment. The accepted quantity of type "N" PTFE bearings will be paid for at the contract unit price.

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SECTION 717
FLEXIBLE JOINT SYSTEMS

SECTION 717.10 PREFORMED COMPRESSION SEAL.

717.10.1 Description. This work shall consist of furnishing and installing a preformed compression seal for joints as shown on the plans or as directed by the engineer. Structural steel for the joints shall be furnished and installed as shown on the plans.

717.10.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Preformed Compression Seals	1073

717.10.3 Construction Requirements.

717.10.3.1 Shop Drawings. Shop drawings for structural steel for expansion joint systems shall be prepared in accordance with Sec 1080. The dimensions of the seal shall be shown on the shop drawings for the armored joint. Shop drawings will not be required when the seal is placed against concrete or existing steel armor.

717.10.3.2 Installation. The preformed compression seal shall be installed in joints in one continuous piece without field splices. Factory splicing will be permitted for joints in excess of 53 feet. The area of steel armor to come in contact with preformed compression seal lubricant adhesive shall be sand blasted prior to installing the seal. Sand blasting will be considered acceptable when the steel surfaces have been cleaned to an SSPC-SP10 degree of cleanliness. Containment and disposal of material shall be in accordance with Sec 202.2. The lubricant adhesive shall be applied in a continuous film to the sides of the seal and to the joint surfaces just prior to placing the seal in the joint. The seal shall be installed with an installation tool recommended by the manufacturer, in a manner that prevents the seal from being damaged and from being in tension. Twisting, curling and nicking the seal will be prohibited. Lubricant adhesive on top of the installed seal shall be removed before drying. Unless the installation tool is capable of installing the seal without elongation prior to placement, the seal shall be pre-cut to the exact length for the joint plus ends as shown in the contract documents. The pre-cut seal shall be installed and measured for stretch. The seal shall be removed and reinstalled if the seal stretch length exceeds five percent of the pre-cut length.

717.10.4 Method of Measurement. Final measurement will not be made except for authorized changes during construction or where significant errors are found in the contract quantity. Where required, the preformed compression seal will be measured to the nearest linear foot based on measurement from roadway face of curb to roadway face of curb along the centerline of the joint. The revision or correction will be computed and added to or deducted from the contract quantity. No measurement will be made of portions of the joint that extend past the roadway face of curbs.

717.10.5. Basis of Payment. Preformed compression seals, including all material, coating, equipment, labor, fabrication, installation and any other incidental work necessary to complete this work, will be paid for at the contract unit price.

SECTION 717.20 STRIP SEAL.

717.20.1 Description. This work shall consist of furnishing and installing a watertight strip seal for joints as shown on the plans or as directed by the engineer. The structural steel for the joints shall be furnished and installed as shown on the plans.

717.20.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Strip Seal	1073

717.20.3 Construction Requirements.

717.20.3.1 Shop Drawings. Shop drawings for structural steel for expansion joint systems shall be prepared in accordance with Sec 1080. The drawings shall show in detail the type, size, location of anchors, and sequence of installation. The dimensions of the seal shall be shown on the shop drawings for the armored joint. The cavity in the steel armor (also known as an extrusion) shall be of a dimensional tolerance that prevents the lug of the strip seal gland from slipping loose. The upper lip of the extrusion shall extend over the bottom lip to avoid pinching the gland when the expansion joint system is in a closed position. Shop drawings will not be required when the seal is placed in existing steel extrusions.

717.20.3.2 Installation. The area of steel armor to come in contact with strip seal lubricant adhesive shall be sand blasted prior to installing the seal. Sand blasting will be considered acceptable when the steel surfaces have been cleaned to an SSPC-SP10 degree of cleanliness. Containment and disposal of material shall be in accordance with Sec 202.2. The strip seal shall be made watertight with a lubricant adhesive for bonding the neoprene gland to the steel extrusion as recommended by the manufacturer. The contractor shall obtain the services of a qualified technical representative, approved by the manufacturer of the expansion system and acceptable to the engineer, to assist during the installation. The installation shall not occur without the technical representative being present.

717.20.4 Method of Measurement. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. Where required, the strip seal will be measured to the nearest linear foot, based on measurement from the roadway face of curb to roadway face of curb along the centerline of the joint. The revision or correction will be computed and added to or deducted from the contract quantity. Portions of the joint that extend past the roadway face of curbs will not be measured for payment.

717.20.5. Basis of Payment. Strip seals, including all material, coating, equipment, labor, fabrication, installation, technical assistance, and any other incidental work necessary to complete this work, will be paid for at the contract unit price.

SECTION 717.30 SILICONE EXPANSION JOINT SEALANT.

717.30.1 Description. This work shall consist of furnishing and installing the backer rod and silicone expansion joint sealant for joints as shown on the plans or as directed by the engineer. Structural steel for the joints shall be furnished and installed as shown on the plans.

717.30.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Silicone Expansion Joint Sealant	1057

717.30.3 Construction Requirements. The contractor shall furnish to the engineer the manufacturer's written product information, installation procedures and instructional information at least two weeks prior to installation. The contractor shall obtain the services of a qualified technical representative approved by the manufacturer of the expansion system and acceptable to the engineer, to assist during the installation. The contractor, the technical representative and the engineer shall meet to review and clarify installation procedures and requirements prior to starting the work. The start of surface preparations and sealant installation shall not occur without the technical representative being present. The technical representative shall be present for at least one day at the start of surface preparations and sealant installation.

717.30.3.1 Shop Drawings. Shop drawings for structural steel for expansion joint systems shall be prepared in accordance with Sec 1080. The dimensions of the seal shall be shown on the drawings for the armored joint. Shop drawings will not be required when the sealant is placed against concrete or existing steel armor.

717.30.3.2 Surface Preparation. The concrete or steel surface shall be prepared for priming and sealant placement. New Portland cement concrete shall be fully cured and allowed to dry a minimum of seven days. The joint shall be cleaned of all gravel, loose material and other contaminates before sand blasting. Areas that will be in contact with the sealant shall be sand blasted with a clean, hard aggregate that will leave little to no dust residue. Sand blasted concrete surfaces will be considered acceptable when areas that will be in contact with the sealant have a roughened surface with clean, exposed aggregate. The surface shall be free of foreign matter or plastic residue. Sand blasted steel surfaces will be considered acceptable when the steel surfaces have

been cleaned to an SSPC-SP10 degree of cleanliness. Containment and disposal of material shall be in accordance with Sec 202.2. After sand blasting is completed, the joint shall be cleaned of debris using oil-free and water-free compressed air or a vacuum, either being at least 90 psi.

717.30.3.3 Priming. Priming shall immediately follow sand blasting and cleaning and will only be permitted to proceed when the air and substrate temperatures are at least 40 F and rising. Sand blasting, priming and sealing shall be performed on the same day. The entire sand blasted surface shall be primed. Application and drying times for primers shall be in accordance with the manufacturer's recommendations. All leftover primer shall be properly disposed.

717.30.3.4 Joint Installation. The backer rod shall be installed as specified on the plans and in accordance with the manufacturer's recommendations. All voids in the installed backer rod shall be filled to prevent sealant leakage.

717.30.3.5 Sealant Placement. The sealant thickness and recess depth shall be as shown in the contract documents and shall be measured during installation at approximately 2 foot intervals. Adjustments to correct sealant thickness to within ± 1/8-inch tolerance shall be made before the sealant begins to set. Sealant placement will only be permitted when the air and substrate temperatures are above 40 F, below 90 F and 5 F above the dew point. The joint surfaces shall be kept clean and dry during sealing. The joint shall remain clean and dry during the sealing operation. Sealing shall be performed using a pneumatic gun in accordance with the manufacturer's recommendations. End of seal treatment at vertical faces of curbs, sidewalks or parapets shall be as recommended by the manufacturer and as shown in the contract documents. Sealant placed incorrectly shall be removed and replaced at the contractor's expense.

717.30.4 Method of Measurement. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. Where required, the silicone expansion joint sealant will be measured to the nearest linear foot based on measurement from the roadway face of curb to roadway face of curb along the centerline of the joint. The revision or correction will be computed and added to or deducted from the contract quantity. Portions of the joint that extend past the roadway face of curbs will not be measured for payment.

717.30.5 Basis of Payment. Silicone expansion joint sealant, including all materials, coating, equipment, labor, fabrication, installation, technical assistance and any other incidental work necessary to complete this work, will be paid for at the contract unit price.

SECTION 717.40 SILICONE JOINT SEALANT FOR SAW CUT AND FORMED JOINTS.

717.40.1 Description. This work shall consist of sealing the saw cut and formed joints as shown in the contract documents.

717.40.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Silicone Joint Sealant for Saw Cut and Formed Joints	1057

717.40.3 Construction Requirements.

717.40.3.1 Saw Cut Joints. Joints shall be sawed as shown on the plans as soon as the concrete has hardened sufficiently to permit sawing of a neat straight joint with minimal raveling, and before uncontrolled shrinkage cracking occurs. All joints shall be sawed to the required dimension and cleaned by sand blasting, wire brushing or other methods approved by the engineer in accordance with the manufacturer's recommendations. Joint interfaces shall be fully cured and dry, or free of moisture at the time of installation. All loose particles shall be removed by oil-free and water-free compressed air or a vacuum of at least 90 psi before the application of the backer rod and sealant.

717.40.3.2 Formed Joints. Any joints 0.25 inch or greater shall be cleaned and packed with backer rod and silicone joint sealant. Any joints less than 0.25 inch shall be cleaned and caulked with silicone joint sealant as shown on the plans. All joint interfaces shall be cleaned by grinding, saw cutting, sand blasting, wire brushing or other methods approved by the engineer in accordance with the manufacturer's recommendations. New

Portland cement concrete shall be fully cured and allowed to dry a minimum of seven days. The joint interfaces shall be free of moisture at the time of installation. All loose particles shall be removed by oil-free and water-free compressed air or vacuum of at least 90 psi before the application of the backer rod and sealant.

717.40.3.3 Joint Backer Rod. The backer rod shall be used in the joint slot to ensure the sealant adheres to the sidewalls or interface of the joint. All joint areas requiring a backer rod shall be packed with a closed-cell, expanded polyethylene foam to obtain the appropriate depth of the sealant. The backer rod shall be slightly oversized for the joint width, and shall be resilient, compressible in nature, nonabsorbent, non-shrinking and compatible with the sealant.

717.40.3.4 Sealant Placement. Sealant shall be placed in the proper configuration as shown on the plans. Joint sealer shall be protected from dust and other foreign matter until cured to a tack-free condition. The sealant shall fill the joint from the bottom to slightly below the surface currently being applied. Immediately after placement and before a skin forms, the sealant shall be tooled to force the sealant against the joint face and to recess the bead approximately 1/8 inch.

717.40.3.5 Containment and disposal of material shall be in accordance with Sec 202.2.

717.40.4 Method of Measurement. No measurements will be made.

717.40.5 Basis of Payment. No direct payment will be made for this work.

SECTION 717.50 OPEN CELL FOAM JOINT.

717.50.1 Description. This work shall consist of furnishing and installing an open cell foam joint system as shown on the plans, as directed by the engineer and in accordance with the manufacturer's requirements.

717.50.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Open Cell Foam Joints	1073

717.50.3 Construction Requirements. The contractor shall have a manufacturer's representative on site for the joint installation. The representative shall be responsible for ensuring the surface preparation and joint installation are done in accordance with the manufacturer's requirements.

717.50.3.1 Field Splices. The Open Cell Foam shall be installed in one continuous piece without field splices, unless otherwise specified on the plans or directed to by the engineer. Open Cell Foam shall be spliced with silicone called for in Sec 1057 and in accordance with the manufacturers recommendations

717.50.4 Method of Measurement. Final measurement will not be made except for authorized changes during construction or where significant errors are found in the contract quantity. Where required, the open cell foam joint will be measured to the nearest linear foot based on measurement from roadway face of curb to roadway face of curb along the centerline of the joint. The revision or correction will be computed and added to or deducted from the contract quantity. No measurement will be made of portions of the joint that extend past the roadway face of curbs.

717.50.5 Basis of Payment. Open cell foam joint, including all material, coating, equipment, labor, fabrication, installation and any other incidental work necessary to complete this work, will be paid for at the contract unit price for Open Cell Foam Joint.

SECTION 717.60 PREFORMED SILICONE OR EPDM EXPANSION JOINTS.

717.60.1 Description. This work shall consist of furnishing and installing a preformed silicone or EPDM expansion joint seal for joints as shown on the plans or as directed by the engineer and in accordance with the manufacturer's requirements.

717.60.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Preformed Silicone or EPDM Expansion Joints	1073

717.60.3 Construction Requirements. The contractor shall furnish to the engineer the manufacturer's written product information, installation procedures and instructional information at least two weeks prior to installation. The contractor shall obtain the services of a qualified technical representative approved by the manufacturer of the expansion joint seal and acceptable to the engineer, to assist during the installation. The contractor, the technical representative and the engineer shall meet to review and clarify installation procedures and requirements prior to starting the work. The start of surface preparations and seal installation shall not occur without the technical representative being present. The technical representative shall be present for at least one day at the start of surface preparations and seal installation.

717.60.3.1 Surface Preparation. The concrete or steel surface shall be prepared for priming and seal placement. New Portland cement concrete shall be fully cured and allowed to dry a minimum of seven days. The joint shall be cleaned of all gravel, loose material and other contaminates before sand blasting. Areas that will be in contact with the sealant shall be sand blasted with a clean, hard aggregate that will leave little to no dust residue. Sand blasted concrete surfaces will be considered acceptable when areas that will be in contact with the sealant have a roughened surface with clean, exposed aggregate. The surface shall be free of foreign matter or plastic residue. Sand blasted steel surfaces will be considered acceptable when the steel surfaces have been cleaned to an SSPC-SP10 degree of cleanliness. Containment and disposal of material shall be in accordance with Sec 202.2. After sand blasting is completed, the joint shall be cleaned of debris using oil-free and water-free compressed air or a vacuum, either being at least 90 psi. Using a rag saturated in denatured alcohol, wipe clean both vertical faces of the expansion joint opening.

717.60.3.2 Priming. Priming shall immediately follow sand blasting and cleaning and will only be permitted to proceed when the air and substrate temperatures are at least 40° F and rising. Sand blasting, priming and installing the seal shall be performed on the same day. The entire sand blasted surface shall be primed. Application and drying times for primers shall be in accordance with the manufacturer’s recommendations. All leftover primer shall be properly disposed.

717.60.3.3 Installation. The preformed silicone or EPDM expansion joint seal shall be installed in joints in one continuous piece without field splices. The locking adhesive and seal shall be applied in accordance with the manufacturer’s recommendations, in a manner that prevents the seal from being damaged and from being in tension. Twisting, curling and nicking the seal will be prohibited. Unless the installation tool is capable of installing the seal without elongation prior to placement, the seal shall be pre-cut to the exact length for the joint plus ends as shown in the contract documents or as directed by the engineer. The pre-cut seal shall be installed and measured for stretch. The seal shall be removed and reinstalled if the seal stretch length exceeds five percent of the pre-cut length at the contractor’s expense.

717.60.4 Method of Measurement. Final measurement will not be made except for authorized changes during construction or where significant errors are found in the contract quantity. Where required, the preformed silicone or EPDM expansion joint will be measured to the nearest linear foot based on measurement from roadway face of curb to roadway face of curb along the centerline of the joint. The revision or correction will be computed and added to or deducted from the contract quantity. No measurement will be made of portions of the joint that extend past the roadway face of curbs.

717.60.5 Basis of Payment. Preformed silicone or EPDM expansion joint, including all material, coating, equipment, labor, fabrication, installation and any other incidental work necessary to complete this work, will be paid for at the contract unit price for Preformed Silicone or EPDM Expansion Joint.

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SECTION 718
TEMPORARY BRIDGE

718.1 Description. This work shall consist of furnishing all material, labor and equipment necessary for fabricating, constructing, transporting and erecting the superstructure components, maintaining, disassembling, cleaning, transporting superstructure components to storage and removing a temporary bridge as shown on the plans or as directed by the engineer.

718.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section/Specification
Removal of Bridges	216
Load Bearing Pile	702
Structural Steel Construction	712
Guardrail and Guard Cable Material	1040
Lumber and Timber	1050
Structural Steel Fabrication	1080
Coating of Structural Steel	1081
Structural Steel Tubing	ASTM A 500, Grade 46

718.3 Construction Requirements. Temporary bridges and approaches shall be constructed at the location, length and elevation shown on the plans or as directed by the engineer. If necessary to prepare the crossing for traffic, approach embankments or excavation and surfacing shall be provided. The contractor shall maintain in good condition the temporary structure, approaches and embankments until the permanent structure is opened to traffic. The contractor shall then remove the temporary structure, all refuse, debris and approach fills. The site shall be left in a neat and acceptable condition before acceptance of the work. Any portion of the superstructure furnished by the contractor shall in its entirety become the property of the Commission.

718.3.1 Substructure. The substructure shall include all portions of this structure not classified as superstructure elsewhere in these specifications. The substructure shall generally include the piling, sway bracing, timber, attaching devices and any excavation or backfill not included as a roadway item necessary to construct this structure. All piling shall be pulled or removed in accordance with Sec 216. After removal, all portions of the substructure will remain the property of the contractor.

718.3.2 Protective Coating. Structural steel tubing furnished by the contractor shall be cleaned and coated using System G in accordance with Sec 1081. The prime coat and epoxy intermediate coat shall be applied in the shop. After disassembly, any areas of the tubing where the coating is damaged shall be cleaned and coated using System G prime coat and epoxy intermediate coat in accordance with Sec 1081. No coating will be required on the remaining superstructure. Protective coating of the steel piling and sway bracing will not be required.

718.3.3 Superstructure Partially Furnished by Contractor. The contractor shall furnish the cap beam units. The portion of the superstructure to be furnished by the Commission will include the superstructure spans. Each end bent cap beam unit shall include the channels, cover plate, stiffener, end plates and bottom bearing plates. Each intermediate bent cap beam unit shall include the angles, cover plate, stiffeners, end plates and bottom bearing plates. Each cap beam unit shall be fabricated and fully assembled in the shop. All holes and slots shall be shop drilled full size. New high-strength bolts, nuts and washers shall be furnished by the contractor, as required for the assembly of the cap beams, as shown on bridge plans.

718.3.4 Superstructure Furnished by the Commission. The superstructure furnished by the Commission will be stored at the location described on the bridge plans. New high-strength bolts, nuts and washers for the superstructure furnished by the Commission shall be used for any reassembling of the temporary bridge units.

718.3.5 Transporting and Erecting Superstructure. The contractor shall transport the superstructure units to the job site for erection. After the substructure piling and sway bracing have been completed to correct line and grade, holes shall be field drilled in the pile at locations shown on the plans to attach the cap beam in conformity with the plan line and grade. Field reaming or enlargement in any manner of holes in any superstructure unit will not be permitted. The structure shall be maintained by the contractor, at the contractor's expense, during usage until final storage. Any damage, regardless of cause, shall be repaired by the contractor, at the contractor's

expense, prior to final acceptance. The contractor's responsibility for work shall be in accordance with Sec 107.

718.3.6 Removing and Storing Superstructure. After the permanent bridge is open to traffic, the superstructure of the temporary bridge shall be disassembled, removed, cleaned and transported to the storage area, as directed by the engineer, to the location described on the bridge plans. The superstructure units shall be cleaned of all dirt and other debris to the satisfaction of the engineer. The contractor shall notify and make arrangements with the engineer a minimum of 24 hours prior to storing the superstructure. The estimated weight of each individual superstructure unit will be 18,000 pounds.

718.3.6.1 Disassembly. The thrie beam rail and channel for the splice between spans at each intermediate bent shall be removed, set back (bent no. 2 to span 1, bent no. 3 to span 2, etc.) and securely attached to the rail or channel on each exterior unit. The remainder of the thrie beam rail shall remain fully assembled and attached as part of each exterior superstructure unit for storage. Splice plates for attaching the exterior units to the interior units shall be removed, turned inward and securely attached to the interior unit connection plates or bearing stiffeners. The cap beams and bottom bearing plates shall be removed and stored as units. The bearing anchor bolts shall be greased and capped before transporting to the storage area. The structural tubing shall be removed and stored. All attaching bolts, nuts, etc. shall be placed on one of the parts from which the hardware was removed.

718.3.6.2 Storage. The sequence of storage shall be such that the end spans are readily accessible without relocating other spans. Storage shall be by span with an exterior unit set in a relatively level position on timber blocks placed just inside each bearing such that the unit is a minimum of 6 inches off the ground. The other exterior unit shall be stacked on top of the first exterior unit, followed by the interior units of the same span. Each stacked unit shall be separated with timber blocks by a minimum of 6 inches. All spans shall be stored in a similar manner. The cap beam units shall be stored on the interior unit of an adjacent span with a minimum of one cap beam unit per span. The structural steel tubing shall be stored on the interior unit of an end span.

718.3.6.3 Hardware. New high-strength bolts, nuts and washers in like sizes shall be furnished by the contractor to the engineer to replace those that are either loosened or removed during disassembly of the temporary bridge. The new high-strength bolts, nuts and washers shall be supplied in separate watertight containers for each span stored.

718.4 Method of Measurement. All excavation necessary in constructing and removing approach embankment, as directed by the engineer, will be measured and included with regular roadway excavation quantities. Measurement of the piles in place will be the actual length measured to the nearest foot for the portion of each pile that remains for the use of the temporary bridge. All other work items will not be measured for payment, but will be considered as part of the lump sum unit.

718.5 Basis of Payment. The substructure, partial furnishing of superstructure, transporting and erecting superstructure, and removing and storing superstructure will be paid for at the contract unit price for each of the pay items included in the contract. Payment will be considered full compensation for all labor, equipment and material, including attaching hardware, to complete the described work. Any salvage value of the substructure shall be reflected in the contract unit price.

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SECTION 720
MECHANICALLY STABILIZED EARTH WALL SYSTEMS

720.1 Description. This work shall consist of furnishing and constructing mechanically stabilized earth wall systems in accordance with these specifications, as shown on the plans or as directed by the engineer. **720.2 Material.** All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Concrete	501
Pipe Pile Spacers	724
Select Granular Backfill for Structural Systems	1010
Geotextile	1011
Miscellaneous Drainage Material	1013
Reinforcing Steel for Concrete	1036
Resin Anchor Systems	1039
Mechanically Stabilized Earth Wall System Components	1052

720.2.1 Whenever a wall system is located adjacent to and within ten feet of the limits of a permanent roadway, the steel reinforcement used in the concrete elements of the wall system shall be epoxy coated. This requirement will not apply to soil reinforcement and corresponding attachments used for connecting the reinforcement to the wall system units.

720.2.2 Reinforcement for wall system units shall be either Grade 60 deformed bars or an equivalent steel welded wire reinforcement. Reinforcement for coping or top cap units shall be Grade 60 deformed bars.

720.2.3 Joint material for large block wall systems shall be used in accordance with the wall manufacturer's recommendations.

720.2.4 The unit fill that is used for small block wall systems shall consist of a granular backfill in accordance with Gradation D or E of Sec 1005.

720.2.5 Class B or B-1 air entrained concrete shall be used for the coping or top cap units used for the wall system. Class B or B-1 concrete shall be used for cast-in-place concrete leveling pads used for the wall system.

720.3 Design Requirements.

720.3.1 Only the mechanically stabilized earth wall systems shown in the bridge prequalified products listing will be allowed for use by the contractor. The bridge prequalified products list may be obtained through Bridge or MoDOT's web site. Any deviations from the prequalified wall system details previously submitted to Bridge shall be specifically outlined in the cover letter submitted with the design plans, details and computations.

720.3.2 Small block wall systems will be permitted for uses where the wall height does not exceed ten feet. This limit may be exceeded up to a maximum height of 12 feet to accommodate peaks in the wall or to accommodate lengths of the wall that do not exceed more than ten percent of the total wall length. The height of the wall will be determined by measuring from the top of the concrete leveling pad to the top of the cap on the wall.

720.3.3 The contractor shall submit six complete sets of the manufacturer's design plans, details and computations for each individual wall structure to the engineer. All submitted information shall be clear and complete, and thoroughly checked before the information is submitted. All submitted information shall be legible and of sufficient contrast to be suitable for archiving in accordance with MoDOT's current practice for archiving. Submitted information determined to be unsuitable for archiving purposes will be returned for corrective action.

720.3.4 The contractor will be solely responsible for the content of the design plans, details and computations that are submitted, and for the performance of the wall system. The contractor shall be solely responsible for ensuring that the information submitted by the manufacturer is in accordance with all contract plans and specifications and with the wall system used. Completed design plans shall contain all material, fabrication and construction requirements for erecting the wall system complete in place. The completed design plans shall show the longitudinal and lateral layout of the drainage systems used for the wall system. The contractor shall be responsible for the internal and external stability of the structure including compound stability. Overall global

stability will be the responsibility of the engineer.

720.3.5 All design plans, details and computations submitted for distribution shall be signed, sealed and stamped in accordance with the laws relating to architects and professional engineers (Chapter 327, RSMo).

720.3.6 Mechanically stabilized earth wall systems shall be designed in accordance with the AASHTO specifications shown on the plans and in accordance with additional publications or specifications referenced within the AASHTO specifications. The seismic performance category, angle of internal friction for the selected granular backfill for structural systems and other design requirements shown on the plans shall be incorporated into the design of the wall system.

720.4 Construction Requirements.

720.4.1 Small Block Wall Systems.

720.4.1.1 The contractor shall use a unit fill to fill the voids of the blocks for the wall system. This unit fill shall extend a minimum distance of 12 inches beyond the extreme back face of the wall system. Each course of the wall system shall have the unit fill in place before the next course of the wall system is placed.

720.4.1.2 Precast top cap units shall be used on small block wall systems. The top cap units shall be permanently attached as shown on the plans, utilizing either a resin anchor system or an equivalent detail.

720.4.1.3 Any equivalent details used shall be part of the prequalified mechanically stabilized earth wall system details on file for the manufacturer of the wall system.

720.4.2 Large Block Wall Systems.

720.4.2.1 A Class 1 geotextile filter cloth shall be placed between the wall and the select granular backfill for structural systems at all joints between the individual wall system units.

720.4.2.2 Precast or cast-in-place coping shall be placed on large block wall systems in accordance with the design plans. Capstone may be used in lieu of coping whenever coping is specified on the design plans. When coping or capstone is used, the maximum distance between construction joints shall be 20 feet. The joints for coping or capstone should align with the vertical joints in the MSE wall face.

720.4.3 Drainage Requirements. A drainage system shall be provided at the base of the wall system near the facing elements and at the interface of the select granular backfill for structural systems and the retained backfill. The drainage system shall consist of a perforated pipe wrapped in a Class 2 geotextile to prevent clogging of the perforations. The pipe shall be placed in such a manner that water drains freely from the pipe. When the wall length is such that the slope of the pipe becomes excessive in the engineer's judgment, lateral drain pipes shall be installed underneath the concrete leveling pad.

720.4.4 Foundation Preparation. The foundation for the wall system shall be graded level for a width equal to or exceeding the length of the reinforcing strips, or as shown on the plans. Prior to wall construction, the foundation, if not on rock, shall be compacted as directed by the engineer. Any foundation soils found to be unsuitable shall be removed and replaced, as directed by the engineer.

720.4.5 Leveling Pad. An unreinforced cast-in-place concrete leveling pad shall be provided at the foundation level for each base unit of the wall system. The leveling pad shall be built to the elevations shown on the plans and shall not be raised in elevation to allow for the use of a particular wall system. The leveling pad shall be built a minimum width of 12 inches and a minimum depth of 6 inches. The concrete on the leveling pad shall be cured a minimum of 12 hours before any of the wall system panels are placed.

720.4.6 Batter Requirements. Wall systems shall be built with some inward batter, as determined by the wall system manufacturer, to accommodate the horizontal movement created by the placement and compaction of selected granular backfill for structural systems. Facing elements out of alignment shall not be pulled or pushed into proper place, as that may cause damage to the facing element or soil reinforcement strips. If misalignment occurs, the select granular backfill for structural systems and the soil reinforcement strips shall be removed and the facing elements reset to the proper alignment.

720.4.7 Pipe Pile Spacers.

720.4.7.1 The contractor shall install pipe pile spacers at pile locations in the select granular backfill of the mechanically stabilized earth walls to protect the soil reinforcement when driving pile for bridge substructure at end bents when shown on the bridge plans. The pipe pile spacers shall be accurately located and capped for future pile construction.

720.4.7.2 The pipe pile spacers shall be in accordance with the requirements of Sec 724 for Group C "Flexible Pipe – Metal" or "Flexible Pipe – Thermoplastic".

720.4.7.3 The pipe pile spacers shall have an inside diameter greater than that of the pile and large enough to avoid damage to the pipe when driving the pile. The size of pipe pile spacers shall be subject to approval by the engineer before work is started. The bottom of the pipe pile spacers shall be placed below the bottom of the MSE wall leveling pad as shown on the plans. The pipe pile spacers shall be filled with sand or other approved material after the pile is placed and before being driven. Shop drawings of the pipe pile spacers will not be required.

720.4.7.4 In lieu of using pipe pile spacers, the contractor will have the option of driving the piles before construction of the mechanically stabilized earth wall and placing the soil reinforcing and backfill material around the piling. The contractor must adequately support the piling to insure that proper pile alignment is maintained during the wall construction. The contractor's plan for bracing the pile shall be submitted to the engineer for review.

720.4.8 Select Granular Backfill for Structural Systems Placement.

720.4.8.1 Select granular backfill for structural systems shall be placed concurrently with the placement of the retained backfill. The placement of the select granular backfill for structural systems shall closely follow the erection of each course of the wall system and shall be placed in such a manner to avoid any damage or disturbance to the wall material or any misalignment of the facing elements of the wall system. Any wall system material that becomes damaged or disturbed during the installation of the wall system shall be removed, replaced or corrected at the contractor's expense, as directed by the engineer. Whenever placement of the select granular backfill for structural systems results in the wall facing system being misaligned or distorted outside the limits of this specification, the contractor shall correct the misalignment or distortion as directed by the engineer.

720.4.8.2 The select granular backfill for structural systems shall be compacted in accordance with Sec 203, with the following exceptions:

(a) The minimum density shall be no less than 95 percent of maximum density, determined in accordance with AASHTO T 99.

(b)When the material used contains more than 30 percent retained on the 3/4-inch sieve, a method of compaction consisting of at least four passes by a heavy roller shall be used.

(c) The moisture content of the material prior to and during compaction shall be uniformly distributed throughout each layer. The placement moisture content shall be no lower than three percentage points less than the optimum moisture content and shall be no more than the optimum moisture content.

(d) Compaction within 3 feet of the back face of the wall system shall be achieved by at least three passes of a lightweight mechanical tamper, roller or vibratory system.

(e) The contractor shall ensure that runoff within the wall system construction site is directed away from the wall facing during construction, and that runoff from adjacent areas of the general construction site is directed such that runoff does not enter the wall system construction site.

(f) Class 1 geotextile material shall be placed between the select granular backfill for structural systems, and the retained backfill and over the top of the select granular backfill for structural systems to prevent piping of in-situ soil into the wall system.

(g) Tamping-type (sheep's foot) rollers shall not be used for compaction of the select granular backfill

for structural systems.

720.4.8.3 The select granular backfill for structural systems shall be initially placed parallel to the wall system, and at the rear and middle of the soil reinforcement strips, and then moved toward the facing elements of the wall system. Construction equipment shall at no time come in direct contact with the soil reinforcement strips. Each course or layer shall be compacted up to or slightly above the location of the next connection for the reinforcement strips prior to placing the next layer of reinforcement strips as designated in the erection sequence provided by the manufacturer of the wall system.

720.4.9 Construction Tolerances.

720.4.9.1 Wall systems shall be built in accordance with the dimensions and elevations specified on the plans and in accordance with the requirements of the system manufacturer. Alignments shall be maintained within the following dimensional tolerances:

Item	Tolerance
Final Horizontal Joint Gaps Between Adjacent Facing Panels (Large Block Walls)	± 1/8 in.
Final Vertical Joint Gaps Between Adjacent Facing Panels (Large Block Walls)	± 1/4 in.
Final Joint Gaps Between Adjacent Modular Block Units (Small Block Walls)	± 1/4 in.
Vertical and Horizontal Alignment of Facing Elements (All Wall Systems)	± 1/16 in. per ft
Soil Reinforcement Strip Elevations (All Wall Systems)	± 1 in.

720.4.9.2 Vertical alignments shall be measured along a theoretical vertical line established from the top of the wall system to the base of the wall system. For small block walls that have a built-in setback, the alignment shall be measured along the theoretical vertical line and the straight line that describes the horizontal setback.

720.4.10 Technical Assistance. The contractor shall be responsible for having a technical advisor from the wall system manufacturer available for assistance during the installation of the wall system.

720.5 Method of Measurement.

720.5.1 Measurement of mechanically stabilized earth wall systems will be made to the nearest square foot. The quantity to be paid will be measured from the wall outline as shown on the plans. No adjustments in the measured quantity will be permitted for additional wall area required to meet the minimum wall elevations shown on the plans for any particular wall system.

720.5.2 Measurement of pipe pile spacers will be made per each.

720.5.3 Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

720.5.4 No measurement will be made for required excavation for placement of the leveling pad for the wall system. All other excavation required for the construction of the wall system will be included in roadway items.

720.6 Basis of Payment. The accepted quantity of mechanically stabilized earth wall systems, complete in place, will be paid for at the contract unit price for each of the pay items included in the contract.

Payment for furnishing and installing pipe pile spacers complete in place including all equipment, labor and any other incidental work necessary to complete this item will be considered completely covered by the contract unit price for pipe pile spacers. No direct payment will be made when the contractor does not use pipe pile spacers.

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SECTION 724
PIPE CULVERTS

724.1 Description. This work shall consist of providing pipe or pipe arch of the diameter or shape designated, laid upon a firm bed and backfilled as specified. Where appropriate this specification will also apply to pipe arches.

724.1.1 The contract will specify either the type of pipe or the group of permissible types of pipe. If a group of permissible types is specified, the contractor may use any of the types listed within the specified group and size range as follows:

		Group A[b]	Group B[b]	Group C
Rigid Pipe		**Size**	**Size**	**Size**
Reinforced Concrete Culvert Pipe		ALL	ALL	ALL
Vitrified Clay Pipe		ALL	ALL	ALL
Flexible Pipe – Metal[a]		**Size**	**Size**	**Size**
Aluminum Coated Steel Pipe		ALL	ALL	ALL
Polymer Coated Steel Pipe		ALL	ALL	ALL
Aluminum Alloy Pipe		ALL	ALL	ALL
Bituminous Coated Steel Pipe		NA	NA	ALL
Zinc Coated Steel Pipe		NA	NA	ALL
Flexible Pipe - Thermoplastic		**Size**	**Size**	**Size**
Polypropylene Pipe	Double Wall	≤ 30”	≤ 60”	≤ 60”
	Triple Wall	30” – 60”	30” – 60”	30” – 60”
Polyethylene Pipe	Corrugated	≤ 24”	≤ 60”	≤ 60”
	Steel Reinforced	≤ 24”	≤ 60”	≤ 60”
Polyvinyl Chloride Pipe (PVC)		≤ 36”	≤ 36”	≤ 36”

[a] Metal Pipe used for storm sewer applications shall be Type IA or Type IR.
[b] Pipe used for storm sewers under the influence of a pavement section or future anticipated influence of a pavement section which has a 3,500 ADT or greater shall be Group A pipe. Pipe used in other storm sewer applications shall be Group B. No other substitutions will be allowed.

724.1.2 If the contract specifies pipe culverts by group and the contractor elects to furnish metal pipe, the culvert shall be constructed in accordance with Sec 725. If the contractor elects to furnish vitrified clay or reinforced concrete pipe, the culvert shall be constructed in accordance with Sec 726. If the contractor elects to furnish thermoplastic culvert pipe, the culvert shall be constructed in accordance with Sec 730.

724.1.3 When Group A, Group B and Group C pipe are specified, two pipe diameters will be shown on the plans at those locations. The first dimension will indicate the diameter of pipe that shall be provided if the contractor elects to provide pipe for that location with a corrugated interior wall, and the second dimension provided in parenthesis will indicate the diameter of pipe that shall be provided if the contractor elects to provide pipe for that location with a smooth interior wall. Helical rib (Type IA) pipe may be considered to have varying hydraulic coefficients and may be substituted in accordance with FHWA HD-5 hydraulic design of highway culverts considering the corrugation configuration at the joints. The specified diameters may be the same or different and will be dependent upon the design features for that pipe location. Regardless of which diameter of pipe is selected for a given location, the pipe flow line shall be maintained at the elevations shown on the plans.

724.1.4 The contractor may elect to furnish pipe one size larger than specified so long as the minimum fill heights are met. No additional compensation shall be given for the larger diameter pipe or any related items necessary to construct the larger pipe.

724.2 Construction Requirements.

724.2.1 Construction Loads. Before heavy construction equipment is operated over the pipe, the contractor shall provide adequate depth and width of compacted backfill or other cover to protect the pipe from damage or displacement. Any damage or displacement shall be repaired or corrected at the contractor's expense.

724.2.2 Installation. Pipe installation shall be according to the plans and specifications. Care shall be taken when preparing the subgrade and compacting fill around the pipe especially in the haunch areas. The contractor shall verify adequate compaction during construction of the pipe by performing density tests.

724.2.3 Pipe Plugs. The ends of all pipe stubs for future connections at inlet and manhole structures, and all pipe installed as part of future sewers, shall be sealed with approved plugs. The plugs shall be installed in such a manner that infiltration of soil into the pipe is prevented.

724.3 Performance Inspection, Performance Report and Evaluation.

724.3.1 The contractor shall conduct either manual performance inspection or remote performance inspection along with performance reporting and evaluation as it relates to this specification.

724.3.2 The contractor shall notify the Engineer at least five workdays before conducting a performance inspection. The inspection shall be performed no sooner than 30 days after the completion of the finished grade when not below pavement and after the completion of the aggregate base when any portion of the culvert pipe is below pavement. The condition of the culvert pipe shall allow for an accurate inspection. The contractor shall inspect the entire length of the pipe. The frequency of inspection shall be as follows:

a) 100% of locations for Group A pipe

b) 25% of locations for Group B. Locations to be determined by the engineer. Criteria for selection will include pipes under large fills or any locations of potential concern.

c) Group C pipe shall be inspected at the discretion of the engineer.

d) If issues are found with any pipe from the performance inspection the engineer may require that all pipe be inspected according to this specification.

724.3.3 The actual inside diameter of flexible pipe products shall be determined for the purposes of measuring deflection by averaging nine equally spaced measurements at one location in the barrel of an unloaded pipe. If the pipe has a corrugated interior, the measurements shall be from the top of corrugation to top of corrugation as viewed from the inside of the pipe.

724.3.4 The contractor shall furnish a video recording of each inspection. The recording shall identify the date and time of the inspection, a description of the culvert pipe, the location, and the viewing direction. The recording shall be for the entire run of the culvert pipe being inspected. The contractor shall provide sufficient enough source of light to allow all areas of concern to be readily observed on the video recording in a digital, reproducible format on one of the following media types: DVD, CD or other media type approved by the engineer.

724.3.5 Manual Inspection. Perform a manual inspection by entering the culvert pipe to record video and to make measurements. Culverts should be entered only by inspection personnel trained in working with confined spaces and using procedures in full compliance with applicable State, Local, and Federal OSHA regulations. The manual inspection shall include the following at a minimum:

1) Measure the deflection of the culvert pipe to the nearest 1/4 inch. A minimum of three measurements shall be taken: vertically from the crown to invert (12 o'clock to 6 o'clock), and at 60 degrees from vertical (2 o'clock to 8 o'clock and 4 o'clock to 10 o'clock).

2) Measure crack width using a crack comparator, micrometer or a feeler gage capable of measuring 0.01 inch. Other measuring devices may be used if approved by the Engineer. Record the measurements and include them in the written inspection performance report including: For rigid culvert pipe, document the location, length, width, and greatest width of each crack exceeding .01 inch. For flexible culvert pipe (Corrugated Metal Pipe and Thermoplastic Pipe), document the location and length of all cracks.

3) For all culvert pipe, measure and record the widest gap at each joint in the run.

4) For culvert pipe with manufactured seams, measure the location, length, and greatest width of any separation at the seam.

5) Measure the location, length and greatest width of each crack and the widest gap at each culvert pipe entering a drainage structure or transition.

724.3.6 Remote Inspection. Perform a remote inspection by using a crawler mounted camera with low barrel distortion to record video and that has the capability to make measurements. In addition deflection shall be measured by either laser profiling and measuring technology or use of a mandrel capable of verifying deflection on a minimum of 9 points. Laser profiling and measurement technology must be certified by the company performing the work to be in compliance with the calibration criteria as per MoDOT TM 84. Reports shall be submitted by electronic media in a format approved by the Engineer.

724.3.7 Inspection Criteria. Based on the type of culvert pipe, in the measurements and acceptance criteria shall be in accordance with the table below. Also record the location of any other defect not listed in the table and describe the defect. Potential defects include, but are not limited to damaged coatings on corrugated metal pipe, racking, dents, protrusions, misalignment of line or grade, slabbing, and excessive corrugating of thermoplastic pipe. For each measurement location in a culvert pipe, record the length from the left end of the pipe according to roadway stationing.

Inspection Criteria				
Pipe Type	Measurement Equipment	Type of Measurement	Limitations	Required Action
Rigid Culvert Pipe	Manual: Video Camera Remote: Crawler mounted camera with crack measuring capability	Joint gaps	Soiltight in accordance with AASHTO PP 63-09	Seal joints with excessive gap
		Crack widths	Greater than .01 inch less than 0.10 crack	Note for future evaluation
			Greater than 0.1 inch crack	Unacceptable
Flexible Culvert Pipe with Hydraulically Smooth Interior	Manual: Video Camera Remote: Crawler mounted camera with crack measuring capability and laser profiler or Crawler mounted camera with crack measuring capability and 9 point minimum mandrel	Joint gaps	Soiltight in accordance with AASHTO PP 63-09	Seal joints with excessive gap
		Crack widths	None allowed	Unacceptable
		Deflection	Greater than 5% less than 7.5%	Replace deficient pipe or 50% of pay item for entire line
			Greater than 7.5%	Unacceptable
Flexible Culvert Pipe with Corrugated Interior	Manual: Video Camera Remote: Crawler mounted camera with crack measuring capability and mandrel	Joint gaps	Soiltight in accordance with AASHTO PP 63-09	Seal joints with excessive gap
		Crack widths	None allowed	Unacceptable
		Deflection	Greater than 5% less than 7.5%	Replace deficient pipe or 50% of pay item for entire line
			Greater than 7.5%	Unacceptable

724.3.8 Performance Report. The contractor shall provide a performance report for each performance

inspection per drainage structure. Each report shall include:

a) Project number and County-Route-Section

b) Date of performance inspection

c) Type and size of culvert pipe including any transitions in pipe run

d) Time of video recording

e) Location (e.g. station and offset) and viewing direction.

f) Summary of all defects including type, measurement, and location

g) For remote inspections using a mandrel, indicate in the performance report the size of the mandrel and whether or not it was successfully pulled through the culvert pipe.

h) For remote inspections using a crawler mounted camera with laser profiler, include:

1) Three dimensional model of the culvert pipe based on the laser profile measurements.

2) Digital profile of culvert pipe extracted from the inspection video

3) Calculations of the ovality, capacity and delta of the culvert pipe

4) Explanation as to why data was unattainable for any section of the culvert pipe

The contractor shall submit a performance report to the Engineer within 5 days of completing the performance inspection of the culvert pipe run. Submit the performance report in an electronic format approved by the Engineer.

724.3.9 Culvert Pipe Evaluation. The culvert pipe shall be evaluated based on the Performance report. Defects exceeding limitations in this specification will require an action plan addressing noted deficiencies. Other defects will require the contractor to submit an action plan to the Engineer.

724.3.10 Repairs. Required repairs shall be made at no additional cost to the Department and to the satisfaction of the Engineer. The contractor shall submit their required action plan including repair process and/or revised installation plan to the Engineer for approval at least 7 days before performing the repairs. The action plan shall provide written confirmation from the culvert pipe manufacturer that the repair methods are appropriate. Any repairs shall have a performance evaluation conducted of the repaired portion of the culvert pipe and any culvert pipe potentially affected by the repair work 30 days after the repair has been made, at no additional cost to the Department.

724.4 Method of Measurement.

724.4.1 Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. When two different diameters of pipe are shown on the plans for a given location for Group A, Group B or Group C pipe, the quantity of pipe installed will be based on the plan quantity for the larger diameter pipe and will not be considered as an appreciable error in the contract quantity if the smaller allowed diameter pipe is used. Where required, measurement of pipe, complete in place, will be made to the nearest foot along the geometrical center of the pipe. The revision or correction will be computed and added to or deducted from the contract quantity.

724.4.2 When concrete pipe is used, the length of the structure may be increased by no more than 3 feet as necessary to avoid cutting the pipe, but such increased length will not be included in the contract quantity for payment.

724.4.3 When PVC pipe is used, measurement will include any other pipe used to protect the pipe from exposure to sunlight.

724.5 Basis of Payment.

724.5.1 The accepted quantities of pipe, complete in place, including all necessary tees, bends, wyes, coupling bands, cutting and joining new pipe to existing pipe or structures, unless otherwise specified, will be paid for at the contract unit price for each of the pay items included in the contract.

724.5.2 The accepted quantities of corrugated metal drop inlets and metal curtain walls, complete in place, including coupling bands, toeplates, nuts and bolts will be paid for at the contract unit price for each of the pay items included in the contract.

724.5.3 Unless specified otherwise, no direct payment will be made for the following:

(a) Beveling, skewing or additional work required in laying pipe with beveled or skewed ends.

(b) Work involved in elongating pipe.

(c) Any required backfilling, except as specified in Sec 206.6.3.

(d) Construction of bedding or for bedding material.

(e) Furnishing and installing plugs.

(f) Material or work required for placing couplings on exposed ends of pipe.

724.5.4 Payment for removal of unsuitable material and for backfilling will be made in accordance with Sec 206.6.3, unless the unsuitable material is a result of the contractor's operations, in which case the removal and backfilling shall be at the contractor's expense.

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SECTION 725
METAL PIPE AND PIPE ARCH CULVERTS

725.1 Description. This work shall consist of providing corrugated metal pipe or pipe arch of the diameter or shape designated, laid upon a firm bed and backfilled as specified. Where pipe is referred to, this specification will also apply to pipe-arch, where appropriate. Pipe shall be in accordance with Sec 724.

725.1.1 If the contract specifies corrugated metallic-coated steel pipe culverts of 60-inch diameter or larger, the contractor may substitute structural plate pipe of like sizes, lengths and thicknesses of steel, constructed in accordance with Sec 727, at the contractor's expense.

725.1.2 If the contract specifies corrugated metallic-coated steel pipe or corrugated aluminum alloy pipe, or if the contract specifies pipe culverts by group and the contractor elects to furnish corrugated metallic-coated steel pipe or corrugated aluminum alloy pipe, the thickness of metal and size of corrugation for the respective pipe size shall be as shown on the plans unless otherwise specified. The overfill height shown on the plans or in the contract shall be used to determine the proper sheet thickness and size of corrugation for the individual pipe culvert. The minimum cover shall be measured as shown on the plans.

725.1.3 When Group A pipe is specified and the contractor elects to furnish polymer coated corrugated metal culvert pipe or corrugated aluminum-coated steel culvert pipe, the following shall apply:

725.1.3.1 The thickness of the coated sheet shall be a minimum thickness as follows:

Pipe Dia. Inches	Minimum Gauge of Steel Pipe	
	2 ⅔" x ½" or ¾" x ¾" x 7 ½" spiral rib Corr.	3" x 1" or 5" x 1" Corr.
< 42"	14	14
42" < 60"	12	12
60" < 78"	10	12
78" < 90"	8	12
90" < 108"	N/A	12
108" and above	N/A	10

725.1.3.2 The predominate soil type in the area of any metal pipe installation shall have a pH in the range of 5 to 9 (4 to 9 for polymer coated pipe) using AASHTO T-289 test method.

725.1.3.3 For bedding or backfill material that has greater than 35 percent passing the #200 sieve, the resistivity of the bedding or backfill shall be > 1500 ohm-cm (> 750 ohm-cm for polymer coated pipe) using AASHTO T-288 test method.

725.1.3.4 The contractor shall conduct any required pH and resistivity testing and report compliance to the engineer at least 30 days prior to installation.

725.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Corrugated Metallic-Coated Steel Culvert Pipe, Pipe-Arches and End Sections	1020
Bituminous Coated Corrugated Metal Culvert Pipe, Pipe Arch	1021
Corrugated Aluminum Alloy Culvert Pipe and Corrugated Aluminum Alloy Structural Plate	1024
Polymer Coated Corrugated Metal Culvert Pipe and Pipe Arches	1027

725.3 Construction Requirements.

725.3.1 Handling. All pipe shall be handled to avoid damage. Pipe having damaged coating, any localized bends in excess of five percent of the specified pipe diameter, or any dent in excess of 1/2 inch will be

unacceptable, regardless of previous approvals. Rejected damaged pipe may be used if repaired to the satisfaction of the engineer.

725.3.2 Laying Pipe.

725.3.2.1 The pipe shall be carefully laid true to lines and grades shown on the plans. Riveted pipe shall be installed with the outside laps of circumferential joints pointing upstream and with no longitudinal lap placed on the bottom 120 degrees of the pipe on the sides. Any pipe that is not in true alignment or that shows any undue settlement after laying shall be taken up and re-laid at the contractor's expense. If shown on the plans or directed by the engineer, camber shall be built into the pipe structure to compensate for settlement from fill loads.

725.3.2.2 Transverse field joints shall be of such design that the successive connection of pipe sections will form a continuous line free from appreciable irregularities in the flow line. Each successive length of pipe in a field joint shall be adjusted longitudinally or circumferentially when necessary such that coupling bands will properly engage the corrugations in both lengths of pipe.

725.4 Installation, Bedding And Backfill Material. Metal pipe, bedding, backfill and installation shall be in accordance with AASHTO LRFD Bridge Construction Specifications Section 26 and as shown on the plans and specifications. When conflicts occur between AASHTO Section 26 and the plans and specifications the plans and specifications shall apply.

725.4.1 Bedding and Backfill Material. Bedding and backfill material shall meet the requirements of AASHTO M 145, A-1, A-2-4, A-2-5 or A-3. Bedding material shall have a maximum particle size of 1.25 inches. Backfill shall be free of organic material, stones larger than 1.5 inches or frozen lumps. Moisture content shall be in the range of optimum content to permit thorough compaction. For pipes with a corrugated exterior backfill gradations shall have a maximum particle size that will permit filling of the corrugations. Flowable backfill, such as low strength mortar, may also be used, provided adequate precautions are taken to prevent the pipe from floating and to fill all voids (including pipe corrugations) in the trench.

725.4.2 Foundation and Bedding Construction. A stable and uniform bedding shall be provided for the pipe and protruding features of the drainage structure. The middle of the bedding equal to one-third the pipe outside diameter should be loosely placed, while the remainder shall be compacted to a minimum 90 percent of maximum density based upon standard proctor test. A minimum bedding depth of twice the corrugation depth shall be provided prior to placement of the pipe unless otherwise specified. When rock or unyielding material is present in the trench, a minimum bottom bedding of 6.0 inches shall be provided. If soft or unstable material is encountered the material shall be removed to a minimum depth of 10 inches below the bottom of the pipe and replaced with suitable granular material. Payment for any unsuitable material will be made per Sec 206.

725.4.3 Backfill Construction. Structural backfill shall be placed and compacted in layers not exceeding a loose lift thickness of 8 inches and brought up evenly. The side to side differential shall not exceed 24.0 inches or one-third of the rise of the structure. Backfill shall continue to not less than 1.0 ft. above the top of the pipe. Structural backfill shall be worked into the haunch area and compacted by hand. All backfill shall be compacted to a minimum 90 percent standard density based upon standard proctor test. Special compaction means may be necessary in the haunch area. Ponding or jetting structural backfill to achieve compaction shall not be permitted without the permission of the Engineer.

725.5 Shop Elongation. Round corrugated steel pipe 48 inches or greater in diameter may be furnished round or shop elongated. The contractor shall maintain elongation during backfilling and embankment construction such that the vertical height of the opening after the embankment has been completed shall be no less than the diameter of the pipe or greater than the pre-elongated height.

725.6 Corrugated Metal Drop Inlets. The contractor shall install corrugated metal drop inlets of the proper size and length at the locations shown on the plans. The drop inlet shall be constructed of the same base metal and thickness of corrugated metal used in the culvert pipe and shall be in accordance with Sec 1020 or Sec 1024.

725.7 Corrugated Metal Curtain Walls. The contractor shall install metal curtain walls of the proper size and shape at locations shown on the plans. Metal curtain walls shall be constructed of the same base metal used in the culvert pipe and shall be of the thickness of metal shown on the plans and in accordance with Sec 1020 or Sec 1024.

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SECTION 726
RIGID PIPE CULVERTS

726.1 Description. This work shall consist of providing concrete and vitrified clay pipe of the diameter or shape designated, laid upon a bed and backfilled as specified on the plans, or as directed by the engineer. Pipe shall be in accordance with Sec 724.

726.1.1 If the contract specifies reinforced concrete pipe or pipe culverts by group and the contractor elects to furnish reinforced concrete pipe, the type of installation and the class of pipe shall be in accordance with the plans for the applicable allowable overfill height.

726.1.2 If the contract specifies vitrified clay pipe or if the contract specifies pipe culverts by group and the contractor elects to furnish vitrified clay pipe, such pipe shall be placed in a trench in accordance with the plans for the allowable overfill height.

726.1.3 If the contract specifies non-reinforced concrete pipe, the contractor may, at no additional cost to the Commission, furnish reinforced concrete pipe of like sizes and strengths in accordance with these specifications.

726.1.4 If reinforced concrete pipe is specified in the contract or elected for use by the contractor, pipe of a higher class may be used, but payment will be made for the class of pipe specified in the contract for that culvert.

726.1.5 The class of pipe or type of installation shall be as shown on the plans or as approved by the engineer.

726.1.6 The type of pipe permitted in extending an existing pipe shall conform to the type used in place, except as otherwise specified in the contract or prohibited by any of the requirements set out herein.

726.1.7 If standard strength vitrified clay pipe is specified in the contract or elected for use by the contractor, extra strength vitrified clay pipe may be used, but payment will be made for standard strength vitrified clay pipe. Only extra strength vitrified clay pipe shall be used under roadways. Standard strength vitrified clay pipe will be permitted only where vehicular traffic is not anticipated.

726.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Reinforced Concrete Culvert	1026
Vitrified Clay Sewer and Culvert Pipe	1030
Reinforced Concrete Elliptical Culvert	1034
Reinforced Concrete Arch Culvert	1035
Plastic Joint Compound for Vitrified Clay and Concrete Pipe	1057
Material for Joints	1057
Mortars and Grout	1066

726.3 Construction Requirements.

726.3.1 Laying. Rigid pipe shall be carefully laid as shown on the plans, with hub, bell or groove ends upstream and with the spigot or tongue end entered the full length into the adjacent section of pipe. Elliptically reinforced pipe shall be oriented and laid such that the top and bottom of the pipe, as marked on the pipe, are in the proper position. If the pipe is to be laid below the ground line, a trench shall be excavated to the required section and depth to permit required compaction of the backfill under the haunches and around the pipe. Any pipe that is not in true alignment or that shows any undue settlement after laying, but before the fill is placed, shall be removed and re-laid at the contractor's expense. Camber shall be built into the pipe structure as shown on the plans or as approved by the engineer. All joints, except for field or private entrance culverts, shall be sealed with an approved plastic compound, tubular joint seal, an external wrap, cement mortar or other approved methods to create a soil tight condition. Rubber gasket joints may be used at no additional cost to the Commission. Where permissible lift holes have been used, the holes shall be filled with approved material or plug and sealed as required for culvert pipe joints. Lifting devices shall have sufficient bearing on the inside of the pipe to avoid damage resulting from a concentration of stresses around the lift holes. The joint between the bell and spigot shall be uniform for the full circumference and within allowable design tolerances.

726.3.1.1 If rubber gasket-type pipe or vitrified clay pipe is specified or used, joints shall be installed in accordance with the manufacturer's recommendations.

726.3.1.2 In sealing rigid pipe with mortar, the mortar contact areas of all pipe ends shall be damp when mortar is applied. After applying mortar to the entire interior surface of the bell or groove, the spigot or tongue end shall be forced into position. Any remaining void in the bell or groove shall be filled with a hub of mortar built up adjacent to the bell, or a bead of mortar built up around a groove-type joint. The interior joints of either type of pipe shall be finished flush with the surface of the pipe. The outside surface of mortar joints shall be cured with membrane curing compound.

726.3.1.3 In sealing rigid pipe with plastic joint compound, trowel grade compound shall be applied to the mating surfaces of both the tongue and groove, or to the entire interior surface of the bell and the upper portion of the spigot. The joints shall be forced together with excess compound extruding both inside and outside the joint. Rope or tape type plastic compound shall be applied in accordance with the manufacturer's recommendations. Excess compound shall be removed from the interior surface where accessible. Tubular joint seals shall be installed as recommended by the manufacturer.

726.3.1.4 If external wrap is used, the wrap shall be installed in accordance with the manufacturer's recommendations.

726.3.2 Bedding. Bedding for reinforced concrete pipe shall consist of Category 1, Category 2 or Category 3 soil as shown on the plans.

726.3.2.1 Category 1 soil shall consist of a well-graded mixture of stone fragments, gravel and sand in accordance with AASHTO M 145, Group A-1 or A-3.

726.3.2.2 Category 2 soil shall consist of non-plastic or moderately plastic granular material with a silt content higher than that of Category 1, and shall be in accordance with AASHTO
M 145, Group A-2 or A-4.

726.3.2.3 Category 3 soil shall consist of silty clays, and shall be in accordance with AASHTO M 145, Group A-5, A-6 or A-7.

726.3.3 Installation.

726.3.3.1 Installation of Pipe Prior to Placing Embankment. After the pipe has been laid, the material in the haunch and lower side zones shall be placed to a minimum width of one pipe diameter outside the pipe. The haunch and lower side material shall be compacted to the required densities shown on the plans. When all material has been placed and compacted up to the springline of the pipe, the remaining fill material shall be placed in accordance with the requirements of the adjacent fill. If a subtrench will be required to install the pipe to the specified grade, the width of the trench shall be shown on the plans. Sufficient clearance shall be provided in order to attain the required compaction in the haunch and outer bedding zone.

726.3.3.2 Installation of Pipe After Placing Embankment. The roadway embankment shall be placed and compacted to the required density to a minimum elevation of one foot below the bottom of the pavement base material. A trench, in accordance with the section shown on the plans, shall be excavated through the embankment to a depth sufficient to place the required bedding and maintain the specified grade of the pipe. Bedding shall be placed to the required thickness and grade and shall not be compacted under the middle one third of the pipe. The bedding outside the middle one third of the pipe and the material in the haunch and lower side zones shall be compacted up to the springline of the pipe. The placement of the remainder of the embankment material above the springline shall be compacted in accordance with the requirements for the adjacent fill.

726.3.3.3 Extra Strength Vitrified Clay Pipe. Vitrified clay pipe shall be laid in a trench with a width, on a plane level with the top of the pipe, no greater than that shown on the plans for the respective pipe diameter. The trench shall have a minimum depth of one outside pipe diameter plus 16 inches. If the original ground line is below an elevation one foot above the top of the proposed pipe, embankment shall be constructed to at least one foot above the proposed pipe prior to excavating the trench. The trench walls shall be as nearly vertical as practical. Prior to laying the pipe, the bottom of the trench shall be covered with a bedding, consisting of a 4-

inch layer of sand. After laying the pipe, the trench shall be backfilled with sand around the pipe for at least 10 percent of the height of the pipe. The sand shall be thoroughly compacted by the use of tampers or by flooding. The remainder of the trench shall be backfilled in accordance with Sec 726.3.4.

726.3.3.4 Bedding in Unsuitable Material. If rock is encountered, the bedding depth shall be increased to 1/12 the outside diameter of the pipe, but no less than 6 inches. The width of the cushion excavation shall be 1.33 times the outside diameter of the pipe, but no less than 24 inches wider than the outside diameter of the pipe. If soft, spongy or unstable material is encountered, the material shall be removed and replaced with soil compacted to the level specified for the lower side zone.

726.3.4 Backfilling. Backfilling shall be placed as soon as practical in accordance with Sec 206. Suitable backfill and embankment material, free from large lumps, clods or rocks, shall be compacted in accordance with Sec 203. Care shall be taken to properly compact the backfill under the haunches of pipe-arch. Before heavy construction equipment is operated over the pipe, the contractor shall provide an adequate depth and width of compacted backfill or other cover to protect the pipe from damage or displacement. Any damage or displacement shall be repaired or corrected at the contractor's expense.

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SECTION 727
STRUCTURAL PLATE PIPE AND STRUCTURAL PLATE PIPE-ARCH CULVERTS

727.1 Description. This work shall consist of furnishing and installing built-up structural plate round pipe or built-up structural plate pipe-arch with a full metal bottom of galvanized corrugated metal plate curved sections bolted together to form the required shape shown on the plans. The thickness of the structural plate shall be as specified in the contract.

727.2 Material.

727.2.1 All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Structural Plate Pipe and Pipe-Arches	1023
Corrugated Aluminum Alloy Structural Plate	1024

727.2.2 The size and shape of the plates shall be such that the finished structure will have the dimensions shown on the plans.

727.3 Construction Requirements.

727.3.1 Handling. All pipe shall be handled with care to avoid damage. Pipe having damaged coating, any localized bends in excess of five percent of the specified pipe diameter or any dent in excess of 1/2 inch will be rejected at the site of the work, regardless of previous approvals. Rejected damaged pipe may be used, if repaired to the satisfaction of the engineer.

727.3.2 Laying Pipe. The structure shall be carefully laid true to lines and grades. Any structure that is not in true alignment or that shows undue settlement shall be taken up and relaid at the contractor's expense. If shown on the plans or directed by the engineer, camber shall be built into the structure to compensate for settlement from embankment loads.

727.3.3 Bedding and Backfill Material. The bed for structural plate pipe and pipe-arch culverts shall be formed in accordance with Sec 725.4, except if rock is encountered, the trench shall be excavated to a minimum depth of 8 inches below the bottom of the pipe.

727.3.4 Backfilling.

727.3.4.1 Except where the backfill or embankment is to be formed of stone or rock fill, the material shall be placed in accordance with Sec 725.4.3, except as modified herein. Layers of backfill or embankment shall be kept at approximately the same elevation on opposite sides of the structure at all times during the progress of the work in order to equalize the loading. This method of filling and compacting shall be continued until the top of the embankment is at an elevation level with the top of the structure.

727.3.4.2 If the backfill or embankment over and around the structural plate pipe or pipe-arch is specified to be formed of stone or rock fill, a protective inner layer of backfill material, in accordance with AASHTO M 145, Classification A-1, A-2-4, A-2-5 or A-3, preferably mixed with earthy material, tamped into place in contact with the structure, and surrounded by a carefully placed outer layer of rock, shall be built up as the work proceeds around the perimeter of the structure above a specially prepared foundation. The protective layer shall be placed during the progress of the backfilling and placing of the embankment or rock fill in a manner and of sufficient thickness to protect the surface of the structure from injury to the coating.

727.3.5 Shop Elongation. The contractor shall maintain elongation during backfilling and embankment construction such that the vertical height of the opening after the embankment has been completed shall be no less than the diameter of the pipe or greater than the pre-elongated height. Steel and aluminum structural plate round pipe shop elongation, if required, shall be as shown on the plans. Pipe arches shall not be elongated.

727.3.6 Beveled End Sections. The plans will indicate where beveled end sections are required and the slope of the cutting line. On skewed round structures with beveled end sections, the end sections shall be rotated as required to better fit the adjacent roadway slope. Shop elongation shall be in accordance with Sec 727.3.5.

727.4 Inspection and Replacement. Inspection and replacement of structural plate pipe and pipe-arch culverts shall be in accordance with Sec 725.4, except deflection testing and maximum deflection allowed will not apply.

727.5 Method of Measurement.

727.5.1 Measurement of structural plate pipe, complete in place, will be made to the nearest foot along the geometrical center of the structure.

727.5.2 Measurement of structural plate pipe-arch, complete in place, will be made to the nearest foot along the center of the vertical dimension of the structure.

727.5.3 Excavation for placing structural plate pipe and pipe-arches will not be measured, except when the excavation for the installation is shown on the plans as Class 3 Excavation.

727.6 Basis of Payment.

727.6.1 The accepted quantities of structural plate pipe or structural plate pipe-arch culverts, complete in place, will be paid for at the contract unit price for each of the pay items included in the contract.

727.6.2 Unless specified otherwise, no direct payment will be made for the following:

(a) Beveling, skewing or for any additional work required in laying structural plate structures with beveled or skewed ends.

(b) Work involved in elongating.

(c) Backfilling, except as specified in Sec 206.6.3.

(d) Construction of bedding or for bedding material.

(e) Excavation and backfilling, except when Class 3 Excavation is shown on the plans in accordance with Sec 206.

(f) Furnishing and installing plugs.

(g) Work or equipment to perform deflection testing.

Specifications Section 30 and as shown on the plans and specifications. When conflicts occur between AASHTO Section 30 and the plans and specifications the plans and specifications shall apply.

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SECTION 730
THERMOPLASTIC PIPE CULVERT

730.1 Description. This work shall consist of providing thermoplastic pipe of the diameter designated, placed and backfilled as specified in the contract documents or as directed by the engineer. Pipe shall be in accordance with Section 724.

730.1.1 If the contract specifies thermoplastic pipe or if the contract specifies culvert pipe by group and the contractor elects to furnish thermoplastic pipe, the allowable overfill height shall be in accordance with the plans, unless specified otherwise. Minimum cover will be measured as shown on the plans.

730.1.2 When furnishing thermoplastic pipe, the pipe shall meet the properties described in the appropriate section of this specification and be installed in accordance with the standard plans. When section properties or fill heights outside of the specification are required for use, a special design shall be prepared by the contractor for approval by the engineer. The special design shall include all relevant engineering data, stub compression values, and be stamped by a professional engineer registered in the State of Missouri.

730.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Metallic-Coated Steel End Sections	1020
Precast Concrete Flared End Sections	1032
Polyethylene Culvert Pipe	1047
Polypropylene Culvert Pipe	1041
Polyvinyl Chloride (PVC) Culvert Pipe	1028

730.3 Construction Requirements.

730.3.1 Handling. All pipe shall be handled to avoid damage. Damaged pipe will be unacceptable and shall be repaired or replaced at the contractor's expense to the satisfaction of the engineer.

730.3.2 Laying.

730.3.2.1 Flexible pipe shall be laid as shown on the plans, with bell ends upstream and with the spigot end entered the full length into the adjacent section of pipe. Any pipe that is not in true alignment or that shows any undue settlement after laying shall be taken up and relaid at the contractor's expense. Camber shall be built into the pipe structure to allow for settlement from fill loads if shown on the plans or directed by the engineer.

730.3.2.2 Joints shall be soiltight and shall be installed such that the connection of pipe sections will form a continuous line free from appreciable irregularities in the flow line. Field joints may be corrugated bands, double bell couplings, bell and spigot pipe ends with a rubber o-ring gasket in accordance with ASTM F 477, or an alternative connection approved by the engineer. All joints shall comply with the soiltight joint performance criteria of AASHTO PP-63.

730.3.3 Ultraviolet Protection.

730.3.3.1 If PVC pipe is specified in the contract or elected for use by the contractor, none of the PVC pipe shall be exposed to sunlight after installation. The minimum distance required to protect the exposed open end of a PVC pipe from sunlight will be one-half of the pipe diameter from the opening. The use of a different pipe material from the appropriate pipe group other than PVC is required in areas requiring ultraviolet protection.

730.4 Installation, Bedding and Backfill. Thermoplastic pipe installation, bedding and backfill shall be installed in accordance with AASHTO LRFD Bridge Construction Specifications Section 30 and as shown on the plans and specifications. When conflicts occur between AASHTO Section 30 and the plans and specifications the plans and specifications shall apply.

730.4.1 Bedding and Backfill Material. Bedding and backfill material shall meet the requirements of AASHTO M145, A-1-a, A-1-b, A-2-4 or A-2-5. Bedding material shall have a maximum particle size of 1.25 inches. Backfill shall be free of organic material, stones larger than 1.5 inches or frozen lumps. Moisture content shall

be in the range of optimum content to permit thorough compaction. For pipes with a corrugated exterior, backfill gradations shall have particle size that will permit filling of the corrugations. Flowable backfill, such as low strength mortar may also be used providing flotation resistance and adequate void fill coverage.

730.4.2 Foundation and Bedding Construction. A stable and uniform bedding shall be provided for the pipe and an protruding features of the drainage structure. The middle of the bedding equal to one-third the pipe outside diameter should be loosely placed, while the remainder shall be compacted to a minimum 90 percent of maximum density based upon standard proctor test. A minimum of 4.0 inches of bedding shall be provided prior to placement of the pipe unless otherwise specified. When rock, soft, unstable, or unyielding material is present in the trench bottom, a 6.0 inche minimum foundation shall be provided in addition to bedding. Payment for any unsuitable material will be made per Sec. 206.

730.4.3 Backfill Construction. Structural backfill shall be placed and compacted in layers not exceeding a loose lift thickness of 8.0 inches and brought up evenly and simultaneously on both sides of the pipe to an elevation not less than 1.0 ft. above the top of the pipe. Structural backfill shall be worked into the haunch area and compacted by hand. All backfill shall be compacted to a minimum 90 percent standard density based upon standard proctor test. Special compaction means may be necessary in the haunch area. Ponding or jetting structural backfill to achieve compaction shall not be permitted without the permission of the Engineer.

730.5 Skewed Ends. A pipe end may be cut to a maximum angle of 10 degrees to provide a skewed end.

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SECTION 731
PRECAST REINFORCED CONCRETE MANHOLES AND DROP INLETS

731.1 Description. This work shall consist of furnishing and installing precast concrete manholes and drop inlets as shown on the plans.

731.2 Material.

731.2.1 All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Precast Drainage Units	1033
Concrete Curing Material	1055
Plastic Joint Compound for Vitrified Clay and Concrete Pipe	1057
Tubular Joint Seal	1057
Mortars and Grout	1066

731.2.2 Concrete for footings shall be Class B, Class B-1 or concrete of a commercial mixture in accordance with Sec 501. Air entrainment will not be required.

731.3 Construction Requirements.

731.3.1 Excavation and Backfilling. Excavation and backfilling for precast reinforced concrete manholes and drop inlets shall be in accordance with Sec 206.

731.3.2 Placement. Precast concrete manhole and drop inlet sections shall be constructed as shown on plans, and joints sealed in accordance with Sec 726.

731.3.3 Footings. Footings shall be constructed as shown on the plans. Concrete shall be float finished and shall be cured in accordance with Sec 502. Forms will not be required.

731.4 Method of Measurement.

731.4.1 Final measurement of precast concrete manholes and drop inlets will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, measurement of precast concrete manholes and drop inlets, complete in place, will be made to the nearest foot as shown on the plans. The revision or correction will be computed and added to or deducted from the contract quantity. The depth of the structure will be the vertical distance from the top of the uppermost precast section to the invert flowline.

731.4.2 Final measurement for excavation will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, excavation will be measured and paid for in accordance with Sec 206. The revision or correction will be computed and added to or deducted from the contract quantity.

731.5 Basis of Payment.

731.5.1 The accepted quantities of precast manholes and drop inlets, complete in place, including any necessary cutting or joining new pipe or existing pipe to the structure unless otherwise specified, will be paid for at the contract unit price for each of the pay items included in the contract.

731.5.2 No direct payment will be made for, backfilling except as specified in Sec 206, footing concrete, steps, weep holes, including excavation, permeable granular backfill, 4-inch drain tile, screen for inlet or any other work incidental thereto.

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SECTION 732
FLARED END SECTIONS

732.1 Description. This work shall consist of furnishing and installing precast concrete or metal flared end sections of the size and shape shown on the plans.

732.1.1 Precast concrete flared end sections shall be used with concrete or vitrified clay culvert pipe.

732.1.2 End sections for thermoplastic pipe may be either precast concrete or metal flared end sections. When Group A Pipe is specified, aluminum coated metal or concrete flared end sections shall be used.

732.1.3 Safety slope end sections may be used with concrete, thermoplastic, or metal culvert pipe.

732.1.4 A tapered sleeve may be required to join an end section to a run of pipe as outlined in the standard plans.

732.1.5 At the option of the contractor and at no cost to the Commission, the contractor may use a tapered sleeve to join thermoplastic pipe to flared end sections when not required by the plans.

732.1.6 At the option of the contractor and at no cost to the Commission, the contractor may use a one size larger flared end section when joining to thermoplastic pipe to aid fitment.

732.2 Material.

732.2.1 All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section/Specification
Metal Flared End Sections	1020
Precast Concrete Flared End Sections	1032
Plastic Joint Compound for Vitrified Clay and Concrete Pipe	1057
Tubular Joint Seal	1057
Mortar for Pipe Joints	1066
Safety Bars and Longitudinal Bars	ASTM A 53, Schedule 40
Bar Grate	ASTM A 575, Grade 1020

732.2.2 Cast-in-place toe walls for precast concrete flared end sections shall be constructed of Class B or B-1 concrete, or concrete of a commercial mixture in accordance with Sec 501. Material, proportioning, air entraining, mixing, slump and transporting of Portland cement concrete shall be in accordance with Sec 501. Air-entrained concrete will not be required. Concrete shall be placed and cured in accordance with Sec 703. Precast toe walls shall be constructed of any of the above specified concrete mixtures or these walls may be constructed of the same mixture used to fabricate the precast concrete flared end sections. Precast toe walls may be cured in accordance with Sec 703 or in the same manner as the flared end sections.

732.3 Construction Requirements.

732.3.1 Flared end sections shall be joined to pipes or pipe-arches as shown on the plans and shall be placed to the line and grade of the structure on a uniformly firm soil foundation shaped to fit the lower part of the end section.

732.3.1.1 Precast Concrete Flared End Sections. The joint material between the end section and the adjoining pipe shall be the same as that used for the pipe joints, and shall be installed in the same manner. Toe walls shall be of the size and shape shown on the plans and may be precast or cast-in-place. Forming of cast-in-place toe walls will not be required.

732.3.1.2 Metal Flared End Sections. The end section shall be joined to the pipe or pipe-arch as shown on the plans. The toe plate, if specified, shall be set in a trench or driven to the proper elevation. Care shall be taken to avoid damage to the metal.

732.3.2 Safety Slope End Section. The safety slope end section shall consist of a metal-flared end section,

safety bars, toe plate extension, if required in the contract, and any fasteners required for attachment to the culvert pipe.

732.3.2.1 Construction Requirements. Safety slope end sections shall be attached as shown on the plans and shall be placed to the line and grade of the structure on a uniformly firm soil foundation shaped to fit the lower part of the end section.

732.3.2.2 Toe Plate Extension. The toe plate extension, if required, shall be attached to the end section as shown on the plans.

732.3.2.3 Safety Bars. The number, size and spacing of safety bars shall be as shown on the plans. A bar grate system, as shown on the plans, may be substituted for safety bars.

732.4 Method of Measurement. Measurement of precast concrete, plastic or metal flared end sections and safety slope end sections will be made per each.

732.5 Basis of Payment. The accepted quantity of flared end sections and safety slope end sections, complete in place, will be paid for at the contract unit price for each of the items included in the contract. When two different diameters of pipe are shown on the plans for a given location for Group B or Group C pipe, the contract unit price for the flared end section or safety slope end section that would be required for the larger diameter pipe will be used for payment purposes. No direct payment will be made for any excavation or bedding required for placement of an end section, toe walls or toe plates. Any damaged sections required to be replaced due to the contractor's actions shall be at the contractor's expense. Payment for tapered sleeves will be included in the contract unit price for pipe.

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SECTION 733
PRECAST CONCRETE BOX CULVERTS

733.1 Description. This work shall consist of furnishing and installing precast concrete box culverts as shown on the plans or as directed by the engineer. Unless otherwise required in the contract, where the construction of cast-in-place single or multi-cell reinforced concrete box culverts is specified, the contractor shall have the option of constructing such culverts using precast reinforced concrete box sections and headwalls subject to the conditions specified in the contract.

733.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Subsurface Drainage Geotextile	1011
Precast Concrete Box Culverts	1049
Plastic Joint Compound for Vitrified Clay and Concrete Pipe	1057
Tubular Joint Seal	1057
Mortars and Grout	1066

733.3 Construction Requirements.

733.3.1 Subgrade Preparation and Bedding. The excavation and backfilling for the precast box sections and end sections shall be in accordance with Sec 206, except a layer of granular material at least 6 inches thick shall be placed immediately below the elevation of the bottom of the box and end sections. The granular material shall be in accordance with Sec 1007 for Type 1 aggregate and shall be placed to extend at least 18 inches on each side of the structure. The bedding shall be compacted to provide uniform support for the bottom of the box and end sections.

733.3.2 Placement. The individual box section shall be placed as shown on the plans with the groove end upstream and the spigot end extended full length into the adjacent downstream section of box.

733.3.2.1 Joints.

733.3.2.1.1 All joints between individual box sections shall be sealed with an approved plastic joint compound or a tubular joint seal. Trowel grade compounds shall be applied to both mating surfaces. Rope or tape-type plastic joint compounds and tubular joint seals shall be applied in accordance with the manufacturer's recommendations. Excess compound shall extrude from both the inside and outside of the joint when box sections are assembled. Excess compound shall be removed from the interior surface. The joint gap between individual box sections shall be uniform for the full perimeter.

733.3.2.1.2 Filter cloth 2 feet in width and double thickness shall be centered over the top and sides of all joints between individual box sections with edges sealed with mastic or two sided tape. Filter cloth shall be a subsurface drainage geotextile in accordance with Sec 1011.

733.3.2.1.3 When cast-in-place concrete box culvert collars are shown on the plans and the alternate precast option is used, precast box culvert ties shall be used in accordance with standard plans to connect individual box sections. Regular strength connections shall be supplied unless specified otherwise.

733.3.2.2 Lift and Core Holes. Lift holes shall be filled with expansive mortar or tapered precast mortar plugs to provide a permanent watertight section, and shall be finished flush on the inside of the box. Lift and core holes are to be sealed with approved materials. Filter cloth at joints may be extended to cover patched holes in lieu of sealing.

733.3.2.3 Multi-Cell Box Culvert. When multi-cell box culverts are used, a 1 1/2-inch minimum space shall be left between the adjacent precast sections. Following the installation of the end sections, the 1 1/2-inch space between the parallel sections shall be entirely filled with mortar for grout. After the mortar has attained sufficient strength, sections shall be backfilled in accordance with Sec 206.

733.4 Method of Measurement.

733.4.1 If the contractor chooses to construct the alternate precast box culvert, measurement will be made as provided for the equivalent cast-in-place structure.

733.4.2 Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, if a precast box culvert is specified in the contract, the precast box culvert, complete in place including end sections, will be measured to the nearest foot along the geometrical center of the culvert floor. The revision or correction will be computed and added to or deducted from the contract quantity.

733.5 Basis of Payment.

733.5.1 The accepted optional precast concrete box culvert, including end sections, will be paid for at the contract unit price for each of the pay items included in the contract.

733.5.2 If a precast box culvert is specified in the contract, the accepted quantities for the precast box culvert, complete in place including end sections, will be paid for at the contract unit price for each of the pay items included in the contract.

733.5.3. No direct payment will be made for furnishing, placing or compacting the Type 1 granular bedding material. Replacement of unsuitable material below the 6-inch bedding will be paid for in accordance with Sec 206.

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SECTION 734
INSTALLATION OF PIPE BY HORIZONTAL BORING METHODS

734.1 Description. This work shall consist of furnishing and installing reinforced concrete pipe culvert (gasket-type) or steel pipe by horizontal boring methods underneath existing pavements at locations shown on the plans or as directed by the engineer. The minimum depth of installation shall be dependent upon the method used and the diameter of the pipe, and will require review and approval from the engineer before the start of this work.

734.2 Material. The class of pipe specified in the contract item will be determined for vertical load only. Additional reinforcement or strength of pipe required to withstand jacking pressure shall be determined by the contractor and shall be furnished at the contractor's expense. If pipe ramming or auger boring is the horizontal boring method specified for use, steel casing pipe shall be used. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Reinforced Concrete Culvert, Storm Drain and Sewer Pipe	1026
Fiberglass-Reinforced Polymer Mortar Pipe	1075

734.3 Construction Requirements.

734.3.1 The contractor shall protect the horizontal bore work area as shown on the plans.

734.3.2 Variations from theoretical alignment and grade for the completed pipe shall not exceed 0.5 feet for each 100 feet of pipe. Pavement or ground surface heave or settlement above the installation will not be permitted. To determine if heave or settlement is occurring, the contractor shall undertake surface monitoring measurements.

734.3.3 The excavated hole shall be no more than 0.1 foot greater than the outside diameter of the pipe. Sluicing and jetting with water as a primary means of soil cutting will not be permitted. When material tends to cave in from outside these limits, a metal shield shall be used ahead of the first section of pipe when pipe jacking, microtunneling or auger boring.

734.3.4 If the excavated hole is formed by Horizontal Directional Drilling (HDD), the boring equipment used to bore the hole shall be of proper type and in proper working order to ensure the work is performed to the satisfaction of the engineer. The size of installations by the directional drilling method shall be limited to those that can be accomplished by using a 24-inch maximum-sized reamer, unless approved by the engineer.

734.3.5 Holes bored by HDD shall be cleaned of excess material before pipe is jacked or pulled into place. Holes bored by the methods of auger boring, microtunnelling or pipe jacking shall be cleaned as pipe is being jacked or pushed simultaneously into place.

734.3.6 Any areas resulting from caving or excavation outside the above specified limits shall be backfilled with a cellular concrete grout designed and produced in accordance with ASTM C 796, and with a method that will fill the voids. The excavated area around the pipe shall be sealed with grout for a minimum distance of 3 feet from the outside face of the fill or cut slope.

734.3.7 If steel casing pipe to be left in place is used with this installation method, the contractor may delete the gasket type joints for the limits of the jacked pipe. Steel casing pipe shall be welded by a certified welder or shall have a mechanical means of locking pipe joints into place.

734.3.8 Entry or exit pits or shafts shall be adequately sloped and shored prior to boring.

734.3.9 If the horizontal boring method chosen for use is pipe jacking or microtunneling, resilient joint cushioning material shall be used between individual pipe segments during the pipe jacking or microtunneling process. This material shall be 0.5 inch thick for pipe diameters up to 30 inches, and shall be 0.75 inch thick for pipe diameters equal to or greater than 30 inches.

734.3.10 If the horizontal boring method chosen for use is auger boring or pipe ramming, an adequate steel leading-edge band shall be used to protect the leading edge of the pipe from obstacles in the boring path.

734.4 Method of Measurement. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, measurement of horizontal bore installed pipe, complete in place, will be made to the nearest foot along the geometrical center of the pipe. The revision or correction will be computed and added to or deducted from the contract quantity. The length of structure may be increased by no more than 3 feet as necessary to avoid cutting the pipe, but such increased length will not be included in the contract quantity for payment.

734.5 Basis of Payment.

734.5.1 All cost for work area protection will be paid for at the contract unit price for each of the pay items included in the contract.

734.5.2 The accepted quantities of horizontal bore installed pipe, complete in place, will be paid for at the contract unit price for each of the items included in the contract. Payment will be considered full compensation for excavation and backfilling of the jacking pits, disposal of excess excavation from boring operations, grout for filling voids, disposal of excess drilling fluids, video inspection or camera recording equipment, and any other incidental items or equipment necessary to complete the described work.

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SECTION 735
CULVERT PIPE LINER

735.1 Description. This work shall consist of providing and installing pipe liner in existing culvert pipes.

735.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Pipe Liner	1046
Grout	1066

735.2.1 The joints shall be soil-tight with no gaskets required.

735.2.2 Approval for interlocking methods may be obtained by submitting the proposed system to Construction and Materials.

735.3 Construction Requirements. Before any pipe liner construction is started, the culvert to be lined shall be thoroughly cleaned of all sediment and debris. Existing culvert ends that are damaged or impede installation shall be straightened or removed at the engineer's direction at the contractor's expense. The dimensions of the pipe liner shall meet the following requirements:

Culvert Pipe Liner Dimensions			
Existing Pipe	Liner		
	Clearance[a]		ID
Size (ID) in.	Minimum in.	Maximum in.	Minimum in.
12	0.5	2	9
15	0.5	3	11
18	0.5	3	13
21	0.5	3	15
24	0.5	4	17
27	1	4	20
30	1	4	22
33	1	4	24
36	1	4	26
42	1	6	30
46	2	6	33
48	2	6	35
54	2	8	39
60	2	9	43
72	2	10	52

[a]Clearance shall be the difference between the inside diameter (ID) of the existing pipe and the outside diameter (OD) of the pipe liner.

735.3.1 The pipe liner shall be joined into a continuous length by an approved interlocking method. Each joint shall be checked for soil-tightness before each section of pipe liner is inserted.

735.3.2 The insertion may be made by pushing or pulling the assembled pipe liner from either end of the culvert. The insertion operation shall not cause the joints to separate. A temporary nose cone or plug may be necessary to guide the pipe liner past minor obstructions. The handling of pipe liner shall be in a manner such that the pipe liner is not damaged. Pipe liner with deep scratches or gouges shall be removed and replaced at the contractor's expense.

735.3.3 After the pipe liner has been completely inserted, inspected in place by the engineer, and cooled to the temperature of the existing culvert, the liner shall be cut off as directed by the engineer and grouted in place.

735.3.3.1 Expansive grout shall be contain only enough water to make the grout stiff, but workable. The grout

shall extend into the annular space between the existing culvert and pipe liner for a minimum distance of 6 inches from the face of the pipe to a flexible grout stop comprised of flexible foamed polyethylene, pavement joint backer rod or other material approved by the engineer. Care shall be taken such that the grouting pressure does not exceed the external hydrostatic collapse resistance of the liner.

735.3.3.2 Drainage of the annular space between the culvert and pipe liner shall be provided by drilling a circumferential line of weep holes in the lower half of the pipe liner approximately 2 inches from the downstream grout stop. The weep holes shall be no less than 3/8 inch or more than 1/2 inch in diameter and shall be spaced circumferentially at 3-inch centers starting at the invert and extending upward to the spring line of the pipe liner.

735.3.4 The pipe liner shall be anchored to the existing culvert by either using a minimum of two 1/2-inch diameter bolts with washers or other methods approved by the engineer. The pipe liner shall be centered in the existing pipe by either anchor bolts installed at the upstream end, spaced equal distance, above the spring line or other methods approved by the engineer.

735.4 Method Of Measurement. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, measurement of pipe liner, complete in place, will be made to the nearest foot along the geometrical center of the pipe liner. The revision or correction will be computed and added to or deducted from the contract quantity. This item shall include all material, labor, equipment and excavation necessary to complete the described work.

735.5 Basis Of Payment. The accepted quantities for the pipe liner, complete in place, will be paid for at the contract unit price for each of the pay items included in the contract.

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SECTION 801
LIME AND FERTILIZER

801.1 Description. This work shall consist of the application of agricultural lime and commercial fertilizer and soil preparation for seeding and sodding on areas shown on the plans or designated by the engineer.

801.2 Material.

801.2.1 Material used for soil neutralization, unless otherwise specified, shall be agricultural lime with no less than 90 percent passing the No. 8 sieve containing no less than 65 percent calcium carbonate equivalent.

801.2.2 Agricultural lime shall be furnished from a source that has been tested and certified in accordance with the Missouri Agricultural Liming Materials Act. The quantity of material required to provide the specified pounds of effective neutralizing material (E.N.M.) per acre shall be determined from the producer or distributor's certification of analysis furnished by the Director of the Missouri Agriculture Experiment Station, Columbia, Missouri in accordance with the Missouri Agricultural Liming Materials Act. The contractor shall provide a copy of this certification to the engineer prior to application. If agricultural lime is furnished as a commercially bagged product, pelletized or otherwise, with a guaranteed product analysis shown on the bag listing the elemental properties and gradation, the E.N.M. shall be provided to the engineer. Material may be accepted on the basis of bag label analysis.

801.2.3 Fertilizer shall be a standard commercial product which, when applied at the proper rate, will supply the quantity of total nitrogen (N), available phosphoric acid (P205) and soluble potash (K20), as specified in the contract. Material may be accepted on the basis of bag label analysis or supplier's certification, and shall be accordance with all applicable Missouri fertilizer laws.

801.3 Equipment. Lime and commercial fertilizer shall be applied by mechanical equipment designed for this purpose.

801.4 Construction Requirements.

801.4.1 The area to be limed and fertilized will be the area specified within the limits of construction. The area shall have a uniform surface free from rills, washes and depressions, and shall conform to the finished grade and cross section shown on the plans. The soil shall be thoroughly broken up, worked, tilled and loosened to a minimum depth of 2 inches. The seedbed or sodbed shall be prepared by loosening the existing soil on the slope, rather than by the addition of loose soil.

801.4.2 Lime and fertilizer shall be applied evenly at the rates specified in the contract, and only when the soil is in a tillable condition. After application, the lime and fertilizer shall be thoroughly mixed into the soil to a minimum depth of 2 inches, except when applied hydraulically on slopes steeper than 2:1. Lime and fertilizer shall be applied separately, but may be incorporated into the soil in one operation. Lime and fertilizer shall be applied no more than 48 hours before the seed is sown unless otherwise authorized by the engineer.

801.5 Method of Measurement. Measurement of the area that has been limed and fertilized will be made to the nearest 1/10 acre.

801.6 Basis of Payment. The accepted quantity of liming and fertilizing will be paid for at the contract unit price. No direct payment will be made for liming and fertilizing areas for which seeding or sodding items are included in the contract.

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SECTION 802
MULCHING

802.1 Description. This work shall consist of applying vegetative mulch and a specified stabilization covering as indicated in the contract.

802.2 Material.

802.2.1 Vegetative Mulch. Vegetative mulch shall be prairie hay or straw from oats, rye, wheat or barley. Prairie hay shall consist of any combination of any of the following plants: Big Bluestem, Little Bluestem, Indiangrass, Sideoats Grama and native wildflowers. Mulch may also be composted material from clearing and grubbing operations. If composted material from clearing and grubbing operations are used the particle size shall be such it can be adequately spread and does not exceed 6 inches in length. Mulch shall be free of prohibited weed seed as stated in the Missouri Seed Law and shall be relatively free of all other noxious and undesirable seed. The mulch shall be clean and bright, relatively free of foreign material and shall be dry enough to spread properly.

802.2.2 Mulch Overspray. Mulch overspray shall be either virgin wood cellulose fibers or recycled paper mulch. The mulch shall be produced by either the ground or cooked fiber process, shall not be water soluble and shall have the following properties:

Property	Requirement
Moisture Content, percent by weight, max	15
Organic Matter-Wood Fiber, percent by weight, min	80
pH	4.3-8.5

802.2.3 Certification. The contractor shall furnish a certification for mulch and a manufacturer's certification that the mulch overspray material are in accordance with these specifications.

802.3 Construction Requirements. All seeded areas shall be mulched. Disturbed areas outside of authorized construction limits shall be mulched at the contractor's expense.

802.3.1 Application. Vegetative mulch shall be applied at a minimum rate of 2 1/2 tons per acre. All mulch shall be distributed evenly within 24 hours following the seeding operation. Following the mulching operation, precautions shall be taken to prohibit foot or vehicular traffic over the mulched area. Any mulch that is displaced shall be replaced at once, but only after the work preceding the mulching which was damaged as a result of the displacement has been repaired to the satisfaction of the engineer. The contractor may use erosion control blankets in lieu of mulch.

802.3.2 Stabilization. Vegetative mulch shall be secured from movement by either mulch overspray or embedment as indicated in the contract documents, or other methods as approved by the engineer.

802.3.2.1 Mulch Overspray. Mulch overspray shall be applied over the vegetative mulch as a separate operation. Mulch overspray shall be applied in accordance with the manufacturer’s recommendations at a minimum rate of 750 pounds per acre.

802.3.2.2 Vegetative Mulch Embedment. Mulch shall be embedded in the soil a sufficient depth to prevent the loss of mulch by wind or water erosion and approximately parallel to the roadbed grade.

802.4 Method of Measurement. This item will not be measured for payment.

802.5 Basis of Payment. No direct payment will be made for providing and securing mulch. The accepted quantities of mulch will be considered completely covered by the contract unit price for seeding.

802.5.1 No direct payment will be made for maintaining mulch prior to acceptance for maintenance. On previously accepted mulched areas, the engineer may authorize areas to be repaired in accordance with Sec 104.3.

802.5.2 No additional payment will be made for erosion control blankets used in lieu of mulch at the contractor’s option.

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SECTION 803
SODDING

803.1 Description. This work shall consist of furnishing and placing sod on areas shown on the plans or as designated by the engineer.

803.2 Material.

803.2.1 The type of sod will be designated on the plans. The sod shall be densely rooted and thriving, free of all prohibited and noxious weeds as defined by the Missouri Department of Agriculture and reasonably free of all other weeds. The sod shall be grown from seed varieties that are favorable for the Missouri climate conditions. The sod may be cut in strips or rolls.

803.2.2 Turf type tall fescue and Kentucky bluegrass sods shall be grown from a blend of at least three separate varieties for each sod. Buffalograss sod shall be of a variety exhibiting salt tolerance.

803.2.3 All sod shall be in accordance with the Missouri Plant Law and the Missouri Department of Agriculture's Code of State Regulations regulating the growth, sale and shipping of nursery stock in the state of Missouri. The contractor shall provide a valid certificate of inspection from the state of origin to the engineer prior to the placement of any sod.

803.3 Construction Requirements. The sod bed shall be prepared in accordance with Sec 801. The bed shall be in a firm but uncompacted condition with a relatively fine texture when the sod is placed. The sod bed and the sod shall be moist when the sod is laid. All sod shall be placed to produce tight joints. Sod placed on slopes 3:1 or steeper and in the flow line of ditches shall be secured with wooden pegs or metal clips.

803.4 Acceptance. No sodded areas will be accepted until the sod is fully rooted into the sod bed and thriving. Sod will not be accepted in the dormant state.

803.5 Method of Measurement. Measurement will be made to the nearest square yard of accepted sodded surface area.

803.6 Basis of Payment. The accepted quantities of sodding will be paid for at the contract unit price. No direct payment will be made for additional sod bed preparation or for the replacement of sodded areas not accepted by the engineer.

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SECTION 804
TOPSOIL

804.1 Description. This work shall consist of furnishing and placing approved selected topsoil at the locations shown on the plans or as directed by the engineer.

804.2 Material. Topsoil shall be obtained from sources approved by the engineer. Topsoil shall be a fertile, friable and loamy soil of uniform quality, without admixture of subsoil material, and shall be free from material such as hard clods, stiff clay, hardpan, partially disintegrated stone, pebbles larger than one inch in diameter and other impurities. Topsoil shall be relatively free from grass, roots, weeds and other objectionable plant material or vegetative debris undesirable or harmful to plant life or which will prevent the formation of a suitable seedbed.

804.3 Construction Requirements.

804.3.1 The engineer shall be notified sufficiently in advance of the opening of any material source to permit the engineer to prepare for necessary checking and measurement. Topsoil shall be secured from areas from which the topsoil has not been previously removed either by erosion or mechanical methods. The soil shall not be removed in excess of the depth approved by the engineer. The contractor shall furnish the source of material, unless otherwise shown on the plans. During the period of removal of the topsoil material, the site shall be kept drained, and when all material has been removed, the site shall be left in a neat and presentable condition to the satisfaction of the engineer.

804.3.2 The surface on which the topsoil is to be placed shall be free of all loose rock and foreign material greater in any dimension than one half the depth of the topsoil to be added. The surface shall be raked or otherwise loosened just prior to being covered with topsoil. Topsoil shall be placed and spread over the designated areas to the depth shown on the plans. After settling, the completed work shall conform to the thickness shown on the plans. After spreading, all large clods and foreign material shall be removed by the contractor.

804.4 Method of Measurement. Topsoil will be measured to the nearest cubic yard, based on area multiplied by the average depth as determined by the engineer.

804.5 Basis of Payment. The accepted quantity of topsoil will be paid for at the contract unit price, including hauling from any distance.

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SECTION 805
SEEDING

805.1 Description. This work shall consist of furnishing and sowing seed as specified in the contract. All disturbed areas shall be seeded except for sodded areas, surfaced areas, solid rock, and slopes consisting primarily of broken rock.

805.2 Material.

805.2.1 The seed shall be grown and processed in the United States or Canada and shall comply with the requirements of the Missouri Seed Law. Certain lots of seed may be desirable for the advancement of a local ecotype when specified, and will be the only seed permitted. The following percentages for purity and germination or pure live seed will be the minimum requirements in the acceptance of seed, unless otherwise permitted by the engineer.

Seed Requirements				
Non-native Grasses	**Scientific Name**	**Purity**	**Germination[a]**	**Pure Live Seed**
Bermuda Grass	Cynodon dactylon	95	80	
Smooth Bromegrass	Bromus inermis	85	80	
Kentucky Bluegrass	Poa pratensis	85	80	
Orchardgrass	Dactylis glomerata	85	80	
Perennial Ryegrass	Lolium perenne	98	85	
Tall Fescue	Festuca arundinacea	97	85	
Red Fescue	Festuca rubra	97	85	
Timothy	Phleum pratense	98	85	
Cereal or Cover Crop		**Purity**	**Germination**	**Pure Live Seed**
Annual Ryegrass	Lolium multiflorum	98	85	
Redtop	Agrostis alba	92	85	
Oat Grain	Avena sativia	98	85	
Rye Grain	Secale cereale	98	80	
Wheat Grain	Triticum aestivum	97	85	
Wildrye, Virginia	Elymus virginicus			60
Wildrye, Canada	Elymus canadensis			60
Legumes		**Purity**	**Germination**	**Pure Live Seed**
Korean Lespedeza	Lespedeza stipulacea	98	85	
Alsike Clover	Trifolium hybridum	98	85	
Red Clover	Trifolium pratense	98	85	
White Clover	Trifolium repens	98	85	
Hairy Vetch	Vicia villosa	97	80	
Partridge Pea	Chamaecrista fasciculate	98	80	
Native Grasses	**Scientific Name**	**Purity**	**Variety(s)**	**Pure Live Seed**
Big Bluestem	Andropgon gerardii		Mo. Ecotype Roundtree Kaw	40
Blue Grama	Bouteloua gracilis			40
Buffalograss	Buchloe dactyloides		Mo. Ecotype Sharp's Improved Texoka	65
Indiangrass	Sorghastrum nutans		Mo. Ecotype Rumsey Cheyenne	50
Little Bluestem	Schizachyrium scoparium		Mo. Ecotype Aldous Cimmaron	40
Eastern Gamagrass	**Tripsacum dactyloides**		Mo. Ecotype	

Sideoats Grama	Bouteloua curtipendula		Mo. Ecotype El Reno Trailway	40
Switchgrass	Panicum virgatum		Mo. Ecotype Trailblazer Cave-in-Rock	80
Wildrye, Virginia	Elymus virginicus			60
Wildrye, Canada	Elymus canadensis			60
Cluster Fescue	Festuca paradoxa		Mo. Ecotype	
Rough Dropseed	Sporobolus compositus		Mo. Ecotype	
Prairie Dropseed	Sporobolus heterolopus			
Prairie Cordgrass	Spartina pectinata			

[a]Will not apply if unhulled or unscarified seed is specified.

805.2.2 If the specified quantity is in pounds of seed, no reduction will be permitted in the specified quantity of seed if the purity or germination or both, are higher than the minimum required by the specifications. If the specified quantity is in pounds of pure live seed, the pure live seed quantity shall be determined from the actual percentage shown by the supplier for native grasses or by multiplying the actual percentages of purity times the actual percentage of germination, including hard seed for other seed.

805.2.3 All leguminous seed shall be inoculated or treated with the proper quantity of cultures approved for the particular legume to be sown. Leguminous seed will include alsike clover, Korean lespedeza, red clover, white clover, hairy vetch, partridge pea and slender bush clover.

805.2.3.1 The inoculant for treating leguminous seed shall be a nitrogen-fixing bacteria culture. The inoculant containers shall be plainly marked with the expiration date for use. The manufacturer's recommendations for inoculating seed shall be followed.

805.3 Construction Requirements.

805.3.1 The seedbed shall be prepared in accordance with Sec 801. Seeding shall be done before the seedbed becomes eroded. Seed shall be uniformly applied at no less than the rates specified.

805.3.2 Disturbed areas outside of authorized construction limits shall be seeded at the contractor's expense.

805.3.3 All seeded areas shall be mulched in accordance with Sec 802.

805.4 Acceptance. Acceptance of permanent seeding will be made when seeded disturbed areas meet the requirements for final stabilization as defined in the current state operating permit for land disturbance. Inspection for acceptance will be made within 60 days after seeding, excluding seeding dates that fall between September 30 and March 1. Seeding that occurs between September 30 and March 1 will be inspected no earlier than May 1.

805.5 Certification. The contractor shall certify the seed and seed mixture meets the contract requirements and be in accordance with Sec 805. The certification shall list the seed type, lot numbers, pure live seed, percent germination, and quantity used for each lot. In lieu of listing the lot specific information, the certification may include attached individual bag label analysis for all seed used.

805.6 Corrective Action. Inadequate stands shall be reworked and reseeded within the time period agreed upon at the contractor’s expense. On previously accepted seeded areas, the engineer may authorize eroded areas to be repaired in accordance with Sec 104.3.

805.7 Method of Measurement. Measurement of seeding will be made of the area seeded to the nearest 1/10 acre.

805.8 Basis of Payment. The accepted quantity of seeding will be paid for at the contract unit price. No direct payment will be made for liming, fertilizing or seedbed preparation.

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SECTION 806
POLLUTION, EROSION AND SEDIMENT CONTROL

806.1 Description. This work shall consist of furnishing, installing, maintaining and removing temporary pollution, erosion and sediment control measures; furnishing and placing permanent erosion control features; or a combination of both as shown on the plans or as directed by the engineer.

806.2 Schedule of Work. Prior to the preconstruction conference and the start of construction, the contractor shall submit schedules for the implementation of temporary pollution control and temporary and permanent erosion control work, as applicable, for construction operations. The contractor's schedule shall address specifically the pollution and erosion control measures planned at all streams or other bodies of water. No work shall start until the pollution and erosion control schedules and methods of operations have been approved by the engineer. Any delay of the work resulting from failure to submit acceptable pollution and erosion control schedules and methods of operations will be considered nonexcusable.

806.3 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as herein.

806.4 Construction Requirements. The engineer will limit the surface area of erodible earth material exposed by clearing and grubbing or by excavation, borrow and fill operations in accordance with the following. The engineer may direct the contractor to provide immediate permanent or temporary pollution control measures to prevent contamination of adjacent streams or other bodies of water. Such work may involve the construction of temporary berms, dikes, dams, sediment basins and slope drains, and use of temporary mulches, seeding or other control devices or methods as necessary to control erosion and pollution.

806.4.1 If erosion and sediment control measures, as shown on the plans, are not suitable due to site conditions, a suitable system of Best Management Practices (BMP) as defined by the applicable Missouri State Operating Permit for land disturbance activities and the Stormwater Pollution Prevention Plan (SWPPP), shall be applied as approved by the engineer.

806.4.2 The contractor shall exercise effective management practices throughout the life of the project to control pollution. Pollutants such as chemicals, fuels, lubricants, bitumen, raw sewage or other harmful material shall not be discharged on or from the project. Temporary pollution control measures, such as storage and handling of petroleum products and other pollutants, shall be coordinated with temporary and permanent erosion and sediment control features specified in the contract to ensure economical, effective and continuous erosion and pollution control. These requirements will also apply to work within easements designated by the Commission.

806.4.3 The contractor shall incorporate all permanent erosion, sediment, and pollution control features into the project at the earliest practical time. Temporary measures shall be used to correct conditions that develop during construction which were not foreseen during the design stage, that are needed prior to installation of permanent pollution control features, or that are needed temporarily to control erosion and sediment that develops during normal construction practices, but are not associated with permanent control features on the project.

806.4.4 Installation of temporary control measures shall be scheduled to coincide with clearing and grubbing operations, but before grading operations begin. The project land area disturbance shall not exceed one acre without installation of erosion and sediment controls. The total project land disturbance area shall not exceed 20 acres without written approval from the engineer.

806.4.5 The engineer may allow additional land disturbance acreage if appropriate BMP's including temporary seeding and mulching, have been applied to previously disturbed areas and the contractor has the resources to apply the BMP's to the expanded area.

806.4.6 Unless otherwise provided or approved in writing by the engineer, construction operations in streams or other bodies of water shall be restricted to those areas that must be entered for the construction of temporary or permanent structures. Streams or other bodies of water shall be promptly cleared of all falsework, piling, debris or other obstructions placed therein or caused by construction operations.

806.4.7 Fording of streams or other bodies of water with construction equipment will not be permitted, except as allowed by the engineer. Temporary bridges or other structures shall be used when frequent crossing of streams or other bodies of water is necessary. Unless otherwise approved in writing by the engineer, mechanized

equipment shall not be operated in streams or other bodies of water except as may be required to construct channel changes and temporary or permanent structures. If a Corps of Engineer Section 404 or Department of Natural Resources Section 401 permit is applicable for a project, the permit requirements and conditions will prevail.

806.4.8 The contractor shall obtain all necessary permits to cover all project-associated activities on external sites that are not located on MoDOT right of way or easements. Project-associated activities includes borrow areas, plant sites, and staging areas. All costs associated with the permits and pollution control shall be at the contractor's expense, including providing, installing, maintaining, and removal of all erosion and sediment control devices, and final stabilization of disturbed areas.

806.4.9 In the event of conflict between these requirements and the pollution control laws, rules or regulations of other federal, state or local agencies, the more restrictive laws, rules or regulations will apply.

806.4.10 The contractor is encouraged to incorporate mulch from the clearing and grubbing operation into the BMP's on the project. BMP's may consist of compost filled socks, compost filter berms, soil protection cover or any other method as approved by the engineer.

806.4.11 Unless otherwise specified, or directed by the engineer, all temporary erosion and sediment control measures shall be removed by the contractor after permanent erosion and sediment control measures are established and the project has achieved final stabilization as defined in the SWPPP. Biodegradable erosion and sediment control materials may be allowed to be incorporated into the project in accordance with the SWPPP, as approved by the engineer. Rock from ditch checks and other temporary sediment devices may be repositioned to serve as ditch liner in accordance with the SWPPP, and as directed by the engineer.

806.4.12 Portland cement concrete residue and wash water and other operations that produce sediment laden runoff shall be managed by an appropriate control measure.

806.4.12.1 Portland cement concrete residue and wash water shall be discharged into a plastic lined pit, plastic lined straw bale enclosure, or other commercially available water tight enclosure suitable for containing concrete residue and wash water as approved by the Engineer.

806.4.12.2 Water from aggregate washing and other operations that produce sediment laden water shall be treated by filtration, settling basins, or other means sufficient to comply with the general water quality criteria established by MDNR.

806.4.12.3 No direct payment will be made for the design, installation, maintenance or removal of controls necessary to contain Portland cement concrete residue and wash water or other water from sediment producing operations.

SECTION 806.10 TEMPORARY BERMS.

806.10.1 Description. This work shall consist of constructing and maintaining temporary berms at the top of slopes or transverse to the centerline of fills as shown on the plans.

806.10.2 Material. Type B berms shall consist of graded material from within the project limits, rock, or other suitable material approved by the engineer. Type C berms shall consist of rock with a predominant size between 4 inches and 12 inches.

806.10.3 Construction Requirements. Temporary berms shall be constructed and maintained to the approximate dimensions shown on the plans.

806.10.3.1 Type B Berms. Type B berms shall be machine compacted with a minimum of three passes over the entire width of the berm. Material removed from Type B berms shall be incorporated in the embankment when possible. The contractor shall remove and dispose of any excess or unsuitable material to a location approved by the engineer.

806.10.3.1 Type B berms shall drain to a compacted outlet at slope drain. On transverse berms, the top width of the berms may be wider and the side slopes flatter to allow equipment to pass over these berms with minimal disruption.

806.10.3.2 Type C Berms. Vegetative mulch, erosion control blanket or geotextile fabric shall be placed on the upslope of the Type C berm. The vegetative mulch shall be placed in such a manner that the final compacted thickness is 2 inches. The material for the vegetative mulch shall be in accordance with Sec 802. The straw layer erosion control blanket or geotextile fabric shall be removed and replaced as directed by the engineer.

806.10.4 Method of Measurement. Measurement of Type B and C berms will be made to the nearest linear foot.

806.10.5 Basis of Payment. The accepted quantities of Type B and C berms will be paid for at the contract unit price and will be considered full compensation for material, installation, maintenance, removal and any other hand work necessary to construct the berms. No payment will be made for the straw layer, erosion control blanket or geotextile fabric on the Type C berm. No payment will be made for any seeding and mulching needed after removal.

SECTION 806.20 TEMPORARY SLOPE DRAINS.

806.20.1 Description. This work shall consist of furnishing, constructing maintaining and removing temporary slope drains to carry water down slopes and to reduce erosion. The method selected shall be approved by the engineer prior to construction.

806.20.2 Construction Requirements. The contractor shall provide temporary, impermeable slope drains to carry water or water with suspended solids down fill slopes until permanent erosion control measures are established. The contractor shall provide temporary slope drains on fillslopes at approximately 500-foot intervals or as directed by the engineer. All temporary slope drains shall be adequately anchored to the slope to prevent disruption of flow. The inlet ends shall include a ditch check and be constructed to channel water into the temporary slope drain. Outlet ends shall have some means of dissipating the energy of the water to reduce erosion downstream and have the ability to capture sediment. After removal, the contractor shall restore the site of the slope drains to the satisfaction of the engineer.

806.20.3 Method of Measurement. Measurement of temporary slope drains will be made to the nearest linear foot.

806.20.4 Basis of Payment. The accepted quantities of temporary slope drains will be paid for at the contract unit price. Payment shall include furnishing, constructing, maintaining and removing temporary slope drains, and restoration of the slope drain sites. No payment will be made for any seeding and mulching needed after removal.

SECTION 806.30 TEMPORARY DITCH AND INLET CHECKS.

806.30.1 Description. This work shall consist of furnishing, constructing, maintaining, removing and disposing of temporary ditch and inlet checks.

806.30.2 Construction Requirements.

806.30.2.1 Rock Ditch Checks. Rock ditch checks shall be constructed in accordance with the plans, or as directed by the engineer, and shall have a minimum effective height of 18 inches. The predominant size of the rock used shall range between 4 inches and 12 inches.

806.30.2.2 Alternate Ditch Checks. Alternate ditch checks shall be constructed in accordance with the manufacturer's specifications, and as shown on the plans, or as directed by the engineer. Alternate ditch checks shall have a minimum effective height of 9 inches, shall follow guidance provided in the SWPPP, and shall perform to the level that meets or exceeds the requirement of the current Missouri Operating Permit.

806.30.2.2.1 Unless otherwise disallowed, the contractor has the option to construct rock ditch checks in lieu of alternate ditch checks. Rock ditch checks constructed in lieu of alternate checks shall have a minimum effective height of 18 inches. Spacing shall be increased, as determined by the engineer, to account for the additional height of rock ditch check. The toe-to-top capacity requirements shown on the plans will be used to determine the spacing.

806.30.2.3 Inlet Checks. Inlet checks shall be installed in accordance with the plans or as directed by the engineer to prevent sediment from entering drop inlets, manholes, and other openings to culverts and closed drainage systems.

806.30.2.3.1 Inlet checks shall be constructed in accordance with Sec 806.30.2.1, rock ditch checks, and shall completely surround the inlet or other structure, as indicated on the plans. Other allowable methods of protecting inlets will be listed in the SWPPP.

806.30.2.4 Curb Inlet Checks. Curb inlet checks shall consist of socks filled with rock, or other fillers of sufficient weight to keep the device in place. Curb inlet checks shall be installed in the gutter or as shown on the plans. Other proprietary devices may be used, as approved by the engineer.

806.30.3 Maintenance. The contractor shall monitor the condition of all temporary checks and repair or replace checks that are not functional. The contractor shall remove sediment in accordance with Sec 806.110. Alternate ditch checks shall be maintained in accordance with this provision and the manufacturer's specifications or as directed by the engineer.

806.30.4 Removal. All types of temporary checks shall remain in service until removal has been approved by the engineer. Removal shall be in accordance with Sec 806.4.11 and as stated herein. The contractor shall remove any sediment from the check, remove the check, and restore the area to match existing ground condition. When necessary, seeding and mulching shall be in accordance with Secs 802 and 805 respectively, and shall be considered incidental.

806.30.5 Method of Measurement.

806.30.5.1 Measurement of rock ditch checks will be made to the nearest linear foot as measured along the top of the check. Rock ditch checks constructed in lieu of alternate checks will be included in this measurement for payment. Inlet checks, except for curb inlet checks, will be included in this measurement for payment.

806.30.5.2 Measurement of alternate ditch checks will be made to the nearest linear foot as measured along the top of the check.

806.30.5.3 No measurement will be made for any portion of a check that exceeds the length necessary to adequately span the ditch as shown on the plans or as directed by the engineer.

806.30.5.4 Measurement of curb inlet checks will be made per each check.

806.30.6 Basis of Payment.

806.30.6.1 The accepted quantities of rock ditch checks, alternate ditch checks, inlet checks, and curb inlet checks will be paid for at the contract unit price for each pay item included in the contract. If the engineer determines unusual conditions warrant complete replacement of a check, payment will be made for the replacement check at the contract unit price.

806.30.6.2 Payment for sediment removal shall be in accordance with Sec 806.110.

SECTION 806.40 SEDIMENT BASINS.

806.40.1 Description. This work shall consist of constructing and maintaining temporary or permanent sediment basins as shown on the plans or as directed by the engineer. This work shall include clearing and excavation to construct the basin, disposal of excavated material, and providing and installing rock or other stabilizing material as approved by the engineer. For temporary basins, removal, backfilling, and site restoration is also included in the work.

806.40.2 Construction Requirements. The sediment basin shall be an excavated or dammed storage area with defined side slopes. Inlet and outlet areas shall be lined with rock of sufficient size to withstand the water flow. In lieu of rock, other allowable liners may be used as described in the SWPPP. Outlets may be constructed with a riser pipe, surface skimmers, or stabilized spillway, or a combination of one or more of these features.

806.40.2.1 The inlet of a sediment basin shall be constructed with a wide cross-section and a minimum grade to

prevent turbulence and to allow deposition of soil particles.

806.40.2.2 Sediment shall be removed and disposed in accordance with Sec 806.110, and before the depth reaches approximately one-half the original depth of the sediment basin in any part of the pool.

806.40.2.3 Temporary sediment basins shall remain in service until removal has been approved by the engineer. Removal shall be in accordance with Sec 806.4.11 and as stated herein. The contractor shall remove any sediment from the basin, backfill, compact all excavations, restore the area to match existing ground conditions, and seeding and mulching in accordance with Secs 802 and 805 respectively.

806.40.3 Method of Measurement.

806.40.3.1 Measurement of excavation to construct sediment basin will be made to the nearest tenth of a cubic yard.

806.40.3.2 Measurement of rock placed to construct sediment basins will be made to the nearest tenth of a cubic yard.

806.40.4 Basis of Payment.

806.40.4.1 The accepted quantities for excavation to construct sediment basins will be paid for at the contract unit price. Payment includes clearing, excavation, removal, backfilling and final grading.

806.40.4.2 The accepted quantity for rock used to construct sediment basins will be paid for at the contract unit price. Payment shall include furnishing, placing, and removal of rock.

806.40.4.3 No direct payment will be made for seeding and mulching necessary to restore the area after removal.

806.40.4.4 Payment for sediment removal shall be in accordance with Sec 806.110.

SECTION 806.50 TEMPORARY SEEDING AND MULCHING.

806.50.1 Description. This work shall consist of furnishing and applying fertilizer, seed, vegetative mulch or other acceptable cover, in disturbed areas authorized by the engineer. Temporary seeding and mulching is utilized to establish a quick ground cover that reduces erosion in disturbed areas where staging requires the area to be disturbed again at a later date, and for areas that are complete but current seasonal conditions are not favorable for applying permanent seeding. Finish grading will not be required except for areas that will not receive further grading prior to permanent seeding. Hydraulic seeding and fertilizing in accordance with Sec 805 will be permitted.

806.50.2 Construction Requirements. Seeding and mulching shall be a continuous operation on all cut and fillslopes, excess material sites and borrow pits during the construction process. All disturbed areas shall be seeded and mulched as necessary to control erosion. When a project is shown in the contract to be constructed in stages and operations in those staged areas are suspended for a significant amount of time, the contractor shall receive payment for temporary seed and mulch. When the engineer allows the contractor to disturb additional ground beyond the restrictions in Sec 806.4.4 solely to enhance the contractor's operation, the contractor shall not receive compensation for temporary seed or mulch, as required by the engineer, for ground cover for areas exceeding the restrictions in Sec 806.4.4.

806.50.2.1 The contractor shall provide permanent seeding and mulching as shown on the plans following temporary seeding. Any preparation of the seed bed that might be necessary prior to permanent seeding shall be considered incidental to temporary seeding.

806.50.2.2 Temporary seeding mixtures of cereal grains shall be applied at a minimum rate of 100 pounds per acre. All erodible seeded areas shall provide a minimum of 20 plants of the species planted per square foot on at least two random counts per acre in representative areas of the field. For areas with a large percentage of rock, the number of living plants shall be proportional to the percentage of erodible surface, as determined by the engineer. The counts will be conducted 60 days after the species is planted.

806.50.2.3 Mulch placed over temporary seed mixtures shall be applied in accordance with Sec 802.

806.50.2.4 Fertilizer shall be applied at a rate of 40 pounds nitrogen (N) per acre.

806.50.2.5 Lime will not be required for temporary seeding.

806.50.3 Method of Measurement. Measurement of temporary seeding areas will be made to the nearest tenth of an acre. No measurement will be made for mulch.

806.50.4 Basis of Payment. The accepted quantities of temporary seeding will be paid for at the contract unit price per acre. Payment for fertilizer and mulch shall be included in the cost of temporary seeding.

SECTION 806.60 SEDIMENT TRAP.

806.60.1 Description. This work shall consist of constructing, maintaining and removing sediment traps as shown on the plans or as directed by the engineer.

806.60.2 Construction Requirements.

806.60.2.1 Sediment traps shall be constructed as shown on the plans or as directed by the engineer. Traps may require excavation, or placement of rock of sufficient size to impound water, or a combination of excavation and placement of rock.

806.60.2.2 Sediment traps shall be installed with clearing and grubbing operations or as directed by the engineer. The contractor shall monitor sediment levels and remove sediment in accordance with Sec 806.110.

806.60.2.3 Sediment traps shall remain in service until removal has been approved by the engineer. Removal shall be in accordance with Sec 806.4.11 and as stated herein. The contractor shall remove any sediment from the trap, backfill, compact all excavations, restore the area to match existing ground condition, and seeding and mulching in accordance with Secs 802 and 805 respectively.

806.60.3 Method of Measurement.

806.60.3.1 Measurement of excavation to construct sediment traps will be made to the nearest tenth of a cubic yard.

806.60.3.2 Measurement of rock placed to construct sediment traps will be made to the nearest tenth of a cubic yard.

806.60.4 Basis of Payment.

806.60.4.1 The accepted quantity for excavation to construct sediment traps will be paid for at the contract unit price. Payment includes clearing, excavation, removal, backfilling, and final grading.

806.60.4.2 The accepted quantity for rock used to construct sediment traps will be paid for at the contract unit price. Payment shall include furnishing, placing, and removal of rock.

806.60.4.3 No direct payment will be made for seeding and mulching necessary to restore the area after removal.

806.60.4.4 Payment for sediment removal will be in accordance with Sec 806.110.

SECTION 806.70 SILT FENCE.

806.70.1 Description. This work shall consist of furnishing, installing, maintaining, and removing of a silt fence to control sediment along slopes and other designated areas. The quantity of silt fence shown on the plans may be increased or decreased, as directed by the engineer. The engineer may also modify the location as necessary to improve the effectiveness of the silt fence. Variations in quantity and location will not be considered as a change in work.

806.70.2 Material. When geotextile fabric is used, material shall be in accordance with Sec 1011. All other material shall be as specified in the SWPPP.

806.70.2.1 Posts. Wood, steel or synthetic posts may be used. Posts shall be of sufficient length, but no less than 4 feet, to ensure adequate embedment while fully supporting the fence and shall have sufficient strength to resist damage during installation and to support applied loads while in service.

806.70.2.2 Prefabricated Fence. Prefabricated fence systems may be used if the systems meet all of the above material requirements.

806.70.3 Construction and Maintenance Requirements.

806.70.3.1 Fabric Fence. The contractor shall install silt fence as shown on the plans and at other locations directed by the engineer. Fence construction shall be adequate to handle the stress from hydraulic and sediment loading. Fabric at the bottom of the fence shall be buried a minimum of 6 inches to prevent flow under the barrier. The trench shall be backfilled, and the soil compacted over the fabric. Fabric splices with a minimum 2-foot overlay shall be located only at a support post. Any installation method acceptable to the engineer will be allowed as long as the effectiveness and intent of the silt fence is achieved.

806.70.3.1.1 Post spacing shall not exceed 5 feet. Posts shall be driven a sufficient depth into the ground or placed on closer spacing as necessary to ensure adequate resistance to applied loads.

806.70.3.1.2 The silt fence shall be fastened securely to the upslope side of the post. When wire support fence is used, the wire shall extend into the trench a minimum of 2 inches.

806.70.3.2 Alternate Fence Types. Alternate silt fence types shall be in accordance with the SWPPP or as approved by the engineer.

806.70.3.3 Maintenance. The contractor shall monitor the condition of all fences and repair or replace fences that are not functional as long as the fences are necessary to contain sediment runoff. Any deficiencies shall be corrected by the contractor in accordance with the SWPPP. In addition, the contractor shall review the effectiveness of silt fences in areas where construction activities have changed the natural contour and drainage runoff. Where deficiencies exist, additional silt fences shall be installed as approved or directed by the engineer.

806.70.3.4 Sediment. The contractor shall remove and dispose of sediment in accordance with Sec 806.110. Segments of silt fence that receive heavy sediment loading may require a secondary silt fence or installation of other controls to adequately contain sediment.

806.70.3.5 Removal. Silt fence shall be removed in accordance with Sec 806.4.11 and as specified herein. The contractor shall remove and dispose of any excess silt accumulation along the fence, shall restore the area to match existing ground condition, and seeding and mulching in accordance with Secs 802 and 805 respectively.

806.70.4 Method of Measurement. Silt fence will be measured to the nearest linear foot from end to end of each separate installation.

806.70.5 Basis of Payment.

806.70.5.1 The accepted quantities of silt fence will be paid for at the contract unit price.

806.70.5.2 No direct payment will be made for seeding and mulching necessary to restore the area after removal.

806.70.5.3 Payment for sediment removal will be in accordance with Sec 806.110.

SECTION 806.80 TEMPORARY PIPE.

806.80.1 Description. This work shall consist of installing and removing temporary pipe utilized to carry water under temporary roadways, silt fences, berms or other locations determined by the engineer and to prevent the contractor's equipment from coming in direct contact with water when crossing an active stream, intermittent streams created during heavy rainfalls or other bodies of water.

806.80.2 Material. Any pipe approved by the engineer may be used.

806.80.3 Construction Requirements. Installation of temporary pipe shall be in accordance with the specifications for permanent pipe and shall prevent water from causing erosion around the pipe. All backfill material for pipes shall be placed in 6-inch lifts and mechanically compacted. Compaction tests will not be required. Temporary pipe placed in intermittent or active streams shall be backfilled with clean rock of sufficient size to withstand normal stream flows.

806.80.4 Method of Measurement. Measurement of temporary pipe will be made to the nearest linear foot for those pipes specified on the plans.

806.80.5 Basis of Payment. The accepted quantities of temporary pipe will be paid for at the contract unit price for temporary pipes specified on the plans. No payment will be made for temporary pipes that the contractor chooses to install to facilitate construction. Unless provided as a pay item in the contract documents, no direct payment will be made for the placement and removal of the backfill material or rock.

SECTION 806.90 EROSION CONTROL BLANKETS AND TURF REINFORCEMENT MATS.

806.90.1 Description. This work shall consist of furnishing and placing erosion control blankets (ECBs) and turf reinforcement mats (TRMs) on slopes or ditches for short-term or long-term protection of seeded areas at locations shown on the plans or as directed by the engineer.

806.90.2 Material. ECBs and TRMs shall be used as designated in the contract or as approved by the engineer. The contractor shall provide ECBs and TRMs of the type specified in the contract and shall provide a manufacturer's certification stating that they are in accordance with Sec 1011.

806.90.3 Construction Requirements. ECBs and TRMs shall be installed and maintained according to the manufacturer's recommendations.

806.90.4 Method of Measurement. Measurement of ECBs and TRMs will be made to the nearest square yard of surface area covered.

806.90.5 Basis of Payment. The accepted quantity of ECBs and TRMs will be paid for at the contract unit price for each of the pay items included in the contract. If ECBs and TRMs are used in lieu of other erosion control measures, payment will be made at the contract unit price for the pay items in the contract for the respective items that the blanket replaces.

SECTION 806.100 TEMPORARY STREAM CROSSING.

806.100.1 Description. This work shall consist of constructing a temporary stream crossing to facilitate the movement of equipment across a stream.

806.100.2 Construction Requirements. The contractor shall be responsible for the design, installation, maintenance and removal of the temporary stream crossing and any structures installed for the construction of the temporary stream crossing. Appropriate measures shall be taken to maintain near normal downstream flows and to minimize flooding upstream. The temporary stream crossing shall be constructed to permit the free movement of the stream’s aquatic life. Fill material shall be clean rock of sufficient size to withstand expected high flows. Only graded rock and/or quarry-run rock shall be used. The rock must be reasonably well graded, with no particle dimension greater than approximately 12 inches, and no particle dimension less than approximately 9 inches. Gravel and dirt should not exceed 15% of the total fill volume.

806.100.2.1 Prior to construction of the temporary stream crossing, all information shall be submitted to the engineer to ensure that it meets the terms and conditions of the Corps of Engineer permit. The contractor shall not begin construction on any temporary stream crossing without written permission from the engineer.

806.100.2.2 All approaches to the temporary stream crossing shall be maintained such that all storm water runoff is diverted to retention devices.

806.100.2.3 When the temporary stream crossing is no longer needed, the crossing shall be removed as soon as

possible and the area shall be restored to pre-project conditions or to the satisfaction of the engineer.

806.100.3 Basis of Payment. No direct payment will be made for the design, installation, maintenance or removal of temporary stream crossings. The contractor shall be responsible for all costs, including damage and penalties.

SECTION 806.110 SEDIMENT REMOVAL.

806.110.1 Description. This work shall consist of removing and disposing of sediment from sediment control devices, such as ditch and inlet checks, sediment basins, sediment traps, silt fence, and other devices that accumulate sediment.

806.110.2 Construction Requirements. The contractor shall monitor sediment levels in all sediment control devices and remove sediment prior to the level reaching approximately one-half the design heights for checks and fences, and one-half the storage capacities for basins and traps. The engineer may require sediment removal from devices prior to levels reaching the specified limits.

806.110.2.1 The contractor shall dispose of the sediment in a location that does not allow the sediment to erode back into the sediment devices or to pollute streams or other bodies of water.

806.110.3 Method of Measurement. Measurement of sediment removal will be made to the nearest tenth of a cubic yard.

806.110.3.1 No measurement will be made for sediment removal that accumulates due to the contractor's failure to complete erosion control measures in accordance with the SWPPP or as directed by the engineer. The engineer shall determine the volume of sediment that will be excluded from payment due to a lack of required erosion control measures.

806.110.3.2 No measurement will be made for removing any remaining sediment during final removal of the sediment control devices.

806.110.4 Basis of Payment. The accepted quantity of sediment removal will be paid for at the contract unit price.

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SECTION 808
PLANTING TREES, SHRUBS AND OTHER PLANTS

808.1 Description. This work shall consist of furnishing and planting material in the locations shown on the plans or as directed by the engineer.

808.2 Material.

808.2.1 Plants.

808.2.1.1 Trees, shrubs and other plants shall be nursery stock and shall be true to type and name in accordance with the current edition of Standardized Plant Names published by the American Joint Committee on Horticultural Nomenclature. The plants shall have well developed branch systems and vigorous healthy root systems. All stock shall be well formed and the trunks of trees shall be uniform. The plants shall be free from insects, disease and defects such as knots, sun-scald, injuries, serious abrasions of the bark or objectionable disfigurements. Thin, weak plants will not be accepted. All nursery stock shall qualify under the AmericanHort Horticultural Standards of the current American Standard for Nursery Stock, ANSI Z60.1. Substitution of plant stock or other material will not be permitted except with approval from the engineer.

808.2.1.2 All measurements for height, spread, branching, caliber and root spread or ball size shall be as specified in the current AmericanHort American Standard for Nursery Stock, ANSI Z60.1. Acceptance of plant material will be made only at the planting site following the completion of the planting work, except that acceptance for height, spread and number of branches will be made before pruning the plant. Each shipment shall be accompanied by an invoice showing sizes and varieties of material and ANSI Z60.1 certification.

808.2.1.3 All plant stock shall be certified free of insects and disease by the Missouri Department of Agriculture.

808.2.1.4 All bare root stock shall be dug and packed with care to avoid injury to or removal of roots. Each variety shall be packed in separate bundles. Each bundle shall be clearly labeled. Roots shall be protected with wet straw, moss or other material such that the plants arrive with roots in a moist and healthy condition.

808.2.1.5 Plants specified by ball diameter shall be balled and wrapped and shall be lifted from the ground in such a manner as to retain as many roots as possible. Such plants shall be dug and transported such as to provide and retain a firm ball of the original soil. The ball shall be wrapped with burlap or other approved material and securely tied to keep the ball firm and intact. Balls shall be adequately protected from rain or sudden changes in weather. Trees or other plants will not be accepted if the balls of earth are loosened or broken.

808.2.1.6 Plants specified as container-grown shall have grown in that container sufficiently long for new fibrous roots to have developed such that the root mass will retain its shape and hold together when removed from the container, however, the root mass shall not have grown in the container long enough to have become pot bound. The container shall be sufficiently rigid to hold the ball shape protecting the root mass during shipping. The containers of all container grown plants shall be removed just prior to planting.

808.3 Construction Requirements.

808.3.1 Planting Dates. Planting shall be performed during either the fall phase or the spring phase or both, as specified in the contract. The beginning dates specified in the contract for the respective phases will be the date to begin work days for the planting in that phase.

808.4 Care and Replacement.

808.4.1 The contractor shall be responsible for the proper care of all plants until final inspection and acceptance of the plants has been made by the engineer.

808.4.2 Any plant that, in the judgment of the engineer, is not in a healthy growing condition at the time of final plant inspection shall be replaced by the contractor, at the contractor's expense, in accordance with the original specifications, except that additional peat moss will not be required for the backfill material. No maintenance will be required for those plants replaced under this replacement specification.

808.4.3 Final Plant Inspection. The final inspection of plants will be made as soon as practical after August 15. Plants not accepted at the time of final plant inspection will be marked and shall be replaced in the fall in accordance with the dates specified in the contract. The contractor will be relieved of all further responsibility for plants that are accepted at the time of final plant inspection.

808.5 Method of Payment. From the total amount of work items and material allowances of each biweekly estimate, there will be deducted 25 percent to be retained until final acceptance.

808.6 Basis of Payment. The accepted quantities of plants, complete in place, will be paid for at the contract unit price for each plant of the type, species and size required by the contract. No direct payment will be made for incidental items such as supporting posts, mulch, peat moss, edging and water necessary for this work.

SECTION 901
HIGHWAY LIGHTING

901.1 Description. This work shall consist of furnishing and installing lighting equipment and material as shown on the plans. All work shall meet NEC, NESC and NEMA standards. Existing lighting shall be maintained in effective operation by the contractor except for shutdowns with approval from the engineer for alterations or final removal.

901.2 Temporary Lighting.

901.2.1 Temporary lighting shall consist of furnishing, installing and maintaining wood poles, luminaires, bracket arms, power cable, connection to a power source, mounting hardware and all other material necessary to provide the temporary installation. Any Commission furnished items shall be installed by the contractor. Temporary lighting specified as part of a temporary signal installation shall be installed on the signal poles unless otherwise shown on the plans.

901.2.2 Luminaires shall be 150-watt high pressure sodium with a Type III medium distribution, semi-cutoff light distribution. Luminaires shall be mounted 30 feet above the pavement unless otherwise shown on the plans. Bracket arms shall be oriented at right angles to traffic flow unless otherwise shown on the plans. Photoelectric controls shall be provided and may be installed in the luminaires or in a separate control box at the option of the contractor, unless otherwise shown on the plans. Any existing lighting shall not be taken out of operation until the temporary lighting is ready for operation and with approval from the engineer. All temporary lighting equipment shall be removed by the contractor after the new installation is in operation or as directed by the engineer. Contractor furnished equipment that will remain the property of the contractor may be new or used stock. Contractor furnished equipment that will become the property of the Commission shall be of new stock and shall meet all applicable specifications. Commission owned equipment will remain the property of the Commission and shall be disposed of as shown on the plans or as directed by the engineer.

901.2.3 The contractor shall pay all electrical costs incurred by operation of the temporary lighting until the lighting is removed or until the lighting is accepted for maintenance. For temporary lighting installations where there is not an existing power supply, the contractor shall make any necessary arrangements for providing power to the temporary lighting. Portable generators may be used to provide power to temporary lighting, but any failure of the lighting system due to generator failure will be considered a malfunction as specified in Sec 901.14. No direct payment will be made for power costs. All wire and cable for temporary lighting shall be suspended overhead with proper clearance or buried as shown on the plans.

901.2.4 Temporary lighting shall be installed to meet the construction schedule. The contractor maintain the lighting in proper operating condition in accordance with Sec 901.14. Any damage to the lighting installation shall be repaired by the contractor at the contractor's expense.

901.3 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section/Specification
Concrete	501
Reinforcing Steel for Concrete	1036
Wood Poles for Power Supplies and Temporary Installation	1050
Electrical Conduit	1060
Electrical Conductors	1061
Pull and Junction Boxes	1062
High-Strength Bolts, Nuts and Washers	1080
Low-Carbon Steel Bolts, Nuts and Washers	1080
Galvanized Coating of Steel Lighting Poles and Appurtenances	1080
Lighting Equipment	1091
High-Strength Anchor Bolts	ASTM F 1554
Structural Low Alloy Steel for Base Plates	AASHTO M 270, Grade 50 (ASTM A 709, Grade 50)
Stainless Steel Bolts, Screws and Washers	ASTM A 193, Grades B5, B6, B7 or B16

Stainless Steel Nuts	ASTM A 194
Circular Steel Pile Foundation	ASTM A 252, Grade 2 or ASTM A 500, Grade B/C
Steel H-Pile Foundation	ASTM A 709, Grade 36
Screw Anchor Foundation Shaft Helix Helix Core	ASTM A 252, Grade 2 or ASTM A 500, Grade B/C ASTM A 575, Grade M 1010 or AASHTO M 270, Grade 36 (ASTM A 709, Grade 36) ASTM A 575, Grade M 1023 or AASHTO M 270, Grade 36 (ASTM A 709, Grade 36)
Connector Plates and Steel Closure Plates for Circular Pipes and Connector Plates for H-Pile and Screw Anchor Foundations	AASHTO M 270, Grade 36 (ASTM A 709, Grade 36)

901.3.1 Bolts, nuts and washers specified to be galvanized shall be galvanized in accordance with AASHTO M 232 (ASTM A 153), Class C, or mechanically galvanized in accordance with AASHTO M 298 (ASTM B 695) Class 55. Except for anchor bolts, galvanizing thickness shall not exceed 6 mils. For anchor bolts and nuts and for high strength bolts and nuts, except those in accordance with ASTM A325, the contractor shall furnish to the engineer a test report certified to be the last completed set of mechanical tests for each size in each shipment. For high strength bolts and nuts in accordance with ASTM A325, the contractor shall furnish to the engineer a copy of the manufacturer's inspection test report for each production lot or shipping lot furnished and shall certify the bolts furnished are in accordance with the specifications. Bolts and nuts in accordance with ASTM A 307 shall be accompanied by a manufacturer's statement that the bolts and nuts were manufactured in accordance with ASTM A 307.

901.3.2 Concrete shall be of the class specified in the contract. Material, proportioning, mixing, slump and transporting of concrete shall be in accordance with Sec 501 for the specific class specified.

901.3.3 Equipment and material shall be of new stock unless the contract provides for relocation of existing units or use of units furnished by others. New equipment and material shall be in accordance with ICEA, NEMA, NESC, NFPA and the regulations of the National Board of Fire Underwriters, as applicable, and shall meet the approval from the engineer.

901.4 Equipment List. An approved list of lighting equipment is required in accordance with Sec 902.4.5 prior to installation.

901.5 Lighting Poles. The contractor shall furnish the length of pole and bracket rise shown on the plans. The cable entrance at the bracket arm shall be a field drilled 1 1/4-inch hole. The edges of the hole in steel poles shall be deburred and coated with commercially available inorganic zinc-rich paint. All cable entrance holes shall be fitted with a suitable rubber grommet. A grounding conductor shall provide grounding continuity for all metallic, noncurrent carrying poles in one circuit. The grounding conductor shall be securely connected to the grounding electrode on the supply side at the main disconnect switch.

901.6 Navigation Lighting. The navigation lighting system shall consist of furnishing and installing all cable, conduit, controllers, lanterns, lamps, supports and all other equipment as shown on the plans. Bridge navigation lights shall be installed in accordance with Title 33 CFR, Part 118, the manufacturer’s recommendations and the following:

901.6.1 Lanterns mounted in an inverted position shall have a hole in the tip of the lens to prevent water from collecting in the lantern. Lamps shall be properly installed and oriented for the applications.

901.6.2 As part of the system, a photoelectric cell shall be provided in accordance with Sec 1091. The photoelectric cell shall be mounted on the control station such that all lanterns within the system operate simultaneously and shall illuminate only during hours of darkness or low visibility.

901.6.3 Equipment used for general illumination of the bridge shall be designed such that the light distribution pattern will not permit high-intensity light to spill over and blind or interfere with marine navigation.

901.6.4 The contractor shall maintain navigational lighting on bridges during all construction and provide permanent navigation lighting on the bridge when the bridge spans the river and falsework has been removed.

Existing navigation lighting shall remain in use or temporary navigation lighting installed during the construction period as required. Upon the notice to proceed, the contractor shall maintain and operate the navigation lights until the permanent navigation lights are in operation and the test period completed. Temporary lights and reflectors shall be of the same color and characteristic and have a range of visibility equal to that prescribed for permanent navigation lights.

901.6.5 The contractor shall notify the engineer in writing the date the navigation lighting system will be ready for testing. With approval from the engineer, the contractor shall place the navigation lighting system in operation for a 15 consecutive day test period. The test period shall not be started until all lanterns in the system are ready to be tested. The system shall be tested as a unit. Any failure or malfunction of equipment during the test period shall be corrected at the contractor's expense and the navigation lighting system tested for an additional 15 consecutive day period. This procedure shall be repeated until the navigation lighting system has operated to the engineer's satisfaction for 15 consecutive days.

901.6.6 When the test period is initiated and until completed, the contractor shall provide a service technician in accordance with Sec 901.14.

901.6.7 Before acceptance of the work, the contractor shall furnish the engineer with maintenance information in accordance with Sec 901.16 of all navigation lighting equipment including, but not limited to, lanterns, lamps and auxiliary equipment.

901.7 Contactors. At the option of the contractor, mercury load relays may be used in lieu of contactors.

901.8 Power Supply Assembly. The power supply assembly shall consist of all equipment mounted on a service pole or pedestal as shown on the plans. The configuration and installation of the equipment mounted on the assembly shall meet the safety requirements and approval of the utility company or municipality furnishing power for operation. All contractor provided meter boxes and disconnect boxes shall be constructed of aluminum or stainless steel. All hinges, catches and other hardware shall be non-ferrous metal or stainless steel.

901.8.1 Service poles shall consist of wood poles and crossarms, insulators, necessary pole line hardware, conduit, ground rods, guy wires and anchors and all other accessories and appurtenances mounted on the pole, except those items furnished by the utility company or municipality, or specified separately in the contract.

901.8.2 Pedestals shall consist of two W6 x 9 or two W6 x 15 galvanized steel posts, a concrete footing and all other accessories and appurtenances mounted on the post, except those items furnished by the utility company or municipality, or specified separately in the contract.

901.8.3 Main disconnect switches shall be separately housed on the power supply. The disconnect cabinet shall contain a Type A or Type B circuit breaker in accordance with Sec 1091, of the rating shown on the plans.

901.8.4 Circuit breaker cabinets and meters shall not be installed on the street or walk side of the pole or pedestal.

901.8.5 Meter sockets provided by the contractor shall be UL approved and shall be in accordance with the requirements of the utility company or municipality providing power.

901.9 Rigid Conduit System. Conduit shall be placed as shown on the plans. Rigid conduit shall be installed in accordance with the applicable requirements of Sec 902.

901.10 Trenching and Backfilling.

901.10.1 The depth of trenching and backfilling for conduit and cable-conduit shall be no less than shown on the plans. Conduit or cable-conduit shall not be placed in a trench prior to inspection of the trench by the engineer. All disturbed areas shall be restored to the satisfaction of the engineer.

901.10.2 Type I, 24-inch trenching for cable-conduit will be specified if the excavated material would be classified as Class A Excavation, as defined in Sec 203 and no material is in evidence that might cause mechanical damage to cable-conduit. The cable-conduit shall be laid on the bottom of the trench and the trench backfilled. In lieu of Type I, 24-inch trenching, the cable-conduit may be installed by plowing. The cable-conduit shall be placed at a minimum depth of 18 inches and the soil over the installation shall be recompacted

to the approximate original in-place density.

901.10.3 Type II, 24-inch trenching for cable-conduit will be specified if the excavated material would be classified as Class A Excavation, as defined in Sec 203 and material is in evidence that might cause mechanical damage to cable-conduit. Type II trenching will also include trenching in rock embankment. The cable-conduit shall be embedded in sand as shown on the plans and the trench backfilled.

901.10.4 Type III, 21-inch trenching for cable-conduit will be specified if material that would be classified as other than Class A Excavation, as defined in Sec 203, is encountered. The cable-conduit shall be embedded in sand as shown on the plans and the trench backfilled.

901.10.5 Trenches shall be excavated to the width and depth necessary for conduit installation as shown on the plans. All trenches shall be backfilled as soon as practical after the installation of conduit or cable-conduit. Cinders, broken concrete and other hard or objectionable material that might cause mechanical damage to conduit or cable-conduit shall not be used for backfilling to an elevation 12 inches above the top of conduit or cable-conduit. The bottom of the trench shall be free of such material before the conduit is placed. Backfill material shall be deposited in layers not exceeding 6 inches deep and each layer shall be compacted to the approximate density of the adjacent material by an approved method before the next layer is placed. Red burial tape imprinted with "CAUTION - BURIED CABLE BELOW" shall be installed in all trenches and plowing operations at approximately 1/3 to 1/2 of the depth of the trench. If the trench is to be located under a shoulder that is to be stabilized, the trenching, installation of conduit or cable-conduit and backfilling the trench shall be completed before the shoulder stabilization construction is started. Unless the lighting poles are in place, a coil of cable or cable-conduit of sufficient length to reach the proposed handhole shall be buried near each pole location. The coil shall be covered such that damage will not occur.

901.11 Pull and Junction Boxes. Pull and junction boxes shall be installed at locations shown on the plans in accordance with Sec 902.

901.12 Pole Foundations and Installation.

901.12.1 Concrete foundations for ground mounted poles shall be Class B concrete and shall have dimensions no less than shown on the plans. Concrete shall be placed, finished and cured in accordance with the applicable provisions of Sec 703. Forms will not be required for concrete placed below the finished ground line. All conduit and anchor bolts shall be rigidly installed before the concrete is placed. All portions of the anchor bolts extending above the foundation shall be threaded. Anchor bolts shall align with bolt holes on the transformer base or base plate. Installation of poles on integral concrete median and foundations shall be as shown on the plans. The concrete foundation shall be flush with the finished grade or surface and shall not extend above the finished grade on slopes.

901.12.2 Steel circular and H-pile foundations for ground mounted poles shall be installed in a hole of the approximate dimensions shown on the plans and secured by tamped, wet limestone screenings. Steel pile foundations with poles attached may be installed as a unit. The steel connector plate shall be at the proper elevation and properly oriented to receive the transformer base. The connector plate shall be flush with the finished grade or surface and shall not extend above the finished grade on slopes.

901.12.3 The torque for screw anchor foundations shall not exceed the maximum torque rating shown on the fabricator's shop drawings. The steel connector plate shall be at the proper elevation and properly oriented to receive the transformer base. The connector plate shall be flush with the finished grade or surface and shall not extend above the finished grade on slopes.

901.12.4 Leveling and raking of poles on structures may be accomplished by the use of shims, not to exceed a total of 1/2 inch on bolts.

901.12.5 If poles are to be placed on existing foundations or structures with anchor bolts in place, the contractor shall furnish poles with a base plate to fit the anchor bolt spacing.

901.13 Luminaires. Luminaires for roadway lighting shall be adjusted to give proper illumination on the roadway. Luminaires for underpass lighting shall be interconnected with one-inch minimum rigid conduit in accordance with Sec 902 unless other provisions are incorporated into the structure. The contractor shall place the standard identification marker, which is included with the lamp, in accordance with the latest version of

ANSI C136.15.

901.14 Circuits. Circuits shall be properly labeled in all handholes, pull boxes and junction boxes by means of round aluminum identification tags with a minimum thickness of 0.1 mil attached to the cables with copper wire. Prior to energizing any circuit, the insulation resistance to ground of each completed lighting circuit shall be tested and shall be no less than 10 megaohms. Any circuit less than 10 megaohms to ground will be rejected. The contractor shall provide a suitable 500-volt direct current, zero to 100-megaohm range resistance measuring device for making the resistance test. The circuit test shall be performed by the contractor in the presence of and documented by the engineer.

901.14.1 After the circuits have been tested and found acceptable, the contractor shall, upon approval from the engineer, energize the lighting circuits for a 15 consecutive day test period. All circuits being energized from a control station shall be tested as a system. The entire system shall be tested as a unit. Any malfunction on any circuit shall be corrected and the system tested for an additional 15 consecutive day period. This procedure shall be repeated until the lighting system has operated to the engineer's satisfaction for 15 consecutive days.

901.14.2 When the test period is initiated and until completed, or following the turn-on of temporary lighting, the contractor shall provide at least one service technician to remain in the area and be available for day, night and weekend trouble calls. The contractor shall furnish the name, address and telephone number where each designated technician can be reached at all times. If the lighting system malfunctions and a designated technician cannot be reached or cannot arrive at the location in a reasonable time in the judgment of the engineer, the engineer may exercise the option to direct MoDOT personnel or a third party to correct the malfunction. If this option is invoked, the entire cost of the work performed by MoDOT personnel or the third party will be computed in accordance with Sec 108.9 and deducted from monies due the contractor. Whether or not the engineer elects to correct the malfunction, nothing in this specification shall be construed or interpreted to relieve the contractor of any liability for personal injury or property damage resulting either directly or indirectly from a malfunction during the test period. The contractor and surety shall indemnify and save harmless the State, the Commission, and the Commission's agents, employees and assigns for any legal liability for such a malfunction.

901.15 Installation of Cable and Cable-Conduit.

901.15.1 Cable-conduit shall be installed in a trench of the type specified. Cable-conduit runs shall be continuous without splice between the control panel, handholes, pull boxes, poles and junction boxes. All conduit ends shall be sealed around the cables with a readily workable, soft, sealing compound. The compound shall be workable at 30 F and shall not melt or run at temperatures up to 175 F. Cable-conduit shall be allowed to "snake" in the trench, but there shall be no sharp bends and if two or more cable-conduits are placed in a common trench, the cable-conduit shall not cross each other. For concrete foundations, rigid conduit of sufficient size to facilitate the pulling of cable-conduit shall be cast in the foundation as shown on the plans. The cable-conduit shall be installed through the rigid conduit. Cable-conduit shall extend a minimum of 18 inches above the top of the foundation. The conduit of the cable-conduit shall then be cut off circumferentially approximately 6 inches above the base plate in the transformer base or pole, leaving the cables exposed for connection. Where placed under paved roadways, other paved areas and any type of shoulder, the cable-conduit shall be installed in rigid conduit. Standard commercial duct fittings shall be used to connect conduit of cable-conduit to rigid conduit as shown on the plans and the cables shall continue without splice through the conduit to the nearest pole base. The ground wire shall be attached to a ground lug.

901.15.2 Splices shall be made only in pull boxes, junction boxes and pole bases. More than four cables shall not be spliced in above ground tee splices in pole bases and junction boxes immediately adjacent to wall mounted brackets or underpass luminaires. More than three pairs of power cables shall not be spliced at any other location. Straight or line splices shall only be made in pole bases and junction boxes immediately adjacent to underpass luminaires or wall-mounted brackets unless otherwise approved by the engineer. For underpass lighting or wall-mounted brackets, the cables shall continue unspliced to the nearest junction box or luminaire housing if junction boxes are not shown on the plans. Tee splices shall only be made at the locations shown on the plans.

901.15.2.1 Cables shall be continuous and unspliced to the first light pole. Line splicing in all types of poles, above ground junction boxes and luminaire housings shall be accomplished with a pre-molded fused connector assembly. Line splicing in all breakaway pole bases shall be accomplished with a pre-molded fused slip connector assembly as shown on the plans. After a conductor splice is made, the conductor splices shall be

insulated with a protective rubber boot designed for the pre-molded connector. All above ground tee splices shall be accomplished with a splice block with a molded plastic insulating cover. Any required taping shall be accomplished with splice tape. All sharp points and edges of the connector shall be padded and all voids filled with extra wraps of plastic tape. Tape shall not be stretched excessively or in such a manner as to cause creeping.

901.15.2.2 Underground cable splices, if specified, shall be made in a pull box. Straight or line splices shall be made with copper-clad pressed sleeves or an approved equivalent. Tee splices shall be made with a pressed sleeve, split or unsplit type, or an approved equivalent. All splices shall be protected with a resin splice kit installed in accordance with the manufacturer's recommendations.

901.15.3 Cable shall be pulled with a minimum of dragging on the ground or pavement. Frame mounted pulleys or other suitable devices shall be used for pulling cables out of conduits into pull boxes. Lubricants may be used to facilitate pulling cable. Slack in each cable shall be provided by coiling 6 feet of cable in each pull box and 3 feet of cable in each junction box. Where cable-conduit enters a pull box, conduit shall be cut away from cables in accordance with Sec 902.

901.16 Maintenance Information. Before acceptance of the work, the contractor shall furnish the engineer four copies of the manufacturers' written instructions for maintenance and operation of all lighting equipment and wiring diagrams of the installation or system. At a minimum, the manufacturer's instructions shall include documented, organized instructions, wiring and component layout diagrams, and parts lists with part numbers.

901.17 Final Clean Up. Final clean up of right of way shall be in accordance with Sec 104.

901.18 Method of Measurement.

901.18.1 Measurement of trenching, including backfilling, except for rigid conduit, will be made to the nearest linear foot along the centerline of the trench. No measurement of trenching will be made for rigid conduit.

901.18.2 Measurement of rigid conduit will be made to the nearest linear foot as shown on the plans. Contract quantities will be used in final payment except as hereinafter provided.

901.18.3 Measurement of power cable, pole and bracket cable, multi-conductor cable, wire and cable-conduit will be made to the nearest 10 linear feet as shown on the plans. Contract quantities will be used in final payment except as hereinafter provided.

901.18.4 Measurement of luminaires and bracket arms, including all required material and hardware, will be made per each as separate items.

901.18.5 Measurement of Type AT poles, including the transformer base and all specified hardware, will be made per each. Foundations for Type AT poles, including all specified material, will be made per each.

901.18.6 Measurement of Type B poles, including all specified hardware, will be made per each. Bridge safety barrier curb blisters will not be measured for payment with the Type B pole.

901.18.7 Measurement of Type MB poles, complete in place, will be made per each as a single item, including the footing and the integral portion of median barrier. No direct payment will be made for the footing or integral portion of median barrier for Type MB poles.

901.18.8 Measurement of control stations, including all specified equipment, will be made per each.

901.18.9 Measurement of power supply assemblies, including all specified equipment and cable, will be made per each. The conduit attached to the power supply pole or pedestal and any necessary attachment hardware shall be included with the power supply and no direct payment will be made.

901.18.10 Measurement of pull boxes, including all specified material, will be made per each.

901.18.11 For those items on which final payment is based on contract quantities, final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

901.18.12 Measurement of temporary lighting installations will be made per lump sum.

901.18.13 Measurement of navigation lighting systems will be made per lump sum.

901.18.14 Measurement of substituted items in accordance with Sec 901.15 will be made based on metric dimensions, quantities and contract unit price.

901.19 Basis of Payment.

901.19.1 Accepted highway lighting will be paid for at the contract unit price for each of the pay items included in the contract.

901.19.2 If the contract does not contain a contract unit price for Type III Trenching, and material that would be classified as other than Class A Excavation, as defined in Sec 203, is encountered on construction, payment for such trenching will be paid for at the contract unit price of three times the contract unit price for Type II Trenching per linear foot.

901.19.3 Accepted navigation lighting systems, complete in place, will be paid for at the contract unit price. Payment will be considered full compensation for all labor, material and equipment to perform the described work, including, but not limited to, furnishing and installing all cable, conduit, controllers, light fixtures, lamps, and supports.

901.19.4 No direct payment will be made for transformer bases.

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SECTION 902
TRAFFIC SIGNALS

902.1 Description. This work shall consist of furnishing and installing traffic signal equipment and material as shown on the plans. All work shall be in accordance with NEC, NESC and NEMA standards.

902.2 General. Existing traffic signals shall be maintained in effective operation by the contractor, except for shutdowns approved by the engineer for alterations or final removal. After any modifications have been made or after work is begun on an existing signal installation, the contractor shall maintain the signals in accordance with Sec 902.21. The contractor shall notify local traffic control agencies at least two days, excluding weekends and state holidays, prior to operational shutdown of any traffic signal. The contractor shall notify the engineer at least two days, excluding weekends and state holidays, prior to disconnecting existing vehicle or pedestrian detection. All traffic signal equipment that the contractor uses or installs on the project, whether furnished by the Commission or the contractor, either on a temporary or permanent basis, shall, upon installation or upon initial use by the contractor, be operated and maintained by the contractor until the project is complete and accepted. Any malfunction of an existing signal installation resulting from the contractor's operation, regardless of the nature of the work, shall be corrected at the contractor's expense in accordance with Sec 902.21. Signal timing will be provided to the contractor by the engineer. Programming of the controller will be the responsibility of the contractor, except when waived by the engineer. If any adjustments are required to the operation of an existing signal installation due to the contractor's operation, the contractor shall provide a minimum of two working days notice to the engineer.

902.3 Temporary Traffic Signals. Installation of temporary traffic signals shall consist of furnishing and installing poles for span wire signals, span and tether wires, control and power cable, power supply and connection to a power source, the controller, signal heads, detectors, luminaires, and all mounting hardware, unless specified otherwise. Maintenance of the installation and all other equipment and material necessary to provide the temporary installation will be the responsibility of the contractor. If the temporary traffic signal installation is not shown on the plans, the contractor shall submit a plan to the engineer for approval prior to the installation of temporary signals. Any existing or Commission furnished signal equipment to be used in the temporary signal shall be shown on the temporary signal plan. Temporary signals shall have the signal heads covered until placed in operation. A minimum of two signal faces, in accordance with Sec 1092, shall be oriented toward each street approach positioned a minimum of 8 feet apart, center to center, and a minimum of 16 feet above the surface of the traveled way to the bottom of the backplate. Existing signals shall not be taken out of operation until the temporary signals are ready for operation and approved by the engineer. A flashing operation shall be used during shutdown of the temporary signals.

902.3.1 All temporary signal equipment shall be removed by the contractor after the new installation is in operation, or as directed by the engineer. Contractor furnished equipment that will become the property of the Commission shall be of new stock and shall meet all applicable specifications. Contractor furnished equipment that will remain the property of the contractor may be new or used. Commission owned equipment will remain the property of the Commission, unless specified otherwise, and shall be disposed of as shown on the plans or as directed by the engineer.

902.3.2 The contractor shall pay all electrical costs incurred by operation of the temporary signals and new signal systems until the signals are accepted for maintenance. For temporary signal installations where an existing signal power supply is not available, the contractor shall make any necessary arrangements to provide power to the temporary signals. Portable generators shall not be used to provide power to temporary signals. No direct payment will be made for power costs. All wire and cable for temporary signals shall be suspended overhead with proper clearance or buried a minimum of 18 inches underground.

902.3.3 Temporary signal installations shall be installed to meet the construction schedule. The contractor shall provide a minimum of two working days notice to the engineer prior to the signal turn-on. The contractor shall maintain the signals in proper operating condition, in accordance with Sec 902.21. Any damage to the traffic signal installation from any cause whatsoever shall be repaired by the contractor at the contractor's expense.

902.4 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section/Specification
Concrete	501

Galvanized Coating of Traffic Signal Posts and Appurtenances	1080
High-Strength Bolts, Nuts and Washers	712
Low-Carbon Steel Bolts, Nuts and Washers	712
Structural Low Alloy Steel	712
Luminaires	901
Signs	903
Reinforcing Steel for Concrete	1036
Wood Poles for Power Supplies and Temporary Installations	1050
Electrical Conduit	1060
Electrical Conductors	1061
Pull and Junction Boxes	1062
Fiber Optic Interconnect	1092
Signal Equipment	1092
High-Strength Anchor Bolts	ASTM F 1554
Nuts for Anchor Bolts	ASTM A 563, Grade C, D or DH or ASTM A 194, Grade 2 or 2H
Stainless Steel Bolts, Screws and Washers	ASTM A 193, Grades B5, B6, B7 or B16
Stainless Steel Nuts	ASTM A 194

902.4.1 Bolts, nuts and washers, except stainless steel, shall be galvanized in accordance with AASHTO M 232 (ASTM A 153), Class C or mechanically galvanized in accordance with AASHTO M 298 (ASTM B 695), Class 55. Except for anchor bolts, galvanizing thickness shall not exceed 6 mils. Anchor bolts shall have a minimum yield strength of 55,000 psi and a minimum elongation of 14 percent in 2 inches or 12 percent in 8 inches. For anchor bolts and nuts, and for high strength bolts and nuts, except those in accordance with ASTM A325, the contractor shall furnish to the engineer a test report certified to be the last completed set of mechanical tests for each size in each shipment. For high strength bolts and nuts in accordance with ASTM A325, the contractor shall furnish a copy of the manufacturer's inspection test report for each production lot or shipping lot furnished to the engineer and shall certify the bolts furnished are in accordance with the requirements specified. Bolts and nuts specified to meet ASTM A 307 shall be accompanied by a manufacturer's statement that the bolts and nuts were manufactured in accordance with ASTM A 307.

902.4.2 Concrete. Concrete shall be of the class specified in the contract. Material, proportioning, mixing, slump and transporting of concrete shall be in accordance with Sec 501 for the specific class specified. Concrete shall be placed, finished and cured in accordance with Sec 703.

902.4.3 Equipment and material shall be of new stock unless the contract provides for relocation of existing units or use of units furnished by others. New equipment and material shall be the product of reputable manufacturers, shall be in accordance with Caltrans 170 Specifications, ICEA, IMSA, ITE, MUTCD, NEMA, RETMA, NEC and the regulations of the National Board of Fire Underwriters, as applicable, and shall meet the approval of the engineer.

902.4.4 The configuration and installation of equipment mounted on substation and service poles shall be in accordance with the requirements of the utility company or municipality furnishing electrical power.

902.4.5 The Commission will include Form D-15 in the Electronic Deliverables listing the lighting and signal equipment to be installed. The contractor shall complete the list by writing in the name of the equipment manufacturer and catalog number of each item listed. A list of preapproved equipment and material is available on the MoDOT web site. Only items on the latest revision of the preapproved list will be accepted for use. A completed list shall be submitted electronically to the engineer and shall be approved in writing before items are installed. Approval of the items on the list will not relieve the contractor of responsibility for satisfactory performance of the installation.

902.5 Signal Heads. Each signal head of one or more signal faces shall be conventional or, if designated on the plans, optically limiting. The contractor may furnish aluminum or polycarbonate signal heads. The position of signal indications shall be as specified in the contract. Each traffic signal face shall consist of a number of identical signal section housings rigidly fastened together. Signal heads shall not be painted in the field.

902.5.1 Housing, Door and Visor. If existing housings are to be combined with new housings, the new

housings shall be adaptable to the existing.

902.5.2 Louvers. Louvers, if specified in the contract, shall be installed in a tunnel visor with the fins or baffles in a vertical position.

902.5.3 Hardware. Fittings shall be secured to the signal housing by a closed threaded nipple and hex nut. Cast nipples shall not be used.

902.5.4 Backplates. Stainless steel bolts, nuts and flat washers shall be used to fasten the backplate to the head. Bolt lengths shall be selected to not interfere with maintenance operations. Any connection to the top of any signal section shall be watertight.

902.5.5 Optically Limiting Signal Heads. The signal section shall be a self-contained assembly consisting of an optical unit, section housing, housing door, terminal block and necessary gaskets to ensure a weatherproof unit. The optically limiting signal head shall be capable of separate mounting or inclusion in a signal face containing two or more signal sections. If existing housings are to be combined with new housings, the new housings shall be adaptable to the existing. Each signal section shall be installed and directed and the optical limiter masked in accordance with manufacturer's recommendations to provide indications in accordance with the plans or as directed by the engineer.

902.5.6 Painting and Finishing. All metal parts reused for modification of a signal installation shall be painted in accordance with the requirements for new material. If the painted surface of any equipment is damaged, the surface shall be repaired to the satisfaction of the engineer.

902.6 Signs. Signs for signal installations, including all material required for sign mounting, shall be furnished by the contractor. Signs shall be manufactured in accordance with Sec 903, and mounted as shown on the plans.

902.7 Posts and Mast Arms. Prior to installation, manufacturer and drawing numbers shall be submitted by the contractor to the engineer for approval in writing. Four copies of applicable pre-approved drawings shall be supplied with the poles.

902.8 Span Wire Assemblies. Span wire assemblies shall include 3/8-inch steel messenger wire, 1/4-inch tether wire, guy wire, all bolts, nuts, washers, clamps, cable straps, and other appurtenances shown on the plans or necessary for proper installation. Messenger wire shall be Class A galvanized, high-strength grade, seven-wire strand in accordance with ASTM A 475. Tether wire shall be seven-wire high-strength steel cable. Splicing of messenger and tether wires will not be permitted. Clamps shall be fabricated from low alloy steel. Steel posts for span wire assemblies shall have wire inlets and cable guides with 1-1/2 inch raintight insulator bushings and other features specified in the contract, and shall be in accordance with Sec 1092. Wood poles and steel posts for span wire assemblies shall be as specified in the contract and as shown on the plans. Luminaire bracket arms, if specified, will be at the contractor’s expense. Conduit, junction boxes, service entrance caps, attachment hardware or other appurtenances on the wood poles or steel posts as shown on the plans will be at the contractor’s expense.

902.9 Power Supply Assembly. The power supply assembly shall be in accordance with Sec 901.

902.10 Luminaire Control. If luminaires are specified as part of the signal conduit and wiring system on the signal posts or on separate light poles, a lighting control cabinet shall be provided and installed as shown on the plans.

902.11 Traffic Controller Assemblies.

902.11.1 Wiring. All wiring shall be insulated, stranded copper wire and shall be neatly bundled and secured with plastic cable ties. For double controller cabinets, all wiring for each intersection shall be terminated in the same compartment of the cabinet as the signal controller for that intersection. Incoming field circuits shall be routed horizontally from the conduit to the back of the cabinet, then vertically to the terminal block. All terminals shall be labeled and not be visibly obstructed. All field leads shall be identified by means of round aluminum identification tags with a minimum thickness of 0.1 mil attached to the cables with a copper wire to correspond with the plans. The outgoing signal circuits shall be of the same polarity as the line side of the power supply, and the common return of the signal circuits shall be of the same polarity as the ground side of the power supply. The power supply shall be provided through three single conductor cables. The ground side of the

power supply shall be carried throughout the controller in a continuous circuit, and shall be secured to a ground bus bar in an approved manner. All field conductors shall be terminated in the controller cabinet.

902.11.2 Back Panel Wiring. All wiring on the backside of the controller back panel shall be neatly bundled and secured with plastic cable ties. Any multi-conductor cable between the controller or auxiliary equipment and the back panel shall be contained in an expandable braided sleeve. All wiring shall be discrete insulated wires and shall be soldered directly to lugs on the back of terminal blocks and sockets. Printed circuit boards shall not be used.

902.12 Interconnect Types. The interconnect type shall be as shown on the plans.

902.12.1 Programming. The contractor shall install the system software in all computers to be used with the system as directed by the engineer, and shall program the local intersection controllers and the system master with all operating parameters and timing provided by the engineer.

902.12.2 Telephone Cable and Conduit. The telephone connection for the closed loop system will be coordinated by the engineer. The contractor shall contact the engineer a minimum of two weeks prior to the installation of the power supply assembly. The telephone network interface block shall be located on the power supply assembly. Two separate one-inch rigid conduits shall be installed for the telephone cable and shall be encased in the concrete base of the power supply and the base of the controller cabinet. One conduit shall be for the telephone cable from the telephone company pedestal to the power supply assembly, and the other conduit shall be from the power supply to the controller cabinet. Trenched telephone conduit may be installed parallel in the same trench as the conduit containing power cable. If telephone company cables cannot be installed at the same time as the telephone conduit, then a nylon pull string shall be installed in the conduit. Telephone cables shall not be exposed, except to facilitate connection to the telephone interface block. Telephone cables shall not be installed in the same conduit as the power cables. Any exposed conduit openings shall be filled with pliable duct sealant. The contractor shall supply the telephone cable between the telephone interface on the power supply and the telephone interface in the controller cabinet. The cable shall be a four-twisted-pair, shielded cable in accordance with local telephone company recommendations.

902.12.3 Closed Loop Interconnect. This work shall consist of furnishing, installing and testing a complete arterial master closed loop system comprised of intersections as shown on the plans. The system shall include all equipment listed or shown on the plans, and shall include any incidental items necessary for the satisfactory operation of the system.

902.12.4 Twisted Pair Interconnect. This work shall consist of furnishing, installing and testing a complete twisted pair interconnect system comprised of intersections shown on the plans. The twisted pair system shall include all equipment listed or shown on the plans and shall include any incidental items necessary for the satisfactory operation of the system.

902.12.4.1 Twisted Pair Interconnect Cable. Splices will not be permitted between controllers.

902.12.4.2 Twisted Pair Interconnect Installation. Twisted pair interconnect cable and the system shall be installed in accordance with the manufacturer's recommendations and as shown on the plans.

902.12.5 Wireless Telemetry Interconnect System. This work shall consist of furnishing, installing and testing a complete wireless interconnect system comprised of intersections shown on the plans. The wireless interconnect system shall include all equipment listed or shown on the plans and shall include any incidental items necessary for the satisfactory operation of the system. Telemetry radios and antennas shall be installed and set up in accordance with the plans, these specifications, and the manufacturer’s recommendations for a fully functioning system.

902.12.5.1 Antenna System. Antennas shall be positioned to receive maximum signal strength by adjusting the antenna direction while monitoring signal strength through the telemetry radio. Antenna mounts shall be securely fastened to the poles as shown on the plans. Antenna cable shall be installed inside metal poles and conduit as shown on the plans. External cable on poles shall not exceed 3 feet unless approved by the engineer. Approved external cable runs exceeding 3 feet shall be secured using manufacturer specified hangers at a maximum spacing of 3 feet. Cable terminations shall be made in accordance with the manufacturer’s recommendations. Connectors shall be installed after cable has been pulled into place. Connectors outside of cabinets shall be sealed in accordance with the manufacturer’s recommendations. Any holes made in metal

poles shall be deburred and protected with grommets. Drip loops shall be provided between the antenna connector and the metal pole entrance or first pole clamp. Cable bends shall be in accordance with the manufacturer's specified bending radius. Antenna cable shall be continuous without splice between the antenna and the antenna surge protector in the controller cabinet.

902.12.5.2 Grounding. A separate ground rod shall be installed for each pole with an antenna. The ground rod shall be as shown on the plans and shall be installed in a pull box adjacent to the pole, where available. Ground wires shall be No. 2 AWG minimum, and shall be securely attached to the ground rod by cadwelding. The ground wire shall be attached to the ground lug in metal poles. For wood pole mounting, the ground wire shall be attached directly to the antenna mount and securely fastened to the pole with wire clamps at 3 feet maximum spacing. Copper compression lugs shall be used to attach the ground wire to ground lugs in poles or on antenna mounts.

902.12.6 Fiber Optic Interconnect System. All system equipment shall be installed in accordance with the plans, standard specifications and the manufacturer's recommendations, and shall result in a fully functioning system.

902.12.6.1 Splice Cabinet. The splice cabinet will be required only when shown on the plans. The splice cabinet shall be installed adjacent to controller cabinets and shall be a Type 336 cabinet with an Electronic Industries Alliance (EIA) 19-inch rack cage and a fiber distribution unit. Splice cabinets shall be installed on a separate concrete base as shown on the plans and in accordance with Sec 902.15.

902.12.6.2 Fiber Optic Closed Loop System Components. The principal components of the fiber optic closed loop system, including but not limited to, the local intersection controller(s), the on-street system master and the system software, shall be supplied by the contractor and shall be compatible with any existing systems.

902.12.6.2.1 System Master Controller. The system master controller shall consist of a fiber-ready NEMA or Type 170 controller as shown on the plans, prom module, Type 170 only, and all necessary connectors and cables. The system master shall include a fiber optic data link. The system master controller shall be installed in the local controller cabinet designated on the plans. A separate cabinet will not be required.

902.12.6.2.2 Local Controller Assembly. The local controller assembly shall consist of a fiber-ready NEMA or Type 170 actuated traffic controller assembly in accordance with Sec 1092 and the plans. The local controller shall include a fiber optic data link.

902.12.6.3. Fiber Optic Interconnect Cable.

902.12.6.3.1 The contractor shall provide trained and experienced personnel to supervise the installation of the fiber optic cable. Fiber optic cable shall be installed by trained personnel having a minimum of one-year current installation experience in fiber optic systems. The contractor shall provide a certification for each person installing fiber cable. The certification shall show the amount of experience, the company or companies where experience was obtained and fiber optic training received. Methods of fiber optic installation, connections, splicing or other types of work with fiber optic cable shall be approved by the engineer before implementation by the contractor.

902.12.6.3.2 Installation of the fiber optic cable shall also be in accordance with the manufacturer's recommendations and practices. If the manufacturer's recommendations or practices appear to conflict with this specification, the matter shall be brought to the attention of the engineer for resolution.

902.12.6.3.3 Fiber optic interconnect cable shall be installed in continuous runs for each system, in conduit, pull boxes, splice cabinets or traffic signal controller cabinets. Splices outside of the splice cabinets or controller cabinets will not be permitted. Only those fiber tubes to be accessed in splice cabinets, controller cabinets and distribution units shall be opened, and only active fibers in that tube or tubes shall be cut and spliced. The manufacturer's recommended procedures for a mid-span access shall be followed. Continuous fiber tubes shall be neatly coiled, ensuring that the minimum bend radii are not violated, and shall be organized in the fiber distribution unit. The continuous fibers in the fiber tube(s) that have been opened shall be coiled in the appropriate splice tray. The fibers to be spliced shall be connected by fusion splicing methods with a maximum loss of 0.10 decibels, and the splice shall be held and secured in a fusion splice organizer on the trays. The dark fibers in the
6-fiber cable shall be secured to the splice organizer on the appropriate tray, but will not need to be spliced.

902.12.6.3.4 The contractor shall document the location and termination of all fibers in the appropriate cabinet. Written documentation shall be left in the cabinet and one copy shall be provided to the engineer.

902.12.6.3.5 Each end of the interconnect cable shall be sealed with a manufacturer approved end cap or pulling grip for use during installation. These caps or grips shall be removed only after complete installation of the cable and for the cable acceptance testing. End caps shall be installed to remain in place where fibers are not to be terminated.

902.12.6.3.6 The minimum bending radius and the maximum pulling force of the interconnect cable, as defined by the fiber optic cable manufacturer, shall not be exceeded during installation. Pulling of the cable shall be hand assisted at each pull box, splice cabinet and controller cabinet. The cable shall not be kinked, crushed or forced around a sharp corner. Pulling equipment may be used, however, all pulling equipment and hardware shall maintain the cable's minimum bend radius. Equipment that may contact the cable, such as sheaves, bending shoes, capstans and quadrant blocks, shall be designed for use with fiber optics. Where pulling equipment such as a winch is used, cable tension shall be continuously monitored. This may include use of a winch with a calibrated maximum tension or a dynamometer or in-line tensiometer.

902.12.6.3.7 If a lubricant is used, the lubricant shall be of the water based type as approved by the cable manufacture and shall be compatible with the pre-lubricated polyvinyl chloride conduit. Prior to use, the lubricant type and manufacturer’s name shall be supplied to the engineer for approval.

902.12.6.3.8 Sufficient slack shall be left at each splice cabinet and controller cabinet to allow proper termination. Each pull box adjacent to a signal cabinet or a splice cabinet shall contain a minimum of 60 feet of coiled cable. Mid-block pull boxes shall contain a minimum of
10 feet of coiled cable. Stored cable shall be neatly coiled as per the manufacturer's minimum bending radius specification. Where the size of the box precludes the coiling of cable above the minimum bending radius, the cable shall pass straight through the pull box.

902.12.6.3.9 The conduit containing only fiber optic interconnect cable shall be polyvinyl chloride or high density polyethylene conduit in accordance with Sec 1060 and shall be orange in color. A No. 14 AWG stranded copper tracer wire or a pull tape with a tracer wire shall be installed in the conduit.

902.12.6.3.10 At each pull box and controller cabinet, the interconnect cable shall be visibly marked "Caution - Fiber Optic Cable" by self-adhesive, weatherproof tags.

902.12.6.4 Testing. After the fiber optic cable installation, each fiber in each section shall be tested for attenuation and continuity, as a minimum. The contractor shall provide all personnel, equipment, instrumentation and supplies necessary to perform all testing. Any sections that fail the testing shall be replaced at the contractor’s expense, and retested. All testing shall be performed in an accepted manner and in accordance with the testing equipment manufacturer's recommendations. All data shall be recorded and submitted to the engineer.

902.12.6.4.1 Attenuation. The end-to-end attenuation shall be measured for each link after installation by insertion loss testing.

902.12.6.4.1.1 The launch cable shall be connected to the light source and the receive cable to the power meter. The two reference cables shall then be connected via a termination hub. A reference power reading (P1) shall then be taken and recorded.

902.12.6.4.1.2 The system link to be tested shall then be inserted between the launch and receive cables using two termination hubs. A test power reading (P2) shall then be taken and recorded.

902.12.6.4.1.3 The link attenuation (A) in decibels shall be recorded as the mathematical difference between the reference power (P1) and the test power (P2).

902.12.6.4.1.4 Insertion loss testing shall be performed in both directions along the link. The direction of the test shall be recorded in the documentation.

902.12.6.4.2 Transmitter/Receiver Power Levels. The output power levels at the network hardware

transmitters and receivers shall be measured and recorded for system documentation. The power meter shall be connected to the transmitter side of the equipment with a system jumper. The transmit power level shall then be read and recorded. The transmitter shall then be re-connected to the cable link and the power meter connected to the receiver side of the equipment. The receiver power level shall then be read and recorded.

902.12.6.4.3 Continuity. Continuity tests shall be used to determine whether a test or system jumper does or does not pass light. A continuity test shall also be used to assure the fibers have not been crossed over in the jumper and to assure that the transmit fiber goes to the receiver fiber. To perform the continuity test, a high-intensity flashlight shall be aimed into the connector at one end, while an observer watches for a flicker of light at the other end.

902.12.6.4.4 Optical Time Domain Reflectometer. An Optical Time Domain Reflectometer (OTDR) shall be used to evaluate the quality and length of cable reels prior to use. The fiber loss in decibels/km and the length of each reel shall be recorded in the documentation. The maximum attenuation of the cable shall be 3.5 decibels/km nominal, measured at room temperature at 850 nanometers, equivalent for single mode. A hard copy of OTDR signature traces for all system links shall be made and provided in the documentation.

902.12.7 System Acceptance Test. In addition to the standard testing requirements, the contractor shall successfully complete and document a four-part system acceptance test, in the presence of the engineer, unless approved otherwise, as follows:

(a) System Master Acceptance Test

(b) Office Computer Acceptance Test

(c) Notebook Computer Acceptance Test

(d) System Operational Test

902.12.7.1 System Master Acceptance Test. The system master acceptance test shall be conducted after all traffic signal improvements and the initial eight-hour training session has been completed. The test shall include the following:

(a) The contractor shall simulate a fault at a local controller and verify that the fault is recorded in the permanent log in the master and that the master automatically dials the office computer and transmits the same information.

(b) The contractor shall verify that scheduled timing plans change based on time of day.

(c) The contractor shall change one offset at a local controller and verify the change has been made and implemented at the local controller.

(d) The contractor shall verify a traffic responsive plan change is made at the appropriate time. This shall be demonstrated with simulated detector data.

(e) The contractor shall verify all programming data for the master and all locals can be downloaded/uploaded via the front panel RS-232 connection on the system master.

902.12.7.2 Office Computer Acceptance Test. The office computer acceptance test shall be conducted after successful completion of the system master acceptance test and shall include the following:

(a) A simulated fault at a local controller shall be recorded in the office computer log. The contractor shall verify the entry by printing a log report.

(b) The contractor shall reschedule a timing plan change and verify that the event happens at the new time.

(c) The contractor shall make a timing plan change and verify the change has been made at the local controller.

(d) The contractor shall print a report that shows all plan changes for the previous 24 hours.

(e) The contractor shall print a report showing volume and occupancy values from all system detectors for the previous 24 hours.

(f) The contractor shall call up a real-time intersection display.

902.12.7.3 Notebook Computer Acceptance Test. The notebook computer acceptance test shall consist of the same tests performed for the office computer acceptance test, except all reports shall be displayed on the screen. This test shall be conducted only after the office computer acceptance test has been successfully completed. In addition, a complete local controller database shall be uploaded and downloaded from one controller to another using only the notebook computer, the cable provided and the two controllers.

902.12.7.4 System Operational Test. The system operational test shall be conducted after the system master, office computer and notebook computer acceptance tests have been successfully completed. The system operational test shall consist of a 30-day operational period, during which system failures are recorded. Any failure or malfunction of equipment during the test period shall be corrected at the contractor's expense, and the signal or system shall be tested for an additional 30 consecutive day period. This procedure shall be repeated until the signal equipment has operated to the engineer's satisfaction for 30 consecutive days. System failures will be defined, as a minimum:

(a) Local intersection controller failing to respond to the system master.

(b) System master failing to respond to either the office or notebook computer.

(c) A system detector failure.

902.12.8 Thirty-Day System Operational Test. The 30-day test shall replace the 15-day test period outlined in Sec 902.21. Liquidated damages will only be accumulated between the end of working days and the start of the final 30 consecutive day test period.

902.12.9 Documentation. Complete system documentation shall be provided. Documentation, as a minimum, shall include the results of all testing and shall be recorded along with date of test, name of person performing the test, brand name, model number, serial number of equipment used during test, and any other pertinent information and data.

902.13 Detectors.

902.13.1 Induction Detector Probes. Detector probes installed under bridge decks shall be protected by completely encapsulating the probe in a conduit system. Probes shall be oriented such that the detection zone is above the bridge deck, and shall be installed in gasketed junction boxes anchored to the bottom of the deck. The junction boxes shall have a minimum size of 6 x 6 x 4 inches and the probes shall be rigidly anchored in the box. The probes shall be no more than 18 inches below the top of the bridge deck. Conduit shall be sized such that the probe and cable can be pulled through the conduit. Any conduit bends shall be such that the probe and cable can be pulled through the bend. External conduit on the structure shall be in accordance with Sec 902.16.

902.13.2 Induction Loop Detectors. A slot for the installation of induction loop cable shall be sawed in the pavement as shown on the plans. Slots shall not be sawed until seven days after placement of Portland cement concrete. Each loop shall have a separate lead-in slot to the conduit. A separate conduit shall be installed between the sawed loop slot and the first pull box for each loop. The conduit opening at the end of the lead-in slot shall be at the bottom of the sawed slot. The slot shall be clean. The cable shall be pushed into the slot without damaging the insulation. After the loop cable is spliced to the lead-in cable, and before the slot is sealed, the resistance of the loop and lead-in cable to ground shall be checked. The resistance test shall be performed by the contractor in the presence of the engineer and documented. After a satisfactory test, showing a resistance no less than 10 megaohms, the slot shall be sealed. The conduit opening at the end of the lead-in slot and any drilled conduit holes in the pavement shall be sealed with a pliable duct sealant prior to the application of loop sealant. All sawed slots shall then be sealed with an approved detector loop sealant. All detector cable between the loop and detector amplifier shall be twisted at least three turns per foot.

902.13.3 Microwave and Ultrasonic Detectors. Microwave and ultrasonic detectors shall be mounted at the

locations shown on the plans in accordance with manufacturer's recommendations. All wiring shall be continuous and unspliced from the detector unit to the controller. The contractor shall make any necessary adjustments for proper operation of the detector.

902.13.4 Video Detection Systems. This work shall consist of furnishing, installing and placing into operation a vehicle detection system that detects vehicles by processing video images and providing detection outputs to a traffic signal controller. The system shall include all equipment shown on the plans and described in these specifications, and shall include any incidental items necessary for the satisfactory operation and maintenance of the system. The video detection system shall be installed per the manufacturer's recommendations. All cable runs shall be continuous without splice from the cabinet to the camera. If requested by the engineer, a factory certified representative from the supplier shall be available for on-site assistance for a minimum of one day during installation.

902.13.4.1 Camera. The bottom of the video camera shall be mounted a minimum of 30 feet above the pavement.

902.13.4.2 Extra Service Outlet. A separate grounded service outlet shall be provided in the controller cabinet for supplying power to the video detection system. Use of the grounded service outlet located on the cabinet door will not be permitted.

902.13.4.3 Monitor. The monitor shall be installed to automatically power on when the cabinet door is opened and automatically power off when the cabinet door is closed. A manual on/off switch shall also be provided.

902.13.5 Detector Loop Sealant. Loop sealant shall be proportioned, mixed and installed per the manufacturer's specifications and recommendations. After the loop slots are cut into the pavement, the surface shall be thoroughly cleaned, and all loose debris shall be removed. After application of the sealant, the roadway shall be tack-free and capable of being open to the motoring public within four hours without tracking. Loop sealant shall fully encapsulate the loop wires as shown on the plans. Backer rods shall be placed to ensure a one-inch depth coverage of loops. Excessive overfill will not be permitted.

902.14 Pull and Junction Boxes. Pull and junction boxes shall be installed at locations as shown on the plans. Pull boxes placed in traveled ways, auxiliary lanes, shoulders and low profile islands shall be concrete.

902.14.1 Conduit shall enter the pull box in the side of the box and shall extend a minimum of 2 inches and a maximum of 4 inches as shown on the plans. If it becomes necessary to increase the excavation depth and extend the pull box, no direct payment will be made. The excavated opening outside the pull box shall be wide enough to allow compaction of the backfill material. Cinders, broken concrete, broken rock or other hard or undesirable material shall not be used for backfilling. The backfill material shall be placed in layers not to exceed 6 inches deep, and each layer shall be thoroughly compacted before the next layer is placed. Where preformed pull boxes are used, the holes for the conduit shall be drilled as recommended by the manufacturer. The holes shall be round and no more than 1/2 inch larger than the conduit.

902.14.2 Drains for pull boxes shall be constructed as shown on the plans.

902.14.3 The top surface of all pull boxes shall be flush with surfaced areas and approximately one inch above earth or sodded areas.

902.14.4 If preformed pull boxes are specified, the contractor may use standard concrete pull boxes in lieu of the Class 1 or 2 preformed pull boxes, or the Type A double concrete pull box in lieu of the Class 3 preformed pull boxes. For installations requiring different voltages for lighting and signal applications, the Type B double concrete pull box may be used in lieu of two preformed pull boxes at the contractor's expense. If the Type B double concrete pull box is specified, no substitutions will be permitted.

902.14.5 Class 5 preformed pull boxes shall be in accordance with all requirements in the contract documents. Installation of Class 5 pull boxes shall be as shown on the plans and in accordance with the manufacturer's recommendations.

902.15 Concrete Bases. Excavation for bases shall be made in a neat and workmanlike manner. While concrete is being placed, forms shall be level and sufficiently rigid to prevent warping or deflection. Concrete shall be Class B or concrete of a commercial mixture in accordance with Sec 501. Conduit, ground rods and anchor bolts

shall be held rigidly in place before and during concrete placement. Tops of all bases shall be finished level and the perimeter edged to a radius of 1/2 inch. Exposed surfaces of bases shall be finished in a workmanlike manner as soon as practical after removing forms. Concrete shall be placed, finished and cured in accordance with Sec 703.

902.15.1 Post Bases. Concrete bases for posts shall be in accordance with the dimensions shown on the plans. Metal forms no less than 26 inches high shall be used for all Type A bases. The top 12 inches of Type F bases shall be formed. Reinforcing steel for concrete bases shall be in accordance with Sec 706. Anchor bolts for steel posts and mast arms shall be as shown on the fabricator's approved shop drawings. Conduit shall extend above all post bases a nominal 4 inches.

902.15.2 Controller Bases. Concrete bases for controllers shall be constructed as shown on the plans. Aprons will be considered part of the controller base. A minimum of four anchor bolts shall be used for single controller cabinets and a minimum of six anchor bolts shall be used for double controller cabinets. The size of anchor bolts for controller cabinets shall be as specified by the cabinet manufacturer. A ground rod shall be placed into the ground with a minimum of 8 feet of earth contact as shown on the plans. Bases for double controller cabinets shall have two ground rods, one positioned in each compartment. Conduit shall extend above all controller bases no more than one inch. Bases for double controller cabinets shall have two conduits to the first pull box, one positioned in each compartment. All conduit openings in the controller cabinet or controller cabinet base shall be sealed with a pliable duct sealant in accordance with Sec 901.15 after wiring is completed.

902.16 Conduit Systems. The contractor may furnish and install rigid steel, intermediate metal, polyvinyl chloride (PVC) schedule 40 or high-density polyethylene (HDPE) conduit. Conduit shall be placed a minimum of 18 inches below finished grade and shall slope to a pull box at a minimum rate of 0.5 percent unless otherwise shown on the plans. A change in direction of conduit shall be accomplished by bending the conduit uniformly to a radius that will fit the location, or by the use of standard bends or elbows. The minimum radius of the bend shall be six times the internal diameter of the conduit. Nipples shall be used to eliminate cutting and threading where short lengths of conduit are required. If it becomes necessary to cut and thread steel conduit, exposed threads will not be permitted. All conduit and fittings shall be free from burrs and irregularities. All conduits shall be cleaned and swabbed before cables are installed. All fittings shall be tightly connected to the conduit. Open ends of conduit placed for future use shall be capped or plugged. If approved by the engineer, conduit may be installed either by trenching or pushing; however, payment will be made by the method specified in the contract for that conduit. Functionally equivalent English measure items may be substituted by the contractor for metric items specified or shown on the plans in accordance with Sec 901.15 upon approval from the engineer.

902.16.1 Tracer Wire. All conduits shall contain a bare or green-jacketed No. 14 AWG stranded copper tracer wire. Tracer wire shall not be pulled into the controller cabinet or bases. An additional 6 feet of tracer wire shall be coiled in each pull box. Tracer wire in pull boxes shall be capped, not electrically bonded to any ground wires, labeled "TRACER" and tagged in accordance with Sec 902.19.

902.16.2 Metal Conduit. All metal conduit ends shall be provided with a bushing to protect the cable from abrasion. All metal conduits shall be electrically bonded by conduit clamps and bare No. 6 AWG stranded copper wire. All metal conduits in the controller base shall be electrically bonded to the power company ground.

902.16.3 Polyvinyl Chloride and High-Density Polyethylene Conduit. A bare No. 6 AWG stranded copper ground wire shall be installed in all conduits, except PVC that contains only fiber optic cable, and shall be attached to the ground lug in signal posts, except as otherwise specified in this section. All bare ground wires shall be electrically bonded. All bare ground wires in the controller base shall be electrically bonded to the power company ground.

902.16.4 Conduit in Trench. Trenches shall be excavated to the width and depth necessary for conduit installation. All trenches shall be backfilled as soon as practical after the installation of conduit. Cinders, broken concrete and other hard or objectionable material that might cause mechanical damage to the conduit shall not be used for backfilling within
6 inches of the top of the conduit. The bottom of the trench shall be free of such material before the conduit is placed. Conduit shall not be placed without approval of the trench from the engineer. Backfill material shall be deposited in the trench in layers not exceeding
6 inches deep and each layer shall be compacted to the approximate density of the adjacent material by an approved method before the next layer is placed. Red burial tape imprinted with "CAUTION - BURIED

CABLE BELOW" shall be installed in all trenches at approximately one-third to one-half of the depth of the trench. All disturbed areas shall be restored to the satisfaction of the engineer.

902.16.5 Pushed Conduit. If pushed conduit is specified, the conduit shall be installed without disturbing the existing surface. Pushed conduit may be placed by jacking, pushing, boring or other approved means.

902.16.6 Conduit in Median. If conduit in median is specified, the conduit shall be placed on the existing pavement prior to construction of the raised median. If conduit is to be placed in concrete traffic barrier, the conduit shall be held rigidly in place before placement of concrete.

902.16.7 External Conduit on Structure. For existing structures, or if provisions are not made in the plans for providing a conduit raceway in new structures as described in Sec 707, the conduit shall be external conduit on structure. Conduit on structure will include conduit on bridges, retaining walls or other structures, and shall be installed as shown on the plans or as directed by the engineer. The final location of all conduit and junction boxes shall be approved by the engineer before installation begins. Conduit shall not be attached to prestressed concrete girders or prestressed, precast concrete deck panels. The conduit shall be secured to the concrete with clamps at no more than 5-foot intervals. Concrete anchors shall be in accordance with federal specification FF-S-325, Group II, Type 4, Class I, and shall be galvanized in accordance with ASTM A 153, B 695-91 Class 50, or constructed of stainless steel. The minimum embedment in concrete shall be 1 3/4 inches. The supplier shall furnish a manufacturer's certification that the concrete anchors meet the required material and galvanizing specifications. If necessary to anchor the conduit to steel bridge members, the attachment method shall not involve drilling, grinding or welding. Attachment method to steel members shall be approved by the engineer. Junction boxes shall be installed as shown on the plans or as directed by the engineer. Junction boxes shall be surface-mounted and installed such that covers are accessible. If the conduit crosses a bridge expansion joint, a conduit expansion fitting shall be used. The expansion fitting shall provide a minimum movement in either direction as shown on the plans or as specified by the engineer. Junction boxes, expansion fittings and any hardware or material required for conduit installation shall be at the contractor’s expense.

902.17 Signal Faces. Vehicle and pedestrian signal faces shall be covered or turned away from approaching traffic until placed in operation. When ready for operation, the signal faces shall be securely fastened in position facing approaching traffic. Incandescent lamps installed by the contractor shall be installed horizontally with the open segment of the filament facing up. Vehicle and pedestrian signal faces shall be aimed laterally at the approximate center of the lane or lanes the signal face controls. Signal faces shall be aimed at a point behind the stop line a distance corresponding to the following requirements:

Approach Speed, mph	Distance, feet
30	160
40	240
50	330
60	430
70	560

902.18 Post Erection. Post bases shall be securely anchored to concrete bases. Pedestal posts shall be erected vertically without the use of leveling nuts. Metal posts for span wire and cantilever mast arms shall be adjusted by leveling nuts. All posts for span wire and cantilever mast arms shall be raked as directed by the engineer. All signal posts shall be grounded by a bare No. 6 AWG stranded copper wire running from the ground lug inside the post to a clamp fastened on metal conduit at the top of the concrete base to a ground rod or through nonmetallic conduit to the ground bus in the controller.

902.19 Wiring.

902.19.1 All cable runs shall be continuous and unspliced from the connections in the terminal block of the signal head or disconnect hanger to the terminal strip in the controller cabinet, from the signal terminal block to another signal terminal block or as shown on the plans. When a terminal compartment is provided, all cable runs shall be continuous from the terminal compartment to the terminal strip in the controller cabinet. When parallel connections are required from an overhead signal head on a mast arm to a side-mounted signal head, cable shall be routed from the controller to the terminal compartment of the signal on the mast arm and then parallel-circuited back to the side mounted signal. All other conductor cable combinations to signal heads shall be as shown on the plans or as directed by the engineer. Where double controller cabinets are specified, wires shall be sorted between the controller and first pull box such that field wires enter the associated controller compartment.

902.19.2 Power cable runs shall be continuous and unspliced from the power disconnect switch located on the power supply to controller cabinet terminals. Power cable shall be encased in conduit of the size shown on the plans. Energized power cables shall run to circuit breakers. The neutral cable shall be terminated on the neutral bus bar and the equipment ground conductor shall be terminated on the ground bus in the controller cabinet.

902.19.3 Where luminaires are required, pole and bracket cable shall be installed between the luminaire and the power source at the base of the post. Each luminaire shall be connected to the power source by No. 12 AWG conductors with suitably sized equipment grounding conductor. A premolded fused connector assembly shall be installed on each conductor carrying current between the source cable and the pole and bracket cable. The assembly and cable shall be insulated with a protective rubber boot designed for the premolded connector.

902.19.4 Induction loop dimensions shall be as shown on the plans. The engineer will determine the exact location of loops. Each induction loop shall be connected to the detector by a separate lead-in cable. Single-conductor No. 14 AWG cable shown on the plans is an approximation of cable quantity required to construct the induction loop. If the number of turns shown on the plans is not in accordance with the manufacturer's recommendation for the sensing units furnished, the plans will be revised, and the induction loop cable will be field measured and quantities adjusted accordingly. Induction loop detector cable shall be installed in accordance with manufacturer's recommendations. Induction loop detector lead-in cable will be shown on the plans as two-conductor No. 14 AWG cable. Should the manufacturer recommend a different type of cable, the two-conductor cable shall be revised to the manufacturer's specification, but will be considered completely covered by the contract unit price for loop detector lead-in cable. Cable for loop detectors shall be continuous from the terminal strip in the controller cabinet to a splice with the detector leads in the pull box adjacent to the detector. The conductor splice shall be soldered without an open flame. The soldered splice shall then be capped and inserted into a direct buried splice kit.

902.19.5 Where practical, color codes shall be followed such that the red insulated conductor connects to the red indication terminal, orange to yellow and green to green. Circuits shall be properly labeled in the controller cabinet and all pull boxes by means of round aluminum identification tags with a minimum thickness of 0.1 mils, attached to the cables with a copper wire. Information stamped on the tags shall identify equipment served by the conductor cable in accordance with designations used on the plans.

902.19.6 Cables shall be pulled through conduit by a cable grip providing a firm hold on exterior coverings. Cable shall be pulled with a minimum of dragging on the ground or pavement. Frame-mounted pulleys or other suitable devices shall be used for pulling cables out of conduit into pull boxes. Lubricants may be used to facilitate pulling cable. Polyester rope will not be permitted to facilitate pulling of cable. Slack in each cable shall be provided by a 6-foot loop coiled in each pull box and a 3-foot loop coiled in each junction box. All signal posts and controllers shall be grounded by bare No. 6 AWG stranded copper wire.

902.20 Test Equipment. During installation of equipment and material, the contractor shall furnish to the engineer suitable equipment to test all or part of the completed facility to establish compliance with requirements of the contract. Minimum test equipment shall be a voltmeter, ohmmeter and ammeter. For testing induction loop detectors, the contractor shall also provide a suitable 500-volt, direct current, 0 to 100- megaohm range, hand-operated, resistance measuring device.

902.21 Test Period. After the project is open to normal traffic, the contractor shall notify the engineer in writing the date the signal or signal system will be ready for testing. Upon concurrence from the engineer, the contractor shall place the signal or signal system in operation for a 15 consecutive day test period. A signal operated independently of other signals or signal systems shall be tested as a single installation. A signal operated as part of a system shall not be tested until all signals in the system are ready to be tested. A system shall be tested as a unit. Any failure or malfunction of equipment during the test period shall be corrected at the contractor's expense, and the signal or signal system tested for an additional 15 consecutive day period. This procedure shall be repeated until the signal equipment has operated to the engineer's satisfaction for 15 consecutive days. The contractor shall, in the presence of the engineer, demonstrate the proper action of the controller's monitor as part of the testing system, if applicable.

902.21.1 When the test period is initiated and until the test period is completed, following the turn on of temporary traffic signals or after work is begun on an existing signal installation, the contractor shall provide at least one service technician to remain in the area and be available for day, night and weekend trouble calls. The contractor shall furnish the name, address and telephone number where each designated technician can be

reached at all times. In the event of a malfunction, the contractor shall provide adequate traffic control for the intersection until the signals are restored to normal operation. Adequate traffic control shall be as shown on the plans or as directed by the engineer. If the signal or signal system malfunctions and a designated technician cannot be reached or cannot arrive at the intersection in a reasonable time in the judgment of the engineer, then the engineer may exercise the option to direct MoDOT personnel or a third party to correct the malfunction in the presence of the engineer. If this option is invoked, the entire cost of the work performed by MoDOT personnel or the third party will be computed as described in Sec 108.9 and deducted from the payments due the contractor.

902.21.2 Whether or not the engineer elects to correct the signal malfunction, nothing in this specification shall be construed or interpreted to relieve the contractor of any liability for personal injury or property damage that results either directly or indirectly from a signal malfunction during the test period. The contractor and surety shall indemnify and save harmless the State, the Commission, the Commission's agents, employees and assigns for any legal liability incurred for such a signal malfunction.

902.22 Maintenance Information. Before acceptance of the work, the contractor shall furnish the engineer with three copies of the manufacturer's instructions for maintenance and operation of all signal equipment including, but not limited to, controllers, conflict monitors, load switches, detectors, software, interconnect and auxiliary equipment. At a minimum, the manufacturer's instructions shall include organized written instructions, wiring diagrams, diagrams showing component layouts and parts lists with part numbers and serial numbers, where applicable. Serial numbers listed by the supplier will be verified with the shipping invoice and on the controller and conflict monitor received for installation. The contractor shall furnish three copies of wiring diagrams of the installation or system. The cabinet wiring diagrams shall include labeling for all field terminal connections and shall provide an orientation of the terminal layout that conforms to the intersection information specified.

902.23 Final Clean Up. Final clean up of right of way shall be in accordance with Sec 104.

902.24 Method of Measurement.

902.24.1 Measurement of temporary traffic signal installations will be made per lump sum.

902.24.2 Measurement for the following items will be made per each:

(a) Signal heads and luminaires,

(b) Posts,

(c) Power supply assemblies, including all specified equipment,

(d) Traffic controller assemblies, including all specified equipment,

(e) System software, including installation,

(f) System master, including all specified items,

(g) Telemetry radios and antennas for wireless interconnect systems, including all specified equipment,

(h) Video detection systems, including all specified equipment,

(i) Pull boxes, including all specified material,

(j) Training, including all specified training,

(k) Modems, including all specified equipment,

(l) Splice cabinet, including all specified items,

And includes all necessary material, hardware, equipment and specified incidental items,

902.24.3 Measurement of push button detectors, microwave detectors and induction probe detectors will be made per each. Measurement of two-channel card rack mounted detectors will be made per each detector card.

902.24.4 Final measurement of concrete for bases will not be made, except for authorized changes in construction or where appreciable errors are found in the contract quantity. Where required, measurement of concrete for bases, including all specified material, will be made to the nearest 1/10 cubic yard as shown on the plans. The revision or correction will be computed, and added to or deducted from the contract quantity.

902.24.5 Final measurement of conduit will not be made, except for authorized changes in construction or where appreciable errors are found in the contract quantity. Where required, measurement of conduit will be made to the nearest linear foot as shown on the plans. The revision or correction will be computed, and added to or deducted from the contract quantity.

902.24.6 Final measurement of conductor will not be made, except for authorized changes in construction or where appreciable errors are found in the contract quantity. Where required, measurement of conductor will be made to the nearest 10 linear feet as shown on the plans. The revision or correction will be computed, and added to or deducted from the contract quantity.

902.24.7 Measurement of signal sign areas will be made to the nearest 1/10 square foot for each sign and to the nearest square foot for the total.

902.25 Basis of Payment. Accepted traffic signals will be paid for at the contract unit price for each of the pay items included in the contract. No direct payment will be made for any incidental items necessary to complete the work unless specifically provided as a pay item in the contract.

902.25.1 Temporary traffic signals will be paid for at the contract unit price. No direct payment will be made for guys, conduit and junction boxes on poles, hardware, lighting bracket arms, or any other item for which separate payment is not provided.

902.25.2 Accepted post bases will be paid for at the contract unit price. Payment will be considered full compensation for all labor, equipment and material to complete the described work, and will include all excavation, removal and disposal of all material encountered within the limits of the work.

902.25.3 Luminaire bracket arms, if specified, will be at the contractor's expense.

902.25.4 No direct payment will be made for cable, conduit and any additional work required to connect the power supply assembly to the utility company facilities.

902.25.5 No direct payment will be made for the card rack assembly and card rack power supplies.

902.25.6 Payment for the telephone cable and associated pushed or trenched conduit will be considered fully covered under the contract unit price for the power supply assembly.

902.25.7 Furnishing and installing the system master controller, including all connectors and cables to provide a fully functioning system, will be paid for at the contract unit price per each. Payment for furnishing and installing telephone interface panels, an extra service outlet, door alarm, dial-up modem and all aspects of the system acceptance test, including all incidental items required to provide a fully functioning system, will be considered completely covered by the contract unit price for the system master.

902.25.8 For closed loop systems, if the Commission does not furnish the system software, the system software will be paid for at the contract unit price per each. If the Commission furnishes system software or has committed to purchase system software in another contract, no payment will be made for the software. This shall include versions of previously supplied software. Installing and programming local intersection controllers and the system master will be at the contractor's expense.

902.25.9 Accepted video detection systems will be paid for at the contract unit price. Payment will be considered full compensation for all labor, equipment and material to complete the described work, and for placing the specified equipment into operation to the satisfaction of the engineer.

902.25.10 No direct payment will be made for junction boxes.

902.25.11 Furnishing and installing telemetry radios, power supplies, interface cables, diagnostic pads and other items necessary for the proper operation of the radios will be paid for at the contract unit price for the Spread Spectrum Telemetry Radio.

902.25.12 Furnishing and installing antenna cable, including connectors, surge arrestors and other items necessary for proper operation, will be paid for at the contract unit price of
RG-8/U Coaxial Cable.

902.25.13 If training is specified in the contract documents, training will be paid for at the contract unit price. Payment will be considered full compensation for all labor, equipment and material to conduct the training.

902.25.14 The accepted quantities of fiber optic cable, including installation, termination and testing of the fiber optic interconnect cables, all connectors, hardware, tags and other incidentals needed to provide a fully functioning system, will be paid for at the contract unit price per linear foot. The installation, termination and splicing of fibers in splice cabinets and fiber distribution units, including all connectors and other incidentals, will be considered fully covered under the contract unit price.

902.25.15 The fiber optic data link in the system master, including all incidental items required for proper operation, will be paid for at the contract unit price per each for the system master.

902.25.16 Furnishing and installing the dial-up modem including all connectors and cables necessary for proper operation will be paid for at the contract unit price per each.

902.25.17 Furnishing and installing the local controller assembly, including all connectors and cables to provide a fully functioning system, will be paid for at the contract unit price per each.

902.25.18 Furnishing and installing the fiber optic data links (modems) in the local controllers including all incidental items required to provide a fully functioning system, will be paid for at the contract unit price per each for controller assembly.

902.25.19 Furnishing and installing the fiber distribution unit for controller cabinets, including all mounting hardware and incidentals, will be paid for at the contract unit price per each for controller assembly.

902.25.20 Furnishing and installing the splice cabinet, including the rack cage, fiber distribution unit, grounding and other incidental items will be paid for at the contract unit price per each.

902.25.21 Payment for the telephone cable and associated pushed or trenched conduit will be considered fully covered under the contract unit price for the power supply assembly.

902.25.22 No direct payment will be made for warranties.

902.25.23 No direct payment will be made for tracer or ground wires.

902.25.24 Highway signal signs an mounting hardware will be paid for at the contact unit price for each of the items included in the contract. No direct payment will be made for incidental items necessary to complete the work, unless specifically provided as a pay item in the contract.

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SECTION 903
HIGHWAY SIGNING

903.1 Description. This work shall consist of furnishing and installing highway signs as shown on the plans. All signs shall be in accordance with the MUTCD. Any signs not detailed on the plans shall be in accordance with Standard Highway Signs by the U.S. Department of Transportation, Federal Highway Administration.

903.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section/Specification
Reinforcing Steel for Concrete	1036
Highway Sign Material	1042
Delineators, Mile and Marker Posts	1044
Paints for Structural Steel	1045
Electrical Conduit	1060
Expansive Mortars	1066
Low-Carbon Steel Bolts, Nuts and Washers	1080
Structural Carbon Steel	1080
Structural Low Alloy Steel	1080
Low-Carbon Steel Anchor Bolts	1080
High-Strength Anchor Bolts	ASTM F 1554
High-Strength Bolts, Nuts and Washers	1080
Galvanized Coating of Structural Steel, Tubular Steel Sign Supports, Sign Trusses and Appurtenances	1081

903.2.1 Sign Posts and Tubular Steel Sign Supports.

Item	Section/Specification
Wood Posts	1050
Steel Pipe Posts	ASTM A 53, Grade B, or ASTM A 500, Grade B
Galvanizing of Steel Pipe Posts	ASTM A 53
Structural Steel Welding Electrodes	AWS A5.1 or AWS A5.5
Structural Steel Posts	AASHTO M270 Grade 50 or 50w
U-Channel Posts	ASTM A 499, Grade 60

903.2.2 Overhead Sign Trusses.

Item	Specification
Aluminum Extruded Tube	ASTM B 221, 6061-T6
Aluminum Permanent Mold Castings	ASTM B 108, A 356.0-T61
Aluminum Sand Castings	ASTM B 26, 356.0-T6
Aluminum Plate	ASTM B 209, 6061-T6
Aluminum Structural Shapes	ASTM B 308, 6061-T6
Aluminum Pipe Handrail	ASTM B 241, 6061-T6 or 6063-T6
Aluminum Pipe Fittings for Schedule 10 Pipe	ASTM B 26, 356.0-T6 or ASTM B 108, A 356.0-T61
Aluminum Grating Bearing Bars Cross Bars	ASTM B 211, 6061-T6 or ASTM B 221, 6061-T6 or 6063-T6 ASTM B 211, 6061-T6 or ASTM B 221, 6061-T6 or 6063-T5 or T6
Aluminum Washers	ASTM B 209, 2024-T4 or Alclad 2024T4
Aluminum Beveled Washers	ASTM B 221, 2024-T4
Filler Wire for Welding Aluminum	AWS A 5.10 ER5356, ER5556
Stainless Steel U-Bolts	ASTM A 276 Chromium-Nickel Grade, min. yield 30,000 psi
Stainless Steel Bolts, Nuts, Screws and Washers	ASTM A 320 or SAE J405D, Austenitic Steel, min. yield 30,000 psi
Structural Steel Welding Electrodes	AWS A 5.1 or AWS A 5.5

903.2.3 Hardware. Bolts, nuts and washers specified to be galvanized shall be galvanized in accordance with Sec 1081. Except for anchor bolts, galvanizing thickness shall not exceed
6 mils. For high strength bolts, the contractor shall furnish to the engineer a copy of the manufacturer's inspection test report for each production lot or shipping lot furnished, and shall certify the bolts furnished are in accordance with Sec 1080.

903.2.4 Concrete. Concrete shall be of the class specified in the contract. Material, proportioning, mixing, slump and transporting of concrete shall be in accordance with Sec 501 for the specific class specified. Concrete shall be placed, finished and cured in accordance with Sec 703.

903.2.5 Equipment and Material. Equipment and material shall be of new stock unless the contract provides for relocation of existing units or use of units furnished by others. New equipment and material shall meet the approval of the engineer.

903.3 Construction Requirements.

903.3.1 Footings for Trusses and Posts.

903.3.1.1 Bolt-Down Installations. Class B concrete shall be used to construct all footings and end supports for overhead sign trusses, tubular steel sign supports and posts with bolt-down bases. Footings shall be formed, unless in the judgment of the engineer, soil conditions permit excavation to be made to the neat lines of the footings and the footings cast against the undisturbed vertical soil face. In all cases, the top 12 inches below finished ground line shall be formed. Footings shall be placed on firm, stable, undisturbed soil to the minimum depth shown on the plans. Backfill shall be thoroughly compacted, and care taken to prevent damage to finished concrete. Backfill shall be brought up level with the finished ground line. Anchor bolts shall be firmly held in proper position, supported at the top, during placement of concrete.

903.3.1.2 Embedded Installations. Class B or B-1 concrete, or concrete of a commercial mixture meeting the requirements of Sec 501 shall be used for the footings for embedded-type sign posts, except as otherwise allowed herein. Posts shall be supported in proper position until the concrete or other approved material has set. Excavation and backfill shall be in accordance with Sec 903.3.1.1, except forming will not be required unless soil conditions warrant forming. Tops of footings shall be finished flush with the slope of the ground. Footings shall be visually inspected for acceptance by the engineer.

903.3.1.2.1 In lieu of the concrete material requirements in Sec 903.3.1.2, the contractor may use a pre-packaged dry commercial concrete mixture that has a manufacturer’s 28-day compressive strength rating of no less than 4,000 psi for the footings for embedded-type sign posts. The concrete shall be thoroughly mixed in accordance with the manufacturer’s recommendations. Strength requirements shall meet or exceed Class B concrete as specified in Sec 501.

903.3.1.2.2 In lieu of concrete, the contractor may use a quick-setting polyurethane foam for the footings for embedded-type sign posts. The foam shall have a minimum compressive strength of 80 psi (550 kPa), in the direction of rise, when tested in accordance with ASTM D 1621, and shall have a minimum density of 4 pounds per cubic foot (65 kg/m3) when tested in accordance with ASTM D 1622. Foam shall not be placed in water. Polyurethane foam shall be mixed in accordance with manufacturer's recommendations. Polyurethane foam will not be permitted if soil conditions are such that forming is necessary.

903.3.1.3 Optional Footings. Substructures for butterfly and cantilever overhead sign trusses and posts may be either drilled shafts or spread footings.

903.3.1.3.1 The quantities shown on the plans reflect the total cubic yards of substructure, based upon drilled shaft quantities.

903.3.1.3.2 No adjustment in payment will be made for providing the equivalent spread footing design that differs in area from the specified drilled shaft design.

903.3.1.3.3 If rock is encountered and the depth of drilled shafts is adjusted accordingly, cubic yard quantities will be recalculated for those locations and payment will be adjusted accordingly. Cubic yard quantities will not be recalculated for spread footings if rock is encountered, unless it is considered differing site conditions in accordance with Sec 104.2 of the standard specifications.

903.3.2 Posts for Ground Mounted Signs.

903.3.2.1 Post Lengths. Post lengths shown on the plans for ground-mounted signs are for bidding purposes only. The contractor shall be responsible for determining post lengths to provide the vertical clearance shown on the plans. Field cutting of posts will be permitted.

903.3.2.2 Post Alignment. Sign posts shall be vertical. Any post bent or otherwise damaged to the extent that the post is considered unfit for use shall be removed and replaced with an acceptable post at the contractor's expense.

903.3.2.2.1 Structural Steel Posts. Structural steel sign posts for ground mounting of signs shall be fabricated and erected as shown on the plans. Welds shall be of full section and sound throughout. Posts with dimensional defects and structural discontinuities will be rejected. Posts built up by welding two lengths together will be permitted, provided the welds are ground smooth and flush with the base metal. Posts and appurtenances shall be hot-dip galvanized after fabrication. Posts with breakaway assemblies shall be cut at the hinge prior to galvanizing, except for field cutting. Hinge plates shall not be attached to the posts at the time of galvanizing. All welds shall be cleaned before galvanizing. All exposed steel areas and damaged galvanizing shall be repaired in accordance with Sec 1081.

903.3.2.2.2 Pipe Posts. Pipe posts shall be fabricated as shown on the plans and shall be hot-dip galvanized after fabrication. Welds shall be of full section and sound throughout. Posts with dimensional defects and structural discontinuities will be rejected. All welds shall be cleaned before galvanizing. Exposed steel areas and damaged galvanizing shall be repaired in accordance with Sec 1081. Friction caps for pipe posts shall be of the dimensions shown on the plans and may be galvanized steel or aluminum alloy.

903.3.2.2.3 Perforated Square Steel Tube Posts. Perforated square steel tube posts shall be installed at locations shown on the plans. Exposed steel areas and damaged galvanizing shall be repaired in accordance with Sec 1081.

903.3.2.2.4 U-Channel Posts. U-Channel posts shall be installed at locations shown on the plans. Exposed steel areas and damaged galvanizing shall be repaired in accordance with Sec 1081.

903.3.2.2.5 Wood Posts. Wood posts shall be installed at locations shown on the plans.

903.3.2.3 Certification. The contractor shall furnish to the engineer three copies of the fabricator’s certification that the material supplied is in accordance with the requirements specified.

903.3.3 Tubular Steel Sign Supports. Tubular sign supports for overhead mounting of signs shall include span, cantilever and butterfly types, complete with poles, beams, mast arms, sign bracket assemblies and other specified appurtenances. All steel shall be hot-dip galvanized after fabrication in accordance with Sec 1081. All welds shall be cleaned before galvanizing. Shop drawings will not be required for these supports.

903.3.3.1 Tapered Steel Poles and Beams. Tapered steel poles and beams shall be a continuous taper tube, fabricated from one length of open hearth sheet steel with one continuous welded longitudinal seam. After fabrication, the material shall have a minimum yield strength of 48,000 psi. Straight steel arms shall be standard or extra heavy pipe, of the dimensions and grades shown on the plans. Bolts, nuts, washers, clamps and sign bracket assemblies shall be hot-dip galvanized or of stainless steel. Clamps shall be fabricated of low alloy steel.

903.3.3.2 Certification. The contractor shall furnish to the engineer three copies of the manufacturer's certification that the tubular steel sign supports are in accordance with the requirements specified.

903.3.3.3 Surfaces. Galvanized material shall be handled to avoid damage to the surfaces. Any material on which the galvanizing has been bruised or broken will be rejected or may, with approval from the engineer, be repaired in accordance with Sec 1081.

903.3.4 Overhead Sign Trusses. Overhead sign trusses shall be steel or aluminum, and shall include all structural steel, structural aluminum, aluminum castings, pipe railing, gratings, supports and appurtenances above the top surface of the concrete footings. Shop drawings in accordance with Sec 1080 shall be furnished to the engineer for approval.

903.3.4.1 Testing and Certification. The contractor shall furnish to the engineer a copy of certified mill test reports on all material furnished, providing the actual chemical analysis and the actual results of physical tests. In lieu of mill test reports for secondary members, the contractor may furnish a certification from the fabricator certifying the material supplied is in accordance with the requirements of these specifications. All test reports and certifications shall be furnished to the engineer before any requests for shop inspection are made.

903.3.4.2 Steel Fabrication and Erection. Structural steel fabrication and erection shall be in accordance with Secs 712 and 1080, except as hereinafter specified.

903.3.4.3 Welder Qualifications. Before starting fabrication of structural aluminum, all welders shall be qualified in accordance with the latest edition of ANSI/AWS D1.2 – Structural Welding Code, Aluminum. The test specimens shall be made using a base metal of aluminum alloy 6061-T6 using filler metal acceptable for welding this alloy and inert gas shield arc. Requalification may be required any time there is specific reason to question the welder's ability.

903.3.4.4 Welding Inspection. All aluminum welds shall be inspected by the fabricator to verify the reliability of production as follows:

(a) Visual inspection of all welds, proof testing of welds, and sufficient destructive testing of weld samples fabricated during the production welding.

(b) Poor welding workmanship noted by visual inspection will be sufficient cause for rejection.

903.3.4.5 Contact Surfaces. Contact surfaces of aluminum flange castings shall be finished to provide at least 50 percent contact after assembly, as indicated by the Standard Machinist's Blue Test.

903.3.4.6 Fabrication of Aluminum Alloy. Fabrication of aluminum alloy material shall be in accordance with the manufacturer's recommendations and the following requirements. Flame cutting will not be permitted. All holes in castings shall be machined for final fit. Welding shall be done by the inert gas shielded arc method, and flux shall not be used. Precautions shall be taken to avoid scoring or marring of aluminum surfaces. The engineer will reject any scoring or marring that gives an objectionable appearance. Cast parts shall have all casting irregularities removed. Tubing shall be seamless, and exterior and interior surfaces shall be clean, smooth and free from slivers, laminations, grooves, cracks or other defects.

903.3.4.7 Shop Inspection. Shop inspection will be in accordance with Sec 1080.

903.3.4.8 Wind Testing. Simulated wind-shop test loading for aluminum trusses will be required as shown on the plans. The load in kips and location of the point of application shall be indicated on the shop drawings.

903.3.4.9 Handling and Storage. Handling and storage of material shall be in accordance with Sec 712. If specified, galvanized high strength bolts and washers shall be in accordance with Sec 903.2.2. Bolts shall be snugly tightened. Connections in which steel and aluminum are in contact shall be protected as shown on the plans.

903.3.4.10 Surfaces. Galvanized and aluminum material shall be handled to avoid damage to the surfaces. Any material on which the galvanizing has been bruised or broken will be rejected or may, with approval from the engineer, be repaired in accordance with Sec 1081.

903.3.5 Sign Storage, Certification and Erection.

903.3.5.1 Storage of Signs. Signs delivered for use on a project shall be stored in a manner meeting the approval of the engineer. Any sign damaged, discolored or defaced during transportation, storage or erection may be rejected.

903.3.5.2 Fabricator's Certification. The contractor shall furnish to the engineer, prior to sign erection, the fabricator's certification stating, "I hereby certify that only material and manufacturing processes in full compliance with the Missouri Department of Transportation job specification requirements were used in the fabrication of signs for Job _____, Route _____, County _____."

903.3.5.3 Erection of Signs. Sign posts shall be set vertically true to line such that the signs will be level, at the proper angle with the roadway, and with the minimum clearances shown on the plans. Mounted signs shall present a smooth flat surface varying no more than 3/8 inch from a 4-foot straightedge placed in any position on the face of the sign after erection. Signs on traffic signal posts shall be mounted with strap or clamp type sign supports as shown on the plans or as approved by the engineer. Signs shall not be mounted on light poles.

903.3.6 Delineators. Delineators shall be installed vertically and any delineator considered unfit for use by the engineer shall be removed and replaced at the contractor's expense.

903.4 Final Cleanup. Final cleanup of right of way shall be in accordance with Sec 104.11.

903.5 Method of Measurement. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity. Where required, measurements will be made in the following manner.

Measurement of concrete for footings and end supports for overhead sign trusses, tubular steel sign supports and posts bolt-down bases, including all concrete, excavation, backfilling, reinforcing steel, anchor bolts and nuts, grout and other incidental items shown on the plans, will be made to the nearest 0.1 cubic yard. Concrete for footings for embedded-type posts including perforated square steel tube, u-channel and wood shall be incidental.

903.5.1 Measurement of the weight of structural steel and pipe posts will be made to the nearest pound for each post and to the nearest 10 pounds for the total, as shown on the plans. Weights will be computed using the theoretical weight of the various sections.

903.5.2 Measurement of sign areas will be made to the nearest 1/10 square foot for each sign and to the nearest square foot for the total. The area of each sign will be that of the smallest rectangular, triangular or trapezoidal shape that will encompass the sign panel.

903.5.3 Measurement of perforated square steel tube, u-channel and wood posts will be made to the nearest linear foot for each post, as shown on the plans.

903.5.5 Measurement of delineators will be made per each.

903.6 Basis of Payment.

903.6.1 Breakaway assemblies for pipe posts and structural steel posts, including the base connection, hinge plate, fuse plate, structural bolts and all other fabrication, complete in place, are incidental, regardless of the post size or shape. Breakaway assemblies for perforated square steel tube posts, complete in place, will be paid for at the contract unit price each, regardless of the post size.

903.6.2 Highway signing will be paid for at the contract unit price for each of the items included in the contract. No direct payment will be made for incidental items necessary to complete the work, unless specifically provided as a pay item in the contract.

903.6.3 Delineator posts will be paid for at the contract unit price. No direct payment will be made for reflective sheeting or post anchors.

903.6.4 Perforate square steel tube, u-channel and wood posts will be paid for at the contract unit price for each of the items included in the contract.

903.6.5 Concrete footings will be paid for at the contract unit price.

903.6.6 Structural steel and pipe posts will be paid for at the contract unit price for each of the items included in the contract.

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SECTION 1001
GENERAL REQUIREMENTS FOR MATERIAL

1001.1 All requirements of Sec 106 will apply to material hereinafter specified. Material or processes requiring pre-qualification or pre-acceptance shall be in accordance with the applicable sections of these specifications. After approval, the material or process will be placed on either the qualified list or the pre-acceptance list (PAL) maintained on MoDOT's web site by Construction and Materials. The contractor shall select materials or processes from the appropriate list for use in MoDOT work. Final acceptance may be based on field inspection.

1001.2 All packaged material shall be plainly marked showing the quantity and nature of the contents and shall be delivered intact.

1001.3 A description of the classification of deleterious material may be found in MoDOT's *EPG 106.3.2.71* on MoDOT's web site.

1001.4 Chat will be defined as an aggregate waste material that was formed in the course of milling operations employed to recover lead and zinc from metal-bearing ore minerals.

1001.5 Crushed stone will be defined as the product obtained by the artificial reduction in the size of rock that has been mined or excavated from ledge formation. Chat as defined in Sec 1001.4 is not included.

1001.6 Gravel will be defined as the coarse granular material, generally considered as material retained on the No. 4 or No. 10 sieve, but may include finer sizes, resulting from the natural disintegration and abrasion of rock, or from processing of weakly bound conglomerate. Gravel may include such material that has been further reduced in size by artificial means.

1001.7 Porphyry will be defined as a fine-grained, dense, igneous rock generally occurring in the Missouri counties of Iron, Madison, St. Francois and their adjacent counties.

1001.8 Wet bottom boiler slag will be defined as a hard, angular by-product of the combustion of coal in wet bottom boilers.

1001.9 Sieves specified for gradation requirements shall have openings as prescribed in AASHTO M 92.

1001.10 Storage and Handling of Aggregate. Aggregate shall be produced, handled and stockpiled to minimize segregation, degradation and contamination. Regardless of the method of storage and handling, all aggregate that is segregated, degraded or contaminated to the extent that the aggregate does not meet specifications, will be considered unacceptable. Aggregate may be reconditioned by any method that produces satisfactory material.

1001.11 Approval of Aggregate Sources. All sources of aggregate shall be evaluated by the engineer for initial approval and source approval as herein prescribed, prior to acceptance of aggregate from that source.

1001.11.1 Sources of crushed stone shall be evaluated for initial approval on a ledge by ledge basis. Each exposed ledge will be identified, and the engineer will describe the ledge boundaries. Only identified ledges shall be used in the manufacture of the final product. A sample for initial approval will be required from each ledge. Resampling will be required if source approvals indicate a significant change has occurred.

1001.11.2 Source approvals will be required a minimum of every year. Source approval samples will be required for each unique combination or ledges. Resampling will be required at closer intervals if, in the judgment of the engineer, any significant change has occurred to the source. Samples of aggregate for source approval shall be taken while the engineer is present.

1001.11.3 Sources approval of natural sand, gravel and manufactured lightweight aggregate shall be evaluated as the final product .

1001.11.4 Sources of aggregate such as chat, slag and other by-products from previously produced material or any other undefined sources will be evaluated on an individual basis.

1001.12 Mining By-Product Aggregate. Chat may be furnished under the following requirements.

1001.12.1 Chat used in hot, warm, or cold mix asphalt, slurry seal, microsurfacing, or in epoxy seal delivered to MoDOT projects or property shall have a total lead content less than 4,500 ppm as determined by EPA Method 3050B, Acid Digestion of Sediments, Sludges, and Soils. Testing shall be conducted a minimum of once per year per source/location of chat.

1001.12.2 Chat used in Portland cement concrete, granular road base, flowable fill, stabilized road base, ice control material, or chip seal delivered to MoDOT projects or property shall have Synthetic Precipitation Leaching (SPLP) testing conducted using EPA SW-846 Method 1312 as required by 40 CFR 278. The leachate testing results shall not exceed the National Primary Drinking Water Standards for lead and cadmium and the gresh water chronic National Recommended Water Quality Criterion for zinc of 120 ug/1. Testing shall be conducted a minimum of once per year per source/location of chat.

1001.12.3 Test reports shall be submitted to Construction and Materials prior to chat being used on any MoDOT project or property. The report shall identify the location of the stockpile, date of sample, and specific test results as required in 40 CFR 278. Attached to the report shall be a certification from the supplier stating that the material furnished does not exceed the lead amounts specified in 40 CFR 278. The Engineer will maintain copies of laboratory test results and certifications for a minimum of three years.

1001.12.4 The supplier shall also provide a summary at the end of each calendar year that identifies the quantity and location of chat shipped for use on MoDOT projects.

1001.13 Dust Suppressants. Approved dust suppressant additives may be used during the crushing or aggregate handling process provided there is no detrimental effect to the aggregate or subsequent products made from the affected aggregate.

1001.13.1 Manufacturer and Brand Name Approval. Prior to approval and use of a dust suppressant additive, the manufacturer shall submit to Construction and Materials a certified test report from an approved independent testing laboratory showing specific test results when tested in accordance with MoDOT Test Method TM 62. The certified test report shall contain the manufacturer's name, brand name of material, date tested, date of manufacture and dosage rate of the additive used. In addition, the manufacturer shall submit to Construction and Materials a sample representing the additive tested by the independent testing laboratory and accompanied by a material data sheet, an MSDS showing the brand name, composition or description of the product, the normal and maximum recommended dosage rates, the manner of identification on containers and a copy of the infrared spectrum. The manufacturer shall certify that the material, when used at or below the maximum dosage rate, does not affect the properties of the aggregate or subsequent products made from the treated aggregate. The manufacturer shall also guarantee that as long as the material is furnished under that brand and designation, the material will be of the same composition as originally approved and will in no way be altered or changed. Upon approval of the additive, the manufacturer and brand name will be placed on a list of qualified dust suppressant additives for aggregate.

1001.13.2 The aggregate supplier shall keep the inspector advised of the use of any dust suppressant material and shall provide for the inspection of such facilities. No dust suppressant shall be applied above the manufacturer's maximum recommended rate.

1001.14 Producer Quality Management Plan

1001.14.1 Scope. This specification covers the acceptance criteria for material items produced under the producer Quality Management Plan (QMP). The producer shall develop a QM plan for MoDOT's acceptance as defined by one of the following:

a) Producer QC and membership in an industry recognized audit program.

b) Producer QC and independent QA testing.

1001.14.2 MoDOT shall perform audits including testing, inspection, and documentation review. QC testing, independent assurance testing, documentation, and conformance to product specifications may be subject to verification by MoDOT at the production facility or at the jobsite. MoDOT may audit the QMP of the producer at any time.

1001.14.3 Quality Management Requirements. The producer's QMP shall include the minimum following requirements:

a) Frequency of QC sampling and testing.

b) Frequency of the producer's QA sampling, testing and identification of a third party testing firm if applicable.

c) Organizational structure of QC staff, job duties, and responsibilities including the identification of a QC manager.

d) Method of documenting product compliance. The producer shall provide documentation of the material meeting specification.

e) Type of material to be produced.

f) An independent dispute resolution testing firm (company name), contact person, address, and phone number.

g) A process for tracking deficient work and corrective actions in accordance with Sec 1001.14.8.

h) A process for addressing non-conforming work and corrective action requests in accordance with Sec 1001.14.9.

i) A list of hold points for QC in accordance with Sec 1001.14.10.

j) A list of MoDOT hold points in accordance with Sec 1001.14.10.

1001.14.4 Third Party Resolution. The third party shall be independent of the producer, contractor, MoDOT, consultants, and all project subcontractors or suppliers. All testing of material for dispute resolution shall be performed by a laboratory that is AASHTO Accreditation Program certified in the areas of the material being tested.

1001.14.5 Testing Personnel. Where applicable, testing shall be performed by individuals who are certified by the MoDOT Technician Certification Program or an accredited laboratory.

1001.14.6 Record Retention. The producer shall maintain copies of the plant QMP, applicable AASHTO, ASTM, MoDOT, and/or LPA standards and approved production drawings. The records shall include information related to all components used to produce final product such as aggregate tests, steel certifications and mill tests, PAL numbers, QC test results and other material component documentation such as the bill of lading for material used in the production of the finished product. Records related to QC tester qualifications shall be retained. Records shall be retained for a minimum of three years and provided to the engineer in electronic form upon request.

1001.14.7 Producer Quality Assurance. When required, QA testing by a third party shall be performed at the frequency required in each specification. Participation in an industry recognized auditing organization may be substituted for a third party QA testing.

1001.14.8 Control fo Deficient Work. Deficient work is considered work that is found to be not specification compliant by QC. Deficient work may be corrected to be specification compliant as defined in the QMP. It is the responsibility of QC to identify, document, and correct deficient work. When QC personnel discovers deficient work that cannot be corrected the work becomes non-conforming. For non-conforming work, QC shall submit a Non-Conformance Report (NCR) to the engineer and contractor for acceptance or rejection.

1001.14.9 Control of Non-Conforming Work. Non-conforming work are items that are not compliant with the specifications and have gone through the QC process undiscovered or uncorrected. When non-conforming work is identified by QC, independent QA, MoDOT QA testing, or auditing of the contractor, a solution will be proposed by the producer in writing and approved or rejected by both the engineer and contractor.

1001.14.9.1 Reoccurring non-conforming work shall be addressed by the producer and Construction and

Materials Division by one of the following methods:

a) The producer develops a corrective action plan.

b) Alteration of the QMP by the producer with the engineer's approval.

c) Review producer's QC results with producer's associated independent organization. Producer to be re-audited by independent organization.

1001.14.10 Hold Points

1001.14.10.1 Hold points are events that require approval prior to continuation of work. Hold points occur at definable stages of work or progress phases when the succeeding work depends on acceptance of the preceding work. QC staff shall provide complete inspection reports and checklist to MoDOT personnel prior to all MoDOT hold points.

1001.14.10.2 QC hold points are established by the QMP for compliance verification prior to any MoDOT hold point. At a minimum, a QC hold point shall occur just prior to or simultaneous with each MoDOT hold point.

1001.14.10.3 A list of MoDOT hold points will be determined by the engineer. The engineer may make changes to the MoDOT hold point list at any time. Following a MoDOT hold point inspection, all non-conforming work identified by MoDOT shall be corrected prior to continuing work and a new hold point shall be scheduled.

1001.14.10.4 MoDOT may waive hold points at any time. Waivers will be in writing sent to the producer as soon as possible from the engineer.

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SECTION 1002
AGGREGATE FOR ASPHALTIC CONCRETE

1002.1 Scope. This specification covers aggregate to be used in asphaltic concrete.

1002.2 Coarse Aggregate.

1002.2.1 All coarse aggregate shall consist of sound, durable rock, free from cemented lumps or objectionable coatings. When tested in accordance with AASHTO T 96, the percentage of wear shall not exceed 50. The percentage of deleterious substances shall not exceed the following values, and the sum of percentages of all deleterious substances shall not exceed 8.0 percent.

Deleterious Material	Percent by Weight
Deleterious Rock	8.0
Shale	1.0
Other Foreign Material	0.5

1002.2.1.1 The above requirements apply to combined aggregates during production when used in accordance with Sec 403.

1002.2.1.2 Crushed stone shall be obtained from rock of uniform quality. Rock tested from any combination of ledges for source approval, and trial mix samples, shall meet the following criteria.

Property	Value
Los Angeles Abrasion, AASHTO T 96, percent loss, max	50
Absorption, AASHTO T 85, percent, max	4.0

1002.2.2 Gravel aggregate shall be washed sufficiently to remove any objectional coating and shall meet the following criteria for source approval and trial mix samples.

Property	Value
Los Angeles Abrasion, AASHTO T 96, percent loss, max	50
Absorption, AASHTO T 85, percent, max	5.5

1002.2.3 Steel slag consisting principally of a fused mixture of oxides and silicates shall be a synthetic aggregate produced as a by-product of basic oxygen, electric or open hearth steel making furnaces. The steel slag shall be aged at least three months after crushing and screening. Steel slag, which has been previously crushed, screened, and aged three months will not be required to receive additional aging. Steel slag from one source shall not be blended with steel slag from a different source.

1002.3 Fine Aggregate.

1002.3.1 Fine aggregate for asphaltic concrete shall be a fine, granular material passing the 3/8-inch sieve, naturally produced by the disintegration of rock of a siliceous nature and/or manufactured by the mechanical reduction of sound durable rock in accordance with Secs 1002.2.1.2 and 1002.2.2. With written approval from the engineer and compliance with this specification, chat sand produced from flint chat in the Joplin area, dolomite chat as produced in the southeast lead belt area, fines manufactured from igneous rock, chert gravel or wet bottom boiler slag may be used as fine aggregate for asphaltic concrete. Fine aggregate shall be free from cemented or conglomerated lumps and shall not have any coating or injurious material. The percentage of deleterious substances shall not exceed the following values:

Item	Percent by Weight
Clay lumps and shale	1.0
Total lightweight particles, including coal and lignite	0.5
Other deleterious substances	0.1

1002.3.2 The total lightweight particle requirement will not apply to wet bottom boiler slag, angular chert sand or manufactured sand.

1002.4 Mineral Filler. Mineral filler shall be in accordance with AASHTO M 17. Prior to approval and use of mineral filler for SMA mixtures, the manufacturer shall submit to Construction and Materials a certified test report from an approved independent testing laboratory showing specific test results when tested in accordance with applicable sections of AASHTO M17 and MoDOT Test Method TM-73. The certified test report shall contain the manufacturer's name, product, date tested and date of manufacture. In addition, the manufacturer shall submit to Construction and Materials a sample representing the mineral filler tested by the independent testing laboratory and accompanied by a material data sheet and an MSDS showing the product and composition or description of the product. The manufacturer shall guarantee that as long as the material is furnished under that brand and designation, the material will be of the same composition as originally approved and will in no way be altered or changed. Upon approval of the mineral filler, the manufacturer and product will be placed on a list of qualified SMA mineral fillers.

1002.5 Hydrated Lime. Hydrated lime shall be thoroughly dry and free of lumps. Hydrated lime shall be in accordance with AASHTO M 303, Type I or II, except the gradation shall be determined in accordance with AASHTO T 37.

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SECTION 1003
AGGREGATE FOR SEAL COATS

1003.1 Scope. This specification covers aggregate to be used for seal coat.

1003.2 Aggregate. Aggregate for seal coats shall consist of sound durable rock particles, free from objectionable coatings.

1003.2.1 When tested in accordance with AASHTO T 96, the percentage of wear shall not exceed 50 percent. The sum of the percentages of all deleterious substances shall not exceed 2.0 percent for Grade A aggregate, 4.0 percent for Grade B or 8.0 percent for Grade C aggregate, and the aggregate shall meet the following criteria:

Property	Grade A1 & A2 Aggregate	Grade B1 & B2 Aggregate	Grade C Aggregate
Deleterious rock, percent by weight, max	2.0	4.0	8.0
Shale, percent by weight, max	0.5	0.75	1.0
Other foreign material, percent by weight, max	0.5	0.5	0.5
Two fractured faces, percent, min	100	100	100
Thin, elongated particles, ASTM D 4791, 5:1, percent, max[a]	10	N/A	N/A
Micro-Deval, AASHTO T 327, percent, max	18	20	N/A

[a]Test material retained on the No. 4 sieve.

1003.2.2 The aggregate shall be in accordance with the following requirements for the grade specified in the contract:

Sieve Size	Grade A1 Aggregate	Grade A2 Aggregate	Grade B1 Aggregate	Grade B2 Aggregate	Grade C Aggregate
	Percent Passing by Weight	Percent Passing by Weight	Percent Passing by Weight	Percent Passing by Weight	Percent Passing by Weight
1/2"	100	100	100	100	100
3/8"	97-100	100	95-100	100	95-100
1/4"	--	97-100	--	95-100	--
No. 4	0-25	--	0-30	--	0-35
No. 8	--	0-30	--	0-30	--
No. 200[a, b]	0-1.0	0-1.5	0-2	0-2.5	0-2

[a]The percent passing the No. 200 sieve may be increased by 1.0 percent provided the aggregate is pre-coated with bituminous material.
[b]These values may be raised by 0.5% at the destination to account for handling provided the material meets this gradation at the source.

1003.2.3 Crushed stone shall be obtained from rock of uniform quality. Rock from individual ledges and gravel tested for initial source approval shall meet the following criteria:

Property	Grade A1 & A2 Aggregate	Grade B1 & B2 Aggregate	Grade C Aggregate
Absorption, AASHTO T 85, percent, max	2.0	4.0	4.0

1003.2.4 Lightweight aggregate shall be in accordance with the following requirements for the grade specified in the contract:

Property	Grade A1 & A2 Aggregate	Grade B1 & B2 Aggregate	Grade C Aggregate
Absorption, ASSHTO T 85, percent, max	n/a	n/a	n/a
Los Angeles Abrasion for Lightweight Aggregate, MoDOT Test Method TM 78, percent, max	50	50	50

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SECTION 1004
GRADED AGGREGATE FOR BITUMINOUS SURFACES

1004.1 Scope. This specification covers aggregate to be used in bituminous surfacing.

1004.2 Coarse Aggregate.

1004.2.1 All coarse aggregate shall consist of sound, durable rock, free from cemented lumps or objectionable coatings. The percentage of deleterious substances shall not exceed the following values and the sum of percentages of all deleterious substances shall not exceed 8.0 percent.

Deleterious Material	Percent by Weight
Deleterious Rock	8.0
Mud Balls and Shale Combined	2.0
Clay, uniformly dispersed	3.0
Other Foreign Material	0.5

1004.2.1.1 The above requirements apply to combined aggregates during production when used in accordance with Sec 401 and 402.

1004.2.1.2 If a density requirement is specified for asphaltic concrete, the total quantity of chert in each size or fraction of produced crushed stone aggregate, including that permitted as deleterious, shall not vary by more than 10 percentage points from the quantity present in the aggregate used in the approved laboratory job mixtures.

1004.2.1.3 Crushed stone shall be produced from rock of uniform quality. Rock tested from any combination of ledges for source approval and trial mix samples shall meet the following criteria.

Property	Value
Los Angeles Abrasion, AASHTO T 96, percent loss, max.	55
Absorption, AASHTO T 85, percent, max.	4.5

1004.2.2 Gravel aggregate shall be washed sufficiently to remove any objectionable coating and shall meet the following criteria for source approval and trial mix samples.

Property	Value
Los Angeles Abrasion, AASHTO T 96, percent loss, max.	55
Absorption, AASHTO T 85, percent, max.	5.5

1004.2.3 Steel slag consisting principally of a fused mixture of oxides and silicates shall be a synthetic aggregate produced as a by-product of basic oxygen, electric or open hearth steel making furnaces. The steel slag shall be aged at least three months after crushing and screening. Steel slag, which has been previously crushed, screened, and aged three months will not be required to receive additional aging. Steel slag from one source shall not be blended with steel slag from a different source.

1004.3 The aggregate shall be in accordance with the following requirements for the grade specified in the contract. If grade is not specified, any listed grade may be used.

Percent Passing								
		Sieve Size						
Grade	Type of Material	3/4 in.	1/2 in.	3/8 in.	#4	#8	#30	#200
1	Crushed Stone or Porphyry	100	95 – 100	65 – 95	20 –55	2 – 20	….	0 – 5
2	Gravel	100	95 – 100	….	40 – 80	15 – 50	0 – 30	0 – 5
3	Chat	100	95 – 100	….	45 – 85	30 – 60	0 – 30	0 – 5

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SECTION 1005
AGGREGATE FOR CONCRETE

1005.1 Scope. This specification covers aggregate to be used for concrete construction.

1005.2 Coarse Aggregate.

1005.2.1 All coarse aggregate for concrete shall consist of sound, durable rock, free from objectionable coatings and frozen and cemented lumps. The percentage of deleterious substances shall not exceed the following values, and the sum of percentages of all deleterious substances, exclusive of Items 5 and 6, shall not exceed 6.0 percent. For crushed stone, the percentage of wear shall not exceed 50 when tested in accordance with AASHTO T 96.

Deleterious Material	Percent by Weight
Deleterious Rock	6.0
Shale	1.0
Chert in Limestone	4.0
Other Foreign Material	0.5
Material Passing No. 200 Sieve Gradations D & E	2.5[a]
Thin or Elongated	5.0

[a] Value may be raised to 3.0 percent, providing the material passing the #200 sieve in the fine aggregate is less than or equal to 1.0 percent.

1005.2.1.1 The above requirements will apply to each size or fraction of aggregate produced.

1005.2.1.2 Crushed stone shall be obtained from rock of uniform quality. Rock tested for initial approval shall be in accordance with the criteria below. Source approval and production samples shall also meet the following criteria:

Property	Value
Los Angeles Abrasion, AASHTO T 96, percent loss, max	50
Absorption, AASHTO T 85, percent, max.: (a) Portland Cement Concrete Pavement (b) Portland Cement Concrete Masonry	 -- 3.5
Soundness, MoDOT Test Method TM 14, percent loss, max.: (a) Portland Cement Concrete Pavement (b) Portland Cement Concrete Masonry	 -- 18.0
Durability Factor, AASHTO T 161 Procedure B, percent, min: (a) Portland Cement Concrete Pavement (b) Portland Cement Concrete Masonry	 75[a] --

[a] Approval will be based on maximum aggregate size produced that meets durability requirements.

1005.2.1.3 Gravel shall be washed and shall be in accordance with the criteria below for initial approval. Source approval and production samples shall also meet the following criteria:

Property	Value
Los Angeles Abrasion, AASHTO T 96, percent loss, max.	45
Absorption, AASHTO T 85, percent, max.	4.5
Soundness, MoDOT Test Method TM 14, percent loss, max.	18.0

1005.2.1.4 The engineer reserves the right to use additional test methods, such as ASTM C 586, AASHTO T 161 or other appropriate tests, to measure the soundness and durability of aggregate for use in concrete when deemed necessary.

1005.2.2 Coarse aggregate for concrete pavement or base course shall be crushed stone or porphyry.

1005.2.3 Grade F Aggregate. Coarse aggregate for Portland cement concrete pavement, base and approach slabs for bridges that is not produced from the Burlington, Keokuk, Cedar Valley (formerly Callaway) or Warsaw limestone formations, which is obtained from sources in the following areas shall have a maximum top size of ¾ inch:

(a) State of Kansas, Iowa and Nebraska.

(b) Counties of Missouri – Adair, Andrew, Atchison, Bates, Benton, Buchanan, Caldwell, Carroll, Cass, Cedar, Chariton, Clay, Clinton, Daviess, DeKalb, Gentry, Grundy, Harrison, Henry, Holt, Jackson, Johnson, Lafayette, Linn, Livingston, Mercer, Macon, Nodaway, Pettis, Platte, Putnam, Randolph, Ray, St. Clair, Saline, Schuyler, Sullivan, Vernon and Worth.

1005.2.4 Coarse aggregate for concrete for structures, except as specified in Sec 1005.2.5, may be gravel or crushed stone. Coarse aggregate for Class B, B-1, B-2, MB-2 or Seal concrete shall be in accordance with either Gradation D or E. Coarse aggregate for Class A-1 concrete shall be in accordance with Gradation E.

Gradation D	Percent by Weight
Passing 1-inch sieve	100
Passing 3/4-inch sieve	85-100
Passing 3/8-inch sieve	15-55
Passing No. 4 sieve	0-10

Gradation E	Percent by Weight
Passing 3/4-inch sieve	100
Passing 1/2-inch sieve	70-100
Passing 3/8-inch sieve	30-70
Passing No. 4 sieve	0-20
Passing No. 8 sieve	0-6

1005.2.5 Coarse aggregate for ornamental concrete shall be crushed stone in accordance with Sec 1005.2.4, Gradation E. However, the use of coarse aggregate containing more than 2 percent chert will not be permitted.

1005.3 Fine Aggregate.

1005.3.1 Fine aggregate for concrete shall be a fine granular material naturally produced by the disintegration of rock of a siliceous nature, or shall be manufactured from an approved limestone or dolomite source as defined in Sec 1005.2. By specific approval from the engineer, chat sand produced from flint chat in the Joplin area or fines manufactured from igneous rock or chert gravel may be used. Fine aggregate shall be free from cemented or conglomerated lumps and shall not have any coating of injurious material. The percentage of deleterious substances shall not exceed the following values:

Deleterious Material	Percent by Weight
Clay Lumps and Shale	0.25
Coal and Lignite	0.50
Total Lightweight Particles, Including Coal and Lignite	0.50
Material Passing No. 200 Sieve (a) Natural Sand (b) Manufactured Sand	 2.0 4.0
Other Deleterious Substances	0.10

1005.3.2 The total lightweight particle requirement will not apply to angular chert sand or manufactured sand.

1005.3.3 Fine aggregate shall produce a mortar having a seven-day compressive strength of at least 90 percent of a control mortar developed at the same proportions, using standard Ottawa sand. Tests shall be performed in accordance with AASHTO T 106. Cement used in the tests shall be Type I, in accordance with Sec 1019. AASHTO T 106 may be waived provided the fine aggregate produces a glass color standard lighter than Organic Platte No. 3, in accordance with AASHTO T 21.

1005.3.4 Fine aggregate for ornamental concrete shall be free from coal and lignite material when tested in accordance with AASHTO T 113.

1005.3.5 All fine aggregate for PCCM shall meet the following gradation requirements:

Sieve	Percent by Weight
Passing 3/8-inch sieve	100
Passing No. 4 sieve	95-100
Passing No. 8 sieve	70-100
Passing No. 16 sieve	45-90
Passing No. 30 sieve	15-65
Passing No. 50 sieve	5-30
Passing No. 100 sieve	0-10

1005.4 Lightweight Aggregate.

1005.4.1 Lightweight aggregates shall be prepared by expanding, calcining, or sintering argillaceous material such as clay, shales, and slates.

1005.4.2 Grading The grading shall be uniform and conform to the requirements given in Table I.

1005.4.3 Unit Weight. The unit weight of lightweight aggregates shall not exceed the following:

Dry, Loose Weight, Max. lb/cu ft
Fine Aggregate 70
Coarse Aggregate 55

1005.4.3.1 Uniformity of Weight. If the unit weight of any shipment of lightweight aggregate when tested in accordance with AASHTO T 19 is found to vary by more than 10 percent from that of the sample submitted for source approval, the aggregate shipment may be rejected.

1005.4.4 Soundness. When tested in accordance with AASHTO T 104, the loss of lightweight fine or coarse aggregate in 5 cycles of the accelerated soundness test shall not exceed 8 percent if sodium sulfate is used or 10 percent if magnesium sulfate is used.

1005.4.5 Drying Shrinkage. The drying shrinkage of concrete specimens prepared and tested in accordance with AASHTO M 195, shall not exceed 0.07 percent.

1005.4.6 Sampling. Samples of fine and coarse aggregate shall be furnished by the contractor for source approval. Other samples shall be taken from shipments at intervals specified by the engineer.

Table I
Grading Requirements for Lightweight Aggregate

		Percent Passing Sieve Sizes									
Grade	**Size**	**1 1/2"**	**1"**	**3/4"**	**1/2"**	**3/8"**	**No. 4**	**No. 8**	**No. 16**	**No. 50**	**No. 100**
Fine Aggregate											
No. 4 to 0		---	---	---	---	100	85-100	---	40-80	10-35	5-20
Coarse Aggregate											
1	1" to 1/2"	100	90-100	20-55	0-10	0-5	---	---	---	---	---
2	1" to No. 4	100	95-100	---	25-60	---	0-10	0-5	---	---	---
3	3/4" to No. 4	---	100	90-100	---	20-55	0-10	0-5	---	---	---
4	1/2" to No. 4	---	---	100	90-100	40-70	0-15	0-5	---	---	---
5	3/8" to No. 8	---	---	---	100	85-100	10-30	0-10	0-5	---	---

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SECTION 1006
AGGREGATE FOR SURFACING

1006.1 Scope. This specification covers aggregate to be used for surfacing.

1006.2 Aggregate for surfacing shall be composed durable particles of rock or reclaimed concrete. When tested in accordance with AASHTO T 96, the wear shall not exceed 60 percent. The deleterious substances shall not exceed the following values and the sum of percentages of all deleterious substances shall not exceed 12 percent.

Deleterious Material	Percent by Weight
Deleterious Rock and Shale	12.0
Mud Balls	5.0
Other Foreign Material	2.0

1006.3 Aggregate shall be in accordance with the following for the grade specified in the contract:

Grade	Type of Material	Percent Passing					
		Sieve Sizes					
		1 in.	3/4 in.	3/8 in.	No. 4	No. 10	No. 200
A[a]	Gravel	100	80-100	---	60[b]	10-35	0-10
B[a]	Crushed Stone or Reclaimed Concrete	100	---	65[b]	---	5-25	---
C	Chat	100	---	---	80[b]	45[b]	---

[a]Type 1 Aggregate for Base may be used, except all material shall be in accordance with Sec 1007.
[b]Indicates maximum permitted.

1006.4 If the quantity is of a size that makes sampling not practical, this material may be accepted on certification or visual inspection as allowed in Sec 106.1.4.

1006.4.1 If the quantity is less than 500 tons, a commercially available grade of aggregate may be accepted on certification or visual inspection.

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SECTION 1007
AGGREGATE FOR BASE

1007.1 Scope. This specification covers aggregate to be used for base.

1007.2 Type 1 Aggregate.

1007.2.1 Type 1 aggregate for base shall consist of crushed stone, sand and gravel or reclaimed asphalt or concrete. The aggregate shall not contain more than 15 percent deleterious rock and shale. The fraction passing No. 40 sieve shall have a maximum plasticity index of six. Any sand, silt and clay and any deleterious rock and shale shall be uniformly distributed throughout the material.

1007.2.2 The aggregate shall be in accordance with the following gradation requirements:

Sieve	Percent by Weight
Passing 1-inch	100
Passing 1/2-inch	60-90
Passing No. 4	35-60
Passing No. 30	10-35

1007.3 Type 5 Aggregate.

1007.3.1 Type 5 aggregate for base shall consist of crushed stone, sand and gravel or reclaimed asphalt or concrete. The aggregate shall not contain more than 15 percent deleterious rock and shale. The fraction passing the No. 40 sieve shall have a plasticity index not to exceed six. Any sand, silt and clay, and any deleterious rock and shale shall be uniformly distributed throughout the material.

1007.3.2 Type 5 aggregate shall be in accordance with the following gradation requirements:

Sieve	Percent by Weight
Passing 1-inch	100
Passing 1/2-inch	60-90
Passing No. 4	35-60
Passing No. 30	10-35
Passing No. 200	0-15

1007.4 Type 7 Aggregate.

1007.4.1 Type 7 aggregate for base shall consist of crushed stone, sand and gravel, or reclaimed asphalt or concrete. The aggregate shall not contain more than 15 percent deleterious rock and shale. The fraction passing the No. 40 sieve shall have a plasticity index not to exceed six. Any sand, silt and clay, and any deleterious rock and shale shall be uniformly distributed throughout the material.

1007.4.2 Type 7 aggregate shall be in accordance with the following gradation requirements:

Sieve	Percent by Weight
Passing 1 1/2-inch	100
Passing 1-inch	70-100
Passing No. 8	15-50
Passing No. 200	0-12

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SECTION 1009
AGGREGATE FOR DRAINAGE

1009.1 Scope. This specification covers material requirements for aggregate as specified for various drainage systems.

1009.2 Quality. All aggregate shall be in accordance with Sec 1002, and shall be of the material and gradation specified herein.

1009.3 Gradation.

1009.3.1 Grade 1. The aggregate shall be sand and shall be in accordance with Sec 1005.3.

1009.3.2 Grade 2. The aggregate shall be a washed sand-gravel mixture in accordance with the following gradation requirements:

Sieve Size	Percent by Weight
1-inch	100
1/2-inch	55-90
No. 10	25-50
No. 40	10-30
No. 100	0-10
No. 200	0-3

1009.3.3 Grade 3. The aggregate shall be gravel, crushed stone, reclaimed concrete, or other approved material meeting on the gradation requirements for Sec 1005.2.

1009.3.4 Grade 4. The aggregate shall be crushed limestone or dolomite or reclaimed concrete, in accordance with the following gradation requirements:

Gradation A	
Sieve Size	**Percent by Weight**
1 1/2-inch	100
1-inch	95-100
1/2-inch	25-60
No. 4	0-10
No. 8	0-5

Gradation B	
Sieve Size	**Percent by Weight**
1-inch	100
3/4-inch	90-100
3/8-inch	20-55
No. 4	0-10
No. 8	0-5

1009.3.5 Grade 5. The aggregate shall be crushed limestone or dolomite or reclaimed concrete, in accordance with the following gradation requirements:

Sieve Size	Percent by Weight
1 1/2-inch	100
1-inch	95-100
1/2-inch	60-80
No. 4	40-55
No. 8	5-25
No. 16	0-8
No. 50	0-5

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SECTION 1010
SELECT GRANULAR BACKFILL FOR STRUCTURAL SYSTEMS

1010.1 Scope. This specification covers backfill material used as part of a mechanically stabilized earth wall system or in other applications requiring an engineered backfill material.

1010.2 Material. Aggregate used for backfill material may consist of gravel, crushed stone, reclaimed concrete, or other approved material meeting the requirements of this Section. The requirements for the gradation of the material, the general makeup of the material, and the testing of the material will apply to all potential uses of this material, unless otherwise specified on the plans or in the contract documents. The electrochemical requirements listed in this specification will apply to backfill material used for mechanically stabilized earth wall systems.

1010.3 General.

1010.3.1 To ensure proper functioning of the structure, the backfill material used for structural applications shall be in accordance with the following:

Sieve Size	Percent Passing by Weight
4-inch	100
No. 40	0-60
No. 200	0-10*

* May be increased to 15% if gradation sample is obtained from the compacted backfill material.

1010.3.2 The frequency of sampling of the backfill material necessary to assure gradation control throughout construction shall be as directed by the engineer.

1010.3.3 The plasticity index (PI) of the backfill material shall be determined in accordance with AASHTO T 90 and shall not exceed 6.

1010.3.4 The angle of internal friction for the backfill material shall be no less than 34 degrees. No testing will be required whenever 80 percent of the particle sizes are greater than 0.75 inch or whenever the backfill material consists entirely of crushed stone. When testing is required, testing shall be in accordance with one of the tests specified below.

1010.3.5 The angle of internal friction may be determined by the direct shear test in accordance with AASHTO T 236. This test shall be performed on the portion of the material finer than the No. 10 sieve, utilizing a sample of the material compacted to 95 percent of the maximum density as determined by AASHTO T 99, Methods C or D (with oversize correction as outlined in Note 7 in that publication), at optimum moisture content.

1010.3.6 For select granular backfill other than crushed stone the organic content of the backfill material shall be less than or equal to one percent and shall be measured in accordance with AASSHTO T 267 for material finer than the No. 10 sieve.

1010.4 Electrochemical Requirements. The following electrochemical requirements will apply to this backfill material whenever the material is used for mechanically stabilized earth wall systems.

1010.4.1 Metallic Soil Reinforcement.

1010.4.1.1 When metallic soil reinforcements are used, the backfill material shall be in accordance with the electrochemical requirements as follows:

Requirement	Test Method
Resistivity > 2000 ohm-cm	AASHTO T 288
pH of 5-10**	AASHTO T 289
Chlorides ≤ 100 ppm	AASHTO T 291
Sulfates ≤ 200 ppm	AASHTO T 290*

* Water soluble sulfates shall be tested in accordance with

AASHTO T 290 Method A-Gravimetric Method with the following modifications: Per section 13, follow subsection 13.1 through 13.3 as stated in the test procedure. Transfer 250 ml of extracted sample to a 400-ml plastic beaker and place in a 90 C oven for 30 minutes. A blank should be run concurrently with the test sample using 250 ml of DI water. After 30 minutes, add 10 ml of barium chloride (100g/L) to test sample and blank. Place test sample and blank back into a 90 C oven and let samples digest for 12 to 24 hours. Filter through a retentive paper, wash the precipitate thoroughly with hot DI water, place the paper and contents in a weighted porcelain crucible, and slowly char and consume the paper without inflaming. Ignite at 1000 C for 2 hours, cool in a desiccator, and determine the mass as grams of barium sulfate. Subtract the blank and convert grams of barium sulfate to mg/kg of sulfate ion content.
** Use pH of 5-9 for aluminized soil reinforcement.

1010.4.1.2 Whenever the resistivity of the backfill material is greater than or equal to 5000 ohm-cm, the chlorides and sulfates requirements may be waived.

1010.4.1.3 Resistivity shall be tested by the contractor in accordance with AASHTO T 288. Resistivity result will be defined by the minimum resistivity noted during the test. Resistivity shall be tested a minimum of once per 30,000 tons, by the Contractor and a minimum of once by quality assurance representing the engineer. Minimum sample frequency is per project, per source, per product. For samples that do not meet specifications a split sample shall be obtained from the source stockpile for final comparison testing. Contact the State Construction and Materials Engineer for acceptance.

1010.4.2 Polymeric Soil Reinforcement. When polymeric soil reinforcements are used, the backfill material shall be in accordance with the electrochemical requirements as follows:

Requirement	Test Method
pH of 4.5-9	AASHTO T 289

1010.5 Certification and Acceptance.

1010.5.1 The contractor shall furnish to the engineer written certification that the backfill material provided complies with the applicable sections of this specification. Test results in the certification shall be within one year from the start of construction of each wall. Copies of all test results for tests performed to ensure compliance with this specification shall be furnished to the engineer. The engineer will assure a minimum of one complete set of quality assurance tests for each complete certification supplied by the contractor, within the same time constraints.

1010.5.2 Acceptance will be based on the written certification, accompanying test reports, and any applicable tests performed as directed by the engineer.

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SECTION 1011
GEOTEXTILE

1011.1 Scope. This specification covers geotextile for use in subsurface drainage, sediment control and erosion control, or as a permeable separator.

1011.2 Acceptance. Acceptance of the material will be based on the manufacturer's certification and upon the results of such tests as may be performed by the engineer.

1011.3 Material. Geotextiles shall be in accordance with the physical and chemical requirements of AASHTO M 288 for the specified application, except as modified in this specification.

1011.3.1 Subsurface Drainage Geotextile. Subsurface drainage geotextile shall be used in subsurface drainage as a filter to protect drainage media from clogging with fines from adjacent soil. Typical applications include the lining of drainage trenches and the wrapping of drainpipes.

1011.3.1.1 The minimum permittivity shall be 1.0 sec-1.

1011.3.1.2 The material shall be AASHTO Class 2.

1011.3.2 Temporary Silt Fence Geotextile. Temporary silt fence geotextile shall be used in supported or non-supported sediment control fencing.

1011.3.3 Permanent Erosion Control Geotextile. Permanent erosion control geotextile shall be used when the erosion control measure will not be removed, such as erosion control of slopes and channels when placed under a rock blanket, rock ditch liner, etc.

1011.3.3.1 The minimum permittivity shall be 1.0 sec-1.

1011.3.3.2 The material shall be either AASHTO Class 1 or Class 2.

1011.3.4 Separation Geotextile. Separation geotextile shall be used as a separation material to prevent mixing of dissimilar material, and to control migration of backfill material through joints in structural elements.

1011.3.4.1 The minimum permittivity shall be 1.0 sec-1.

1011.3.4.2 The material shall be AASHTO Class 1.

1011.3.5 Erosion Control Blankets. Erosion control blankets (ECB) shall be categorized based on performance testing for the C-factor by ASTM D6459 and physical testing for the minimum tensile strength by ASTM D5035. Erosion control blankets shall meet the following requirements.

ECB Type	Description	Material Composition	Longevity	Max Slope	C-factor	Minimum Tensile Strength
1.A	Mulch Control Nets	A photodegradable synthetic mesh or woven biodegradable natural fiber netting	3 months	5:1	≤ 0.10 @ 5:1	5 lb/ft
1.B	Netless Rolled Erosion Control Blankets	Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form an RECP	3 Months	4:1	≤ 0.10 @ 4:1	5 lb/ft
1.C	Light-Weight Double-Net Erosion Control Blankets	Natural and/or polymer fibers mechanically bound together by two rapidly degrading, synthetic or natural fiber netting	3 months	3:1	≤ 0.15 @ 3:1	50 lb/ft
1.D	Heavy Double-Net Erosion Control Blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings	3 months	2:1	≤ 0.20 @ 2:1	75 lb/ft
2.A	Mulch Control Nets	A photodegradable synthetic mesh or woven biodegradable natural fiber netting	12 months	5:1	≤ 0.10 @ 5:1	5.0 lb/ft
2.B	Netless Rolled Erosion Control	Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form an RECP	12 months	4:1	≤ 0.10 @ 4:1	5.0 lb/ft
2.C	Light-Weight Double-Net	Natural and/or polymer fibers mechanically bound together by two	12 months	3:1	≤ 0.15	50 lb/ft

	Erosion Control Blankets	degrading, synthetic or natural fiber netting			@ 3:1	
2.D	Heavy Double-Net Erosion Control Blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two degrading, synthetic or natural fiber netting	12 months	2:1	≤ 0.20 @ 2:1	75 lb/ft
3.A	Mulch Control Nets	A slow degrading synthetic mesh or woven natural fiber netting	24 months	5:1	≤ 0.10 @ 5:1	25 lb/ft
3.B	Erosion Control Blankets	An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix	24 months	1.5:1	≤ 0.25 @ 1.5:1	100 lb/ft
4	Erosion Control Blankets	An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix	36 months	1:1	≤ 0.25 @ 1:1	125 lb/ft

1011.3.5.1 Anchors. Anchors as recommended by the erosion control product manufacturer shall be used.

1011.3.5.2 Test Methods.

1011.3.5.2.1 ASTM D6459 testing shall be performed on loam soil. The calculated C-factor for the tested slope shall be determined from the reported C-factor regression equation using an erosivity value of 224. Type 1.A, Type 2.A, and Type 3.A mulch control nets must be tested in conjunction with pre-applied mulch material. Minimum tensile strength shall be tested in accordance with ASTM D5035 in the machine direction.

1011.3.5.2.2 Texas Department of Transportation and the Texas Transportation Institute testing for product acceptance on 3:1 or 2:1 sand may be substituted for acceptance of ASTM D6459 on loam soil.

1011.3.5.3 Pre-Qualification List: Prior to use, the manufacturer shall furnish a manufacturer's certification to the Construction and Materials division stating the name of the manufacturer, the chemical composition of the filaments or yarns and certifying that the material supplied is in accordance with this specification. The certification shall include recent results of tests for all specified requirements. Final acceptance of erosion control blankets will be based on certification and field performance.

1011.3.5.4 Acceptance. Final acceptance of erosion control blankets will be based on the erosion control blankets being utilized as pre-qualified and actual field performance.

1011.3.6 Turf Reinforcement Mats. Turf reinforcement mats (TRM) shall be certified by the manufacturer for open flow channels and shall meet the following calculated shear stress:

TRM Type	Calculated Shear Stress (lbs/ft^2)
Type 1	3.5 – 6
Type 2	6.1 – 8
Type 3	8.1 – 10
Type 4	10.1 or greater

1011.3.6.1 Anchors. Anchors as recommended by the product manufacturer shall be used.

1011.3.6.2 Test Methods. Turf reinforcement mats tested and evaluated by either ASTM D6460 or by the Texas Department of Transportation and Texas Transportation Institute independent testing. The test results must indicate the maximum allowable shear strength. ASTM D6460 shall be tested on the loam soil.

1011.3.6.3 Pre-Qualification List: Prior to use, the manufacturer shall furnish a manufacturer's certification to the Construction and Materials division stating the name of the manufacturer, the chemical composition of the filaments or yarns and certifying that the material supplied is in accordance with this specification. The certification shall include recent results of tests for all specified requirements. Final acceptance of turf reinforcement mat will be based on certification and field performance.

1011.3.6.4 Acceptance. Final acceptance of turf reinforcement mats will be will be based on the turf reinforcement mat being utilized as pre-qualified and actual field performance..

1011.3.7 Unbonded Concrete Overlay Interlayer. Unbonded concrete overlay interlayers shall have the following material properties:

Property	Requirement	Test Method
Fabric Type	Non-woven Geotextile	
Mass per unit area	Min. 14.8 oz/sq.yd	ASTM D 5261
Thickness under load (pressure)	0.29 psi: ≥ 0.12 in 2.9 psi: ≥ 0.10 in 29 psi: ≥ 0.04 in	ASTM D 5199, modified under loads of 0.29, 2.9, and 29 psi
Tensile strength	≥ 685 lb/ft	ASTM D 4595
Maximum elongation	≤ 130%	ASTM D 4595
Water permeability in normal direction under load (pressure)	$\geq 3.3\times10^{-4}$ ft/s [under pressure of 2.9 psi]	ASTM D 5493
Water permeability in the plane direction of the fabric (transmittivity) under load (pressure)	$\geq 1.6\times10^{-3}$ ft/s [under pressure of 2.9 psi] $\geq 6.6\times10^{-4}$ ft/s [under pressure of 29 psi]	ASTM D 6574
Weather resistance	Resistance ≥ 60%	EN 12224
Alkali resistance	≥ 96% Polypropylene/Polyethylene	

1011.4 Certification. The contractor shall furnish a manufacturer's certification to the engineer for each lot of material furnished stating the name of the manufacturer, the chemical composition of the filaments or yarns and certifying that the material supplied is in accordance with this specification. The certification shall include or have attached typical results of tests from specific lots for all specified requirements.

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SECTION 1012
GEOCOMPOSITE DRAINAGE MATERIAL

1012.1 Scope. This specification covers material for use as geocomposite drains.

1012.2 Acceptance. Acceptance of the material will be based on the manufacturer's certification and upon the results of such tests as may be performed by the engineer.

1012.3 Material.

1012.3.1 General. During shipment and storage, the geocomposite material shall be protected from direct sunlight, ultraviolet rays, temperatures greater than 140 F, mud, dust and debris.

1012.3.2 Edge Drain. The edge drain shall consist of a plastic core completely surrounded by geotextile.

1012.3.2.1 The edge drain shall have nominal dimensions of 1 to 1 1/2 inches in thickness x 12 inches in height.

1012.3.2.2 The edge drain shall have a minimum flow capacity of 15 gallons per minute per foot of width, as determined by ASTM D 4716, when tested under a confining stress of 10 psi or more at a gradient of 0.1 or less.

1012.3.2.3 The edge drain shall have a minimum compressive strength of either 7,000 psf at a maximum deformation of 10 percent of the original thickness when tested in accordance with ASTM D 1621, or 8,000 psf at a maximum deformation of 20 percent when tested in accordance with ASTM D 695.

1012.3.2.4 The core shall provide a minimum of 10 percent open area to facilitate water entry or cross flow and shall be composed of plastic, which is physically and chemically stable under a normal range of service conditions.

1012.3.2.5 The geotextile shall be in accordance with Sec 1011 for subsurface drainage geotextile.

1012.3.3 Vertical Drain at End Bents. The vertical drain shall consist of a plastic core with a geotextile attached to one or both sides.

1012.3.3.1 The vertical drain shall be no less than 3/8 inch or no greater than one inch in thickness.

1012.3.3.2 The vertical drain shall have a minimum flow capacity of 5 gallons per minute per foot of width in either principal direction.

1012.3.3.3 The vertical drain shall have a minimum compressive strength of 6,000 psf at a maximum deformation of 10 percent of the original thickness, when tested in accordance with ASTM D 1621.

1012.3.3.4 The core shall be composed of plastic which is physically and chemically stable under a normal range of service conditions.

1012.3.3.5 Geotextile shall be in accordance with Sec 1011 for subsurface drainage geotextile.

1012.4 Certification. The contractor shall furnish a manufacturer's certification to the engineer for each lot of material furnished stating the name of the manufacturer, and that the material supplied is in accordance with this specification. The certification shall include or have attached typical results of tests from specific lots for all specified requirements, including the geotextile.

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SECTION 1013
MISCELLANEOUS DRAINAGE MATERIAL

1013.1 Scope. This specification covers material requirements for various plastic pipes and other miscellaneous items required to provide underdrainage and edge drainage as specified elsewhere.

1013.2 Acceptance. Acceptance of the material will be based on visual examination and the results of such tests as required by the engineer.

1013.3 Material. Pipe material shall be PVC or HDPE.

1013.3.1 Plastic Pipe. The pipe material shall have a minimum pipe stiffness of 46 psi.

1013.3.1.1 Corrugated PVC sewer pipe with a smooth interior and fittings shall be in accordance with ASTM F 949.

1013.3.1.2 Smooth wall PVC underdrain pipe and fittings shall be in accordance with ASTM D 3034.

1013.3.1.3 Corrugated PE pipe with a smooth interior and fittings shall be in accordance with AASHTO M 252, Type S or SP.

1013.3.1.4 Schedule 40 PVC pipe shall be in accordance with ASTM D 1785.

1013.4 Rodent Screens. Rodent screens shall be press-formed of 3 or 4 mesh, 21 gage or heavier, stainless steel or hot-dipped galvanized wire screen or approved equivalent, to provide a cup-shaped screen that will provide a friction-tight fit when inserted into the drain outlet.

1013.5 Certification. The contractor shall furnish a manufacturer's certification to the engineer for each lot of plastic pipe material furnished stating the name of the manufacturer and certifying that the material supplied is in accordance with this specification.

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SECTION 1015
BITUMINOUS MATERIAL

1015.1 Scope. This specification covers bituminous material to be used in highway construction.

1015.2 Approval of Source. The contractor shall obtain approval of the source of bituminous material from the engineer before any shipments to the work site are made.

1015.3 Sampling, Testing and Acceptance Procedures .The supplier shall certify that the bituminous material complies with the specification requirements.

1015.3.1 Certification. The supplier shall furnish the truck driver a copy of the bill of lading, manifest or truck ticket to be available to MoDOT at the destination prior to unloading. The engineer at the source shall be furnished a copy. The bill of lading, manifest or truck ticket shall provide the following information regarding the shipment: type and grade of material, specific gravity at 60 F, net gallons, consignee, truck number, identification number, weight of truck before and after loading, destination, date loaded, name and location of the source, and a certification statement. The certification statement shall be signed by an authorized representative of the supplier and shall be substantially as follows:
"This certifies that the bituminous material in this shipment is in accordance with MoDOT specifications for the grade specified and the weights (masses) shown hereon were obtained on MoDOT approved scales and are correct within the specified scale requirements."

1015.3.2 Sampling. The engineer will at random observe the sampling and testing of truck shipments and tanks, and will select representative samples of the material being supplied for testing in the field or in the Central Laboratory. When test results certified by the supplier are not representative of the material being shipped, the source approval will be withdrawn. A source may be reinstated when proof is furnished that the deficiency has been corrected and adequate controls are in effect to guarantee delivery of material meeting specifications. Sampling and test methods for asphalt shall be as follows:

Property	Method	RC	MC	PG
Sampling	AASHTO T 40	X	X	X
Water	AASHTO T 55	X	X	X
Flash Point (Tag Open Cup)	AASHTO T 79	X	X	
Flash Point (Cleveland Open Cup)	AASHTO T 48			X
Viscosity, Centistokes	AASHTO T 201	X	X	
Distillation	AASHTO T 78	X	X	
Penetration	AASHTO T 49	X	X	
Ductility	AASHTO T 51	X	X	
Solubility in Trichlorethylene	AASHTO T 44	X	X	X
Ash in Bituminous Material	AASHTO T 111			
Viscosity (Rotational)	ASTM D 4402			X
Dynamic Shear	AASHTO 315			X
Rolling Thin Film Oven Test	AASHTO T 240			X
Pressure Aging Test	AASHTO R28			X
Creep Stiffness	AASHTO T 313			X
Direct Tension	AASHTO T 314			

1015.3.3 Sampling Equipment. The supplier shall furnish the required sampling equipment and shall sample the contents of the truck under the direction of the engineer. The supplier shall keep all sampling equipment clean and in good condition. Sampling devices on truck transports will be approved provided an adequately insulated valve is used with a pipe or nipple inserted a suitable distance into the tank.

1015.3.4 Truck Log. Each truck transport shall carry a log showing types of material and the dates hauled with respect to previous shipments, or the supplier shall furnish to the engineer such information with respect to the previous load.

1015.3.5 Intermediate Storage. Intermediate storage tanks for storage and transfer of material between the refinery or terminal and the point of acceptance shall be equipped for sealing and shall be reserved exclusively for MoDOT work. Use of any material from unsealed tanks will be subject to delay until material can be sampled, tested and approved.

1015.3.6 Other Transportation. At sources from which liquid bituminous material is being accepted by certification, the applicable requirements of the foregoing sections shall be followed for shipments of material in transportation units other than trucks. The certification and all information regarding each shipment shall be furnished to the engineer at the source.

1015.3.7 Railroad Shipments. For railroad shipments from refineries where inspection is not maintained by MoDOT, the supplier shall sample each car load at the source and submit the sample promptly to the Central Laboratory. A bill of lading or identification sheet shall accompany each sample and contain the following information: car number, type and grade of material, quantity represented, including gross gallons, temperature and net gallons at 60 F, destination of shipment, project number and consignee. A certification statement as specified in Sec 1015.3.1 shall accompany each sample. Approval of the source may be withdrawn if samples submitted are not representative of the material shipped in the car.

1015.4 Proportioning and Blending Bituminous Material Constituents. All material shall be properly proportioned and thoroughly blended in suitable tanks prior to delivery to transportation equipment, or material may be proportioned and blended by use of automatic proportioning equipment. All automatic-proportioning blenders shall meet the approval of the engineer and shall be equipped with precision instruments, including electrically interlocked motors and automatic meters.

1015.5 Application Temperatures for Bituminous Material.

Bituminous Material	Temperature, Degrees Fahrenheit			
	Spraying		Mixing	
	Min	Max	Min	Max
Asphalt Binder				
PG 46-28	260	325	----	----
All Other Grades	285	350	275	350
Liquid Asphalt RC-MC				
Grade				
30	70	150	50	110
70	100	180	90	140
250	150	220	130	170
800	180	260	170	210
3000	210	290	200	240
Asphalt Emulsions				
RS-1	120	140	----	----
RS-2	125	185	----	----
SS-1	120	160	70	160
SS-1h	120	160	70	160
SS-1vh	160	180	140	160
CRS-1	125	185	----	----
CRS-2	125	185	----	----
CSS-1	120	160	70	160
CSS-1h	120	160	70	160
EA-90P	130	180	----	----
CRS-2P	130	180	----	----
CHFRS-2P	130	180	----	----

[a] The minimum mixing temperature shall be lowered to 200 when a warm mix technology, as approved by the engineer, is used.

1015.5.1 Application temperatures of other grades of emulsions shall be as specified in the contract.

1015.5.2 The spraying temperature for non-modified PG 46-28 asphalt binder shall be 260 - 325 F, and for all other higher temperature non-modified performance grades, the spraying temperature shall be 285 - 350 F. The mixing and compaction temperatures for performance graded asphalt binder shall be determined by rotational viscosity testing as defined in ASTM D 4402.

1015.5.3 When material to be applied by pressure distributor is, due to refining or blending procedures,

delivered at a temperature above the specified limits, the material may be applied at the higher temperature provided satisfactory application can be obtained at the specified rate and provided sufficient precaution is exercised with respect to the fire hazard.

1015.6 Measurement of Bituminous Material. Field weight or field volumetric determinations of the material actually incorporated into the work will be used for measurement of the quantity of bituminous material for payment. The volume of material supplied from intermediate storage tanks will be determined from the net weight of the material. The net weight will be determined from the gross weight of the loaded transport vehicle used to deliver the material to the project less the empty transport vehicle weight. The volume correction methods specified below will be used for determining the volume of bituminous material. Scales for determining the weight of bituminous material shall be in accordance with Sec 310.

1015.6.1 Liquid Bituminous Material and Asphalt Binder - Volumetric Determination. Measurement of the material will be based on the volume at 60 F. The volume correction factors of ASTM D 1250, Table 24b, will be used for converting the material from the volume at the observed temperature to the volume at 60 F. The volume of uncalibrated distributors and tank trucks will be determined from the net weight of the material. The net weight will be determined from the gross weight of the loaded delivery vehicle less the empty delivery vehicle weight. For computing the volume in gallons from weight, the following formula will be used:

$$G = \frac{W}{SG \times 8.328}$$

where:
G = Volume in gallons at 60 F.
W = Weight of material in pounds.
SG = Specific Gravity of material at 60 F.

1015.6.2 Emulsified Asphalt. Measurement of the material will be based on the volume at 60 F using a coefficient of expansion of 0.0003 per degree F for converting the material from the volume at the observed temperature to the volume at 60 F.

SECTION 1015.10 PEFORMANCE GRADED ASPHALT BINDER.

1015.10.1 General. Performance graded asphalt binder shall be an asphalt-based binder produced from petroleum residue either with or without the addition of non-particulate organic modifiers. The grade shall be as specified in the contract.

1015.10.2 Basis of Acceptance. Suppliers furnishing performance graded asphalt binders to MoDOT projects by certification shall be in accordance with AASHTO R 26, except as noted herein. To become pre-qualified to furnish material, a written request shall be sent to Construction and Materials, along with a copy of the supplier's QC plan. Split samples may be required. Changes in formulation, base stock or methods of manufacture of qualified performance graded binders shall be noted and may require requalification.

1015.10.2.1 Quality Control Plan Requirements. The QC plan shall be in accordance with AASHTO R 26 with the following exceptions and modifications:

(a) The plan shall be written to cover multiple terminals or shipping facilities, in addition to the primary manufacturing facility, provided specific requirements for each location are clearly stated.

(b) The plan shall state the lot size used to designate the frequency of QC and specification compliance testing for each performance grade to be supplied. The lot size will depend upon the method of manufacture and may be designated on a tank basis, or on a time basis in the case of binders that are blended into trucks or tanks or that are continually blended into "live" tanks.

(c) For terminals or manufacturing facilities, the minimum reduced frequency of testing for QC or specification compliance shall be one series of tests every two weeks for "live" tanks or blenders and one series of tests every four weeks for "static" tanks that have had no material added between testing, per lot per grade of binder shipped.

(d) Quality Control testing may be used to determine that binders being shipped from terminals or

manufacturing facilities have not been contaminated, provided that such testing is shown to be of sufficient accuracy to detect contamination and to assure that material meets required specifications. Surrogate tests may be used for QC testing of non-modified performance graded binders.

(e) Terminals or shipping facilities that blend performance graded binders from different sources, that blend to produce a different performance grade, or that blend to modify the properties of an existing performance grade shall perform complete AASHTO M 320 specification compliance testing.

(f) The shipping facility shall document that each transport vessel was inspected prior to loading and was found to be acceptable for the material being shipped. The inspection shall be documented by a statement on the bill of lading or truck ticket, or by maintaining a record of transport vessel inspections at the shipping facility, which shall be available for review by MoDOT.

1015.10.2.2 Quality Control Plan Test Data. The facility shall retain test data of specification compliance and QC testing for five years. At a minimum, the name of the facility, the dates of testing activity, results of individual specification compliance and QC tests identified by blender or tank number, and the mean, minimum and maximum test result for each specification compliance and QC test performed shall be readily available to MoDOT upon request.

1015.10.2.3 Approval of Laboratories. The supplier's primary testing laboratory shall be approved by MoDOT. The approval process will include split sample testing, and may include an on-site visit by department personnel. The primary testing laboratory shall be regularly inspected by the AASHTO Materials Reference Laboratory (AMRL). Any satellite testing laboratory operated by a supplier shall be inspected at the same frequency by the supplier's primary AMRL inspected laboratory staff, and a copy of the inspection report shall be forwarded to MoDOT.

1015.10.2.4 Failure to Comply. Failure to fulfill any of these requirements may result in disqualification of the performance graded binder supplier. If a primary manufacturing facility is disqualified, all terminals shipping performance graded binder manufactured at the primary facility and who are not performing AASHTO M 320 specification compliance testing will automatically be disqualified. In cases of dispute, test results obtained by MoDOT will be considered final.

1015.10.3 Characteristics. Performance graded asphalt binder shall be in accordance with AASHTO M 320 for the grade specified, except as follows. AASHTO T 111, Inorganic Matter or Ash in Bituminous Materials, may be substituted for AASHTO T 44, Solubility of Bituminous Materials, at the specification value indicated prior to the addition of ground tire rubber (GTR.) All blends containing GTR shall include 4.5 percent transpolyoctenamer rubber (TOR) by weight of the GTR. The direct tension test will be waived. The following additional requirements will apply:

Binder Characteristics		
Absolute Temperature Spread Between Upper and Lower Temperature for PG Binder Grade[a]	**Elastic Recovery[b], Percent, Minimum, AASHTO T 301**	**Separation Test[c], Percent Difference, Maximum, ASTM D 5976**
86 C	-	-
92 C	55	10
98 C	65	10
104 C	75	10

[a]Temperature Spread = Upper PG Temperature minus Lower PG Temperature.
[b]Elastic recovery test to be performed on the residue from the Rolling Thin Film Oven Test at 25 C and 10 cm elongation.
[c]Separation test to be performed in accordance with ASTM D 5976, except test upper and lower portions as original binder for G* value according to AASHTO T 315 except for GTR binders that require continuous agitation.

1015.10.3.1 In lieu of AASHTO M 320, AASHTO M 332 may be substituted eliminating the elastic recovery requirement, except for use with Sec 413.30, Ultrathin Bonded Asphalt Wearing Surface. The equivalent grading will PG 64-22, Grade S for PG 64-22, Grade H for PG 70-22 and Grade V for PG 76-22. Specialty grades will be tested at the grade temperature for the desired characteristics, i.e. PG 58-28 for RAS mixtures.

1015.10.4 Characteristics for GTR. Ground tire rubber shall be ambient ground, free of wire or other contaminating materials and not contain more than 0.1 percent fabric. Cryogenically ground rubber may be used by demonstrating that the GTR is satisfactorily suspended during all phases of production and storage. The gradation of the GTR shall be as follows:

Ground Tire Rubber	
Sieve Size	**Percent Passing by Weight**
No. 8	100
No. 16	100-96
No. 30	100-90
No. 50	20 min.

1015.10.4.1 Modification Process. The percentage by weight of binder shall be included with each lot of material. Ground tire rubber modified asphalt binder shall be tested and certified in accordance with Sec 1015.10.2 and may be incorporated by any of the following methods:

1015.10.4.1.1 Blending at HMA Plant. All sampling and testing shall be performed in accordance the requirements for terminal blending including high and low temperature testing.

1015.10.4.1.2 Terminal Blending. Blending and certification shall be in accordance with Sec 1015.

1015.10.5 Storage. Performance graded asphalt binder shall be furnished as a uniform mixture shipped directly to the project site from the asphalt binder supplier's permanent plant address or intermediate storage facility, suitable for direct use. Asphalt binder shall be capable of being stored at the project site without separation or settling. Automatic blending will be allowed at the terminal. Intermediate blending of asphalt binder and additives will not be allowed at the project site, unless the asphalt binder is sampled at a point in the operation which captures the final blended binder with all additives incorporated.

SECTION 1015.20 LIQUID BITUMINOUS MATERIAL.

1015.20.1 Basis of Acceptance. Suppliers electing to furnish liquid bituminous material to MoDOT projects by QC/QA certification shall furnish material in accordance with Sec 1015.20.2. To become pre-qualified to furnish material, a written request shall be submitted to Construction and Materials, along with a copy of the supplier's QC plan. For source approval for any supplier of liquid bituminous material, split samples and an on-site laboratory inspection may be required. A manufacturer may forgo a formal QC plan and elect to perform full compliance testing, and certify each batch of material. If a manufacturer elects to forgo a formal QC Plan, all truck shipments shall be loaded from approved storage tanks that have been sampled, tested and certified by the supplier. If a manufacturer so elects, and automatic blending equipment is used, blender material will be approved for use provided the finished product is in accordance with this specification. At least one complete specification compliance test shall be conducted every two weeks on each grade of material furnished for MoDOT work from the blender. A certified copy of the test results shall be furnished to the engineer. For all liquid bituminous material, AASHTO T 111, Inorganic Matter or Ash in Bituminous Materials, may be substituted for AASHTO T 44, Solubility of Bituminous Materials, at the specification value indicated.

1015.20.2 Quality Control Plan Requirements. The QC plan shall be in accordance with the following:

(a) The plan may be written to cover multiple terminals, shipping facilities, blending or manufacturing facilities.

(b) The plan shall state the location, organization and responsible personnel for each facility, including the physical address and telephone contact information. In general, following the guidelines in AASHTO R 26 will be acceptable.

(c) The plan shall state the minimum testing frequency for all material supplied. At a minimum, each grade of material supplied to MoDOT shall have complete specification compliance testing conducted monthly. Polymer modified material shall have complete specification compliance testing conducted every two weeks. The manufacturer's internal QC testing frequency shall be approved by MoDOT prior to implementation. The manufacturer shall perform sufficient tests and at a frequency to ensure specification compliant material is being supplied to MoDOT at all times. For emulsified asphalt, QC

testing on each batch, at a minimum, shall consist of viscosity, sieve test, determination of residue by either distillation or evaporation and an identifier test, if applicable, for that particular grade, either cement mixing, particle charge or demusibility. The manufacturer may elect to perform additional QC tests. For cutback material, QC testing shall be a minimum of the viscosity on a daily basis when material is being shipped to MoDOT work.

(d) In the event of a failing sample, the manufacturer shall follow the steps outlined in AASHTO R 26, Sec. 9.2. If a sample fails to comply with any specification requirement at the Central Laboratory, the manufacturer may only ship new material of that grade after full specification compliance testing. After the manufacturer has certified through specification compliance testing that three consecutive batches are in accordance with the material specification, the manufacturer may return to the testing frequency outlined in the QC/QA plan. If a second sample of the same grade from the same facility fails to comply with any specification requirement within the same calendar year, approval of that facility to supply that grade under QC/QA may be withdrawn. If approval for a grade is withdrawn, that material may only be supplied to MoDOT work after full certification compliance testing has been performed at the Central Laboratory. Re-approval to supply under the supplier's QC/QA Plan will occur only after three consecutive batches meet specifications after testing at the Central Laboratory. Failure of multiple grades from a single facility tested at the Central Laboratory may result in that facility being removed from approval to supply material to MoDOT. Reinstatement will occur only after all materials in question have been tested at the Central Laboratory and have met all specifications, and documentation from the supplier outlining the reason for the failures and what corrective measures have been taken are to the satisfaction of MoDOT.

(e) The shipping facility shall document that each transport vessel was inspected prior to loading and was found to be acceptable for the material shipped. The inspection shall be documented by a statement on the bill of lading or truck ticket, or by maintaining a record of transport vessel inspections at the shipping facility, which shall be available for review by MoDOT.

The results of QC/QA testing shall be retained by the supplier for a period of three years. A report containing all test results for any material shall be available to MoDOT upon request.

1015.20.3 Type RC Liquid Asphalt. Type RC liquid asphalt shall be produced by fluxing an asphaltic base with suitable petroleum distillates. The material shall show no separation or curdling prior to use and shall not foam when heated to the application temperature. The material shall be in accordance with AASHTO M 81, invoking Note 3 using penetration in lieu of viscosity for the grade specified in the contract.

1015.20.4 Type MC Liquid Asphalt. Type MC liquid asphalt shall be produced by fluxing an asphaltic base with suitable petroleum distillates. The material shall show no separation or curdling prior to use and shall not foam when heated to the application temperature. The material shall be in accordance with AASHTO M 82, invoking Note 4 using penetration in lieu of viscosity for the grade specified in the contract.

1015.20.5 Emulsified Asphalt. Non-polymer emulsified asphalt shall be in accordance with AASHTO M 140 or AASHTO M 208, for the type and grade specified in the contract.

1015.20.5.1 Polymer Modified Asphalt Emulsion - Seal Coat. Bituminous material for polymer modified asphalt shall be in accordance with the following:

Polymer Modified Asphalt Emulsion				
Test[a]	**CRS-2P**		**EA-90P**	
	Min	**Max**	**Min**	**Max**
Viscosity, SSF @ 50 C	100	400	100	400
Storage Stability Test[b], 24 hour, percent	----	1	----	1
Classification Test	Pass	----	----	----
Particle Charge Test	Positive	----	----	----
Sieve Test,percent	----	0.3	----	0.3
Demulsibility, 0.02 N $CaC1_2$, percent	----	----	30	----
Distillation:				
Oil distillate by volume of emulsion, percent	----	3	----	3
Residue from distillation[c] , percent	65	----	65	----
Tests on Residue from Distillation:				

Penetration,25 C, 100 g, 5 sec	100	200	100	200
Ductility, 4 C, 5 cm/minute, cm	30	----	25	----
Ash[d], percent	----	1	----	1
Float Test at 60 C, sec	----	----	1200	----
Elastic Recovery[e], percent	58	----	58	----

[a]All tests shall be performed in accordance with AASHTO T 59 except as noted.

[b]In addition to AASHTO T 59, upon examination of the test cylinder, and after standing undisturbed for 24 hours, the surface shall show no appreciable white, milky colored substance and shall be a homogeneous brown color throughout.

[c]AASHTO T 59 shall be modified to maintain a 399 F ± 10 F maximum temperature for 15 minutes.

[d]Percent ash shall be determined in accordance with AASHTO T 111, *Ash in Bituminous Material*.

[e]Elastic recovery shall be determined as follows. Condition the ductilometer and samples to be treated at 50 F. Prepare the brass plate, mold and briquet specimen in accordance with AASHTO T 51. Keep the specimen at the specified test temperature of 50 F for 85 to 95 minutes. Immediately after conditioning, place the specimen in the ductilometer and proceed to elongate the sample to 20 cm at a rate of pull of 5 cm/min. After the 20 cm elongation has been reached, stop the ductilometer and hold the sample in the elongated position for 5 minutes. After 5 minutes, clip the sample approximately in half by means of scissors or other suitable cutting devices. Let the sample remain in the ductilometer in an undisturbed condition for one hour. At the end of this time period, retract the half sample specimen until the two broken ends touch. At this point note the elongation (x) in cm. Calculate the percent recovery by the following formula:

$$\% \text{ Recovery} = \frac{20 - X}{20} \times 100$$

Polymer Modified Asphalt Emulsion		
Test[a]	**CHFRS-2P**	
	Min.	**Max.**
Viscosity, SFS @ 50 C	100	400
Storage Stability Test, 24 hour, percent	---	1.0
Demulsibility, 35 ml 0.8% dioctyl sodium sulfosuccinate, percent	60	---
Sieve Test, percent	---	0.10
Particle Charge Test	Positive	
Distillation[b]		
Oil Distillate, by volume of emulsion, percent	---	0.5
Residue from distillation, percent	65	---
Tests on Residue from Distillation:		
Polymer content, weight, percent (solids based)	3.0	---
Softening Point, C	54	---
Float test at 60 C, s	1800	130
Penetration, 25 C, 100 g, 5 s	80	---
Viscosity @ 60 C, Poise	1300	---
Solubility in Trichloroethylene, percent	95	---
Elastic Recovery[c] @ 10 C , percent	65	

[a]All tests shall be performed in accordance with AASHTO T-59 except as noted.

[b]AASHTO T59 shall be modified to maintain a 177 ± 5 C maximum temperature to be held for 20 minutes. Complete the total distillation in 60 ± 5 minutes from the first application of heat.

[c]Elastic recovery shall be determined as follows. Condition the ductilometer and samples to be treated at 10 C. Prepare the brass plate, mold, and briquet specimen in accordance with AASHTO T 51. Keep the specimen at the specified test temperature of 10 C for 85 to 95 minutes. Immediately after conditioning, place the specimen in the ductilometer and proceed to elongate the sample to

20 cm at a rate of pull of 5 cm/min. After the 20 cm elongation has been reached, stop the ductilometer and hold the sample in the elongated position for 5 minutes. After the 5 minutes, clip the sample approximately in half by means of scissors or other suitable cutting devices. Let the sample remain in the ductilometer in an undisturbed condition for one hour. At the end of this time period, retract the half sample specimen until the two broken ends touch. At this point note the elongation recovery (X) in cm. Calculate the percent recovery by the following formula:

$$\% \text{ Recovery} = \frac{20 - X}{20} \times 100$$

1015.20.5.1.1 Polymer Modified Asphalt Emulsion - Tack Coat. Bituminous material for polymer modified asphalt shall be in accordance with the following:

Slow Setting Polymer Modified Asphalt Emulsion[a]					
		SS-1HP		CSS-1HP	
Test on Emulsion	Method	Min	Max	Min	Max
Viscosity, Saybolt Furol @ 25°C (77°F), s	AASHTO T 59	20	100	20	100
Particle Charge Test		Negative		Positive	
Storage Stability Test[b], 24 hr, percent	AASHTO T 59	--	1	--	1
Sieve Test, percent	AASHTO T 59	--	0.50	--	0.50
Residue by Distillation[c], percent	AASHTO T 59	57		57	
Oil Distillate by Distillation, percent	AASHTO T 59	--	--	--	--
Test on Residue from Distillation					
Penetration 25°C, 100 g, 5 s	AASHTO T 49	40	90	40	90
Elastic Recovery[d], 20 cm, 5 cm/min, 60 min, %	AASHTO T 301	30	--	30	--
Solubility in Trichloroethylene[e], %	AASHTO T 44	97.5	--	97.5	--

[a] The emulsified asphalt shall be in accordance with Sec 1015.20.5 of the 2011 Missouri Standard Specifications for Highway Construction, except as indicated above, and shall be modified with a styrene-butadiene diblock or triblock copolymer or a styrene butadiene rubber.
[b] In addition to AASHTO T 59, upon examination of the test cylinder, and after standing undisturbed for 24 hours, the surface shall show no appreciable white, milky colored substance and shall be homogeneous brown color throughout. The storage stability test may be waved provided the asphalt emulsion storage tank at the project site has adequate provisions for circulating the entire contents of the tank, provided satisfactory field results are obtained.
[c] AASHTO T 59 shall be modified to use a lower distillation temperature of 177° C (350° F).
[d] AASHTO T 301 shall be modified to allow the residue to be obtained from distillation as long as the distillation temperature is modified as stated above. The test on residue shall be conducted at a temperature of 10° C (50° F).
[e] In lieu of performing AASHTO T 44, AASHTO T 111, Ash in Bituminous Material, may be performed with a maximum allowable percent ash of 1.0 percent.

1015.20.5.2 Asphalt Emulsion for Micro-Surfacing. Bituminous material for micro-surfacing shall be a polymer modified asphalt emulsion, grade CSS-lh, in accordance with the following table. The bituminous material shall show no separation after mixing. A minimum of 3.0 percent polymer content, by mass, of an approved polymer shall be milled into the asphalt emulsion at the time of manufacture of the emulsion. The emulsion shall be sampled in accordance with AASHTO T 40.

Micro-Surfacing Emulsion (MSE-1)			
	Min.	**Max.**	**Test Method**
Viscosity, Saybolt Furol at 77 F, s	20	100	AASHTO T 59
Storage stability test, 24 hr, percent	- -	1[a]	AASHTO T 59
Particle charge test positive[b]			AASHTO T 59
Sieve test, percent	- -	0.50	AASHTO T 59

Residue, percent	62	- -	AASHTO T 59
Tests on Residue from Distillation	**Min.**	**Max.**	**Test Method**
Penetration, 77 F, 100 g, 5 s,	40	90	AASHTO T49
Ductility, 25 C, 5cm/min, cm,	40	- -	AASHTO T 51
Solubility in Trichloroethylene, %	97.50	- -	AASHTO T 44

[a]The storage stability test may be waived provided the asphalt emulsion storage tank at the project site has adequate provisions for circulating the entire contents of the tank, and provided satisfactory field results are obtained.
[b]If the particle charge test is inconclusive, material having a maximum pH value of 6.7 will be acceptable.

1015.20.5.3 Scrub Seal Emulsion. Scrub seal emulsion shall be smooth and homogeneous, polymer modified, shall contain an asphalt rejuvenator and shall be in accordance with the following:

Scrub Seal Emulsion (SSE-1)			
	Min.	**Max.**	**Test Method**
Saybolt Furol Viscosity, SFS @ 77 F	30	100	AASHTO T 59
Storage Stability Test[a] , 24 hr., %	--	1[a]	AASHTO T 59
Demulsibility, 35 ml of 0.02N, $CACl_2$, %	--	60	AASHTO T 59
Sieve Test[b], percent	--	0.3	AASHTO T 59
Residue by Distillation[(c)] @ 401 ± 10 F, %	60	--	AASHTO T 59
Oil Distillate by Volume, percent	--	3	AASHTO T 59
Tests on Residue from Distillation	**Min.**	**Max.**	**Test Method**
Penetration @ 77 F, 5 s, 100 g, dmm	100	300	AASHTO T 49
Float Test @ 140 F, s	1200	--	AASHTO T 50
Ash, percent	--	1	AASHTO T 111
Elastic Recovery, 10 C, 200 mm elongation, 60 min. recovery, percent	30	--	ASTM D 5976
Saturates[d], percent	- -	20	ASTM D 4124

[a]Upon examination of the test cylinder after standing undisturbed for 24 hours, the surface shall show no white, milky colored substance and shall be a homogeneous brown color throughout.
[b]A percentage of 0.30 will be acceptable for samples taken at the point of use or shipped to the Central Laboratory for testing.
[c]ASTM D 244 shall be modified to include a 205 ± 5 C maximum temperature to be held for 15 minutes.
[d]ASTM D 4124 shall be modified to use Alumina, CG - 20 Grade, available from Aluminum Company of America, Pittsburgh, PA.

1015.20.5.4 Hard Penetration Asphalt Emulsions (SS-1vh). The hard penetration asphalt emulsions shall be in accordance with the following:

Emulsion Properties of Hard Penetration Asphalt Emulsions (SS-1vh)			
Test on Emulsion	**Method**	**Min.**	**Max.**
Viscosity, Saybolt Furol @ 25º C (77º F), s	AASHTO T 59	20	100
Storage Stability Test[a], 24 hr., percent	AASHTO T 59	--	1.0
Sieve Test, percent	AASHTO T 59	--	0.30
Residue by Distillation, percent	AASHTO T 59	50	--
Oil Distillate by Distillation, percent	AASHTO T 59	--	1
Tests on Residue from Distillation	**Method**	**Min.**	**Max.**
Softening Point, º F	AASHTO T 53	149	200
Penetration 25º C (77º F), 100 g, 5 s	AASHTO T 49	--	40
G* / sin delta @ 76º C – 10 rad/sec, kPa	AASHTO T 315	1.0	--
Solubility in Trichloroethylene[b], %	AASHTO T 44	97.5	--

[a]In addition to AASHTO T 59, upon examination of the test cylinder, and after standing undisturbed for 24 hours, the surface shall show no appreciable white, milky colored substance and shall be homogeneous brown color throughout. The storage stability test may be waved provided the asphalt emulsion storage tank at the project site has adequate provisions for

circulating the entire contents of the tank, provided satisfactory field results are obtained.

[b]In lieu of performing AASHTO T 44, AASHTO T 111, Ash in Bituminous Material, may be performed with a maximum allowable percent ash of 1.0 percent.

1015.20.6 Ultrathin Bonded Wearing Surface. Bituminous material for ultrathin bonded wearing surface shall be in accordance with the following.

1015.20.6.1 Asphalt Binder. The asphalt binder shall be in accordance with Sec 1015.10, and specifically as follows:

Tests	Method	Min.	Max.
Separation Test, %	AASHTO PP-5		10
Elastic Recovery Test, %	ASTM D 6084	65	

1015.20.6.2 Polymer Modified Emulsion Membrane. The anionic or cationic emulsion shall be polymer modified and shall be in accordance with one of the following:

Anionic Polymer Modified Emulsion Membrane (PEM-1)			
Tests on Emulsion	**Method**	**Min.**	**Max.**
Viscosity, Saybolt Furol @122°F, s	AASHTO T 59	25	125
Storage Stability Test[a], 24 h, percent	AASHTO T 59		1
Sieve Test[b], percent	AASHTO T 59		0.3
Residue by Distillation[c], percent	AASHTO T 59	63	
Oil Distillate by Distillation, percent	AASHTO T 59		2
Demulsibilty, % 35 ml, 0.02 N $CaCl_2$	AASHTO T 59	60	
Tests on Residue From Distillation			
Penetration	AASHTO T 49	90	150
Elastic Recovery, percent	AASHTO T 301	60	

Cationic Polymer Modified Emulsion Membrane (CPEM-1)			
Tests on Emulsion	**Method**	**Min.**	**Max.**
Viscosity, Saybolt Furol @122°F, s	AASHTO T 59	25	125
Storage Stability Test[a], 24 h, percent	AASHTO T 59		1
Sieve Test[b], percent	AASHTO T 59		0.3
Residue by Distillation[c], percent	AASHTO T 59	63	
Oil Distillate by Distillation, percent	AASHTO T 59		2
Demulsibility, % 35 ml, 0.8% dioctyl sodium sulfosuccinate	AASHTO T 59	60	
Tests on Residue From Distillation			
Penetration	AASHTO T 49	90	150
Elastic Recovery, %	AASHTO T 301	60	

[a]After standing undisturbed for 24 hours, the surface shall show no white, milky colored substance, but shall be a smooth homogeneous color throughout.

[b]The sieve test will be waived if successful application of the material has been achieved in the field.

[c]AASHTO T 59 shall be modified to include a 400 F ± 10 F maximum temperature to be held for a period of 15 minutes.

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SECTION 1017
GROUND GRANULATED BLAST FURNACE SLAG

1017.1 Scope. This specification covers ground Granulated Blast Furnace Slag (GGBFS) for use in Portland cement concrete.

1017.2 General. All GGBFS shall be in accordance with AASHTO M 302, Grade 100 or 120, except as herein specified. Only GGBFS from sources qualified in accordance with these specifications will be permitted.

1017.2.1 GGBFS may only be used with AASHTO M 85, Type I or Type II Portland cement, unless otherwise directed by the engineer.

1017.2.2 The mixing of different grades and sources of GGBFS will not be permitted.

1017.2.3 The term "manufacturer", as used in this specification, will be the company grinding the granulated blast furnace slag to produce GGBFS. The term "marketing entity", as used in this specification, will be the supplier or broker of the GGBFS. The marketing entity will be responsible for complying with these specifications.

1017.2.4 All tests shall be performed in a MoDOT approved laboratory.

1017.3 Sampling, Testing and Acceptance Procedures. All marketing entities and terminals furnishing GGBFS to MoDOT projects shall be qualified as herein described. All GGBFS will be subject to inspection and sampling by MoDOT at the source of manufacture, an intermediate shipping terminal or destination. MoDOT shall be allowed unlimited access to all facilities and records as required to conduct inspection and sampling.

1017.3.1 Marketing Entity Qualification. In order to become qualified, a written request shall be sent by the marketing entity to Construction and Materials, along with a copy of the marketing entity's QC plan. The production source and terminals may be inspected to verify the information and to establish personal contact with the QC personnel.

1017.3.1.1 The following information shall be included in the request for qualification:

(a) An outline of the QC program from the source of manufacture to the point where the product is relinquished to the purchaser. The QC program shall cover all tests in accordance with the specification and include the testing frequency for each test. The name of the testing laboratory shall be included. Each sample shall not represent less than 500 tons.

(b) A copy of the testing laboratory's most recent Cement and Concrete Reference Laboratory (CCRL) inspection report and the latest CCRL proficiency sample report. The CCRL inspection shall cover all tests in accordance with the specification. Documentation showing satisfactory resolution of all inspection deficiencies shall be included.

(c) Complete name and address of the GGBFS source and owner. If located in an area without precise address identification, a complete map description shall be furnished. If more than one source is used, all sources shall be listed.

(d) Grade of GGBFS produced.

(e) Description of storage facilities, including capacities, set-aside capabilities and sampling method(s).

(f) A copy of a typical bill of lading with the required certification statement.

(g) A split sample of the GGBFS proposed for use, obtained over a minimum of one production day. The marketing entity's test results for the split sample shall also be submitted. The marketing entity shall provide reference cement if the cement used is unavailable to the area.

1017.3.1.2 In order to maintain qualification, the following will be required:

(a) QC test results covering the production of all GGBFS proposed for use in MoDOT projects,

including the high, low and average results shall be kept on file by the marketing entity. Sampling and testing shall be in accordance with these specifications.

(b) A sample shall be tested for each 2000 tons intended for use. The sample shall be tested by the marketing entity for fineness, No. 325 sieve analysis and Blaine, air content, 7-day and 28-day Slag Activity Index, percent sulfide sulfur (S) and percent sulfate ion (SO3), taken from a composite sample representing each 2000 tons of GGBFS transported to the storage silo. The composite shall be comprised of a minimum of four samples, each representing not more than 500 tons. Automatic samplers may be used in lieu of the individual 500-ton grab samples.

(c) A copy of the most recent CCRL inspection and proficiency sample reports and any deficiency resolutions shall be forwarded promptly to MoDOT.

(d) Semi-annual split samples for the class of approved GGBFS will be obtained by MoDOT for joint testing by the marketing entity. Marketing entity test results on the split samples shall be furnished to Construction and Materials when completed.

(e) All QC test results shall be available for a minimum of three years, for MoDOT review upon request.

(f) Only GGBFS in compliance with these specifications shall be allowed into a silo destined for MoDOT projects.

1017.3.2 Terminal Qualification. In order to become a qualified terminal, a written request shall be sent from terminal personnel to Construction and Materials. A letter shall accompany the request from each affected and qualified marketing entity, advising of the intent to ship through the respective terminal. Any changes in GGBFS sources shall be updated in the same manner. Terminals will be inspected to ensure adequacy to accept, retain and ship GGBFS from qualified marketing entities.

1017.3.3 Failure to Comply. Failure to fulfill any of these requirements may result in disqualification of the GGBFS manufacturer, marketing entity or terminal. In cases of dispute, test results obtained by MoDOT will control.

1017.3.4 Disqualified Facilities. If a facility has been disqualified, the marketing entity will be required to designate the silo, bin or storage facility from which the marketing entity proposes to furnish GGBFS for MoDOT projects. Each silo, bin or storage facility designated must be sampled, tested, sealed and approved by MoDOT prior to shipment. The marketing entity shall also sample, test and report the test results for each designated silo, bin or storage facility. This procedure will continue until adequate QC has been established.

1017.3.5 Shipping. GGBFS continually sampled and tested via autosamplers at a location, frequency and duration acceptable to MoDOT, may be continuously shipped direct from a marketing entity. All GGBFS manually sampled and tested shall be held in the silo or bin until such time as the test results are completed prior to shipping.

1017.3.6 Storage. All GGBFS intended for use shall be sampled, tested and placed in a designated silo or bin.

1017.4 Acceptance. The marketing entity shall certify that the material complies with the specification requirements. When a qualified marketing entity or terminal is shipping GGBFS for, or purchasing GGBFS from, another qualified marketing entity, the bill of lading or delivery receipt shall be from the shipping company. The certification statement showing the actual manufacturer shall be prominently placed on the bill of lading or delivery receipt. A copy of the bill of lading or delivery receipt shall accompany each shipment and shall be furnished to MoDOT at the shipping and destination points.

1017.4.1 The bill of lading or delivery receipt for each shipment to MoDOT projects shall carry the following certification statement:
"This is to certify this Grade _____ GGBFS originated from a MoDOT qualified manufacturer, has been maintained to meet MoDOT specifications and was loaded from silo number _____."
_____ Name and Location of Manufacturer
_____ Name and Location of Shipping Facility
By_____ Signature and Name of Marketing Entity

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SECTION 1018
FLY ASH FOR CONCRETE

1018.1 Scope. This specification covers fly ash for use in Portland cement concrete.

1018.2 General. Only fly ash from sources qualified in accordance with these specifications will be permitted. The mixing of different classes and sources of fly ash will not be permitted. All fly ash shall be in accordance with AASHTO M 295, Class C or F, except as herein specified.

1018.2.1 Class C fly ash shall meet either (a) or (b) of the following requirements:

(a) The 7-day Strength Activity Index with Portland cement shall be at a minimum of 85 percent of the control.

(b) The Calcium oxide content shall be 23 percent, minimum.

1018.2.1.1 All Class C fly ash shall have a minimum Strength Activity Index with Portland cement of 85 percent of the control at 28 days.

1018.2.2 The percent each of silicon dioxide (SiO2), aluminum oxide (Al2O3) and iron oxide (Fe2O3) shall be reported in addition to the total of the three.

1018.2.3 Loss on Ignition shall not exceed 1.5 percent unless supplies provide test data verifying performance and durability in fly ash concrete applications for sources exceeding this requirement.

1018.2.4 The term "manufacturer", as used in this specification, will be the actual manufacturer of the fly ash. The term, "marketing entity", as used in this specification, will be the supplier or broker of the fly ash. The marketing entity shall be responsible to be in accordance with these specifications.

1018.2.5 Cement used for testing fly ash shall be in accordance with AASHTO M85.

1018.2.6 All marketing entities, terminals, and independent testing laboratories shall be qualified prior to acceptance of any material.

1018.3 Laboratory Qualification.

1018.3.1 In order to become qualified, a written request shall be sent by the marketing entity to Construction and Materials, along with a copy of the laboratory's QC Plan, the QC departments most recent Cement and Concrete Reference Laboratory (CCRL) certification and the latest CCRL Pozzolan proficiency sample report. The CCRL inspection shall cover all tests required by the specification. Documentation showing satisfactory resolution of all inspection deficiencies shall be included. In addition, the plant may be inspected to verify the information and to establish personal contact with the QC personnel.

1018.3.2 Failure to Comply. Failure to comply with any of these requirements and/or specified herein may result in the issuance of a strike. If a laboratory accumulates three strikes, the laboratory shall be disqualified. For every year a laboratory does not receive a strike, a strike will be removed from the laboratory's accumulated total. In cases of dispute, test results obtained by MoDOT will control.

1018.3.3 Disqualified Facilities. If a laboratory has been disqualified, the marketing entity must utilize an existing MoDOT approved laboratory or qualify a laboratory fulfilling MoDOT requirements. A disqualified laboratory will be unable to maintain qualification based on requirements governed in this specification.

1018.4 Marketing Entity Qualification. In order to become qualified, a written request shall be sent by the marketing entity to Construction and Materials, along with a copy of the marketing entity's QC plan and the following information. The power plant and terminals may be inspected to verify the information and to establish personal contact with the QC personnel.

1018.4.1 The following information shall be included in the request for qualification:

(a) An outline of the QC program from the coal yard to the point where the product is relinquished to

the purchaser. The QC program shall cover all tests required by the specification, and shall include the testing frequency for each test. The name of the testing laboratory shall also be included.

(b) A copy of the testing laboratory's most recent Cement and Concrete Reference Laboratory (CCRL) inspection report and the latest CCRL proficiency sample report. The CCRL inspection shall cover all tests required by the specification. Documentation showing satisfactory resolution of all inspection deficiencies shall be included.

(c) Complete name and address of the fly ash source and owner. If located in an area without precise address identification, a complete map description shall be furnished.

(d) Complete name and address or map location of the coal mine. If more than one source of coal is used, all sources shall be listed.

(e) Type of coal used.

(f) Class of fly ash produced.

(g) A description of production procedures including, but not limited to, any additives mixed with the coal during production, any additive or dust suppressant used to collect the fly ash, ash collection methods, production capacity in tons (Mg) per day, and the proportions and proportioning procedures of any blended coals.

(h) Description of storage facilities, including capacities and set-aside capabilities.

(i) A copy of a typical bill of lading in accordance with the certification statement.

(j) A split sample of the class of fly ash proposed for use, obtained from the autosampler over a minimum of one production day. The marketing entity's test results for the split sample shall also be submitted.

1018.4.2 In order to maintain qualification, the following will be required:

(a) Quality control test results covering the production of all fly ash proposed for use in MoDOT projects, including the high, low and average results for each class shall be kept on file by the marketing entity. Sampling and testing frequency shall be in accordance with ASTM C 311. Results shall include the percent each of silicon dioxide (SiO2), aluminum oxide (Al2O3) and iron oxide (Fe2 O3) in addition to a total of all three.

(b) A copy of the most recent CCRL inspection and proficiency sample reports and any deficiency resolutions shall be forwarded promptly to MoDOT.

(c) Semi-annual split samples for the class of approved fly ash shall be obtained by MoDOT for joint testing by the marketing entity. Marketing entity test results on the split samples shall be furnished to Construction and Materials when completed.

(d) All QC test results shall be available for a minimum of three years, for MoDOT review upon request.

(e) All monthly or each 3200-ton samples shall be available for a minimum of one year, for MoDOT testing upon request.

(f) Only fly ash in compliance with these specifications shall be allowed into a silo destined for MoDOT projects.

1018.4.3 Failure to Comply. Failure to comply with any of these requirements and/or specified herein may result in the issuance of a strike. If a marketing entity accumulates three strikes, the marketing entity shall be disqualified. For every year a marketing entity does not receive a strike, a strike will be removed from the marketing entities' accumulated total. In cases of dispute, test results obtained by MoDOT will control.

1018.5 Terminal Qualification. In order to become a qualified terminal, a written request shall be sent from terminal personnel to Construction and Materials. A letter shall accompany the request from each affected and qualified marketing entity, advising of the intent to ship through the respective terminal. Any changes in fly ash source shall be updated in the same manner. Terminals shall be inspected to ensure adequacy to accept, retain and ship fly ash from qualified marketing entities.

1018.6 Sampling, Testing and Acceptance Procedures. All fly ash will be subject to inspection and sampling by MoDOT at the power plant, an intermediate shipping terminal or destination. MoDOT shall be allowed unlimited access to all facilities and records in order to conduct inspection and sampling.

1018.6.1 Failure to Comply. Failure to fulfill any of these requirements may result in disqualification of the fly ash manufacturer, marketing entity or a terminal. In cases of dispute, test results obtained by MoDOT will control.

1018.6.2 Disqualified Facilities. If a facility has been disqualified, the marketing entity may elect to designate the silo, bin or storage facility from which the marketing entity proposes to furnish fly ash for MoDOT projects. If this option is used, each silo, bin or storage facility designated must be sampled, tested, sealed and approved by MoDOT prior to shipment. The marketing entity shall also sample, test and report the test results for each designated silo, bin or storage facility.

1018.6.3 Shipping. Fly ash shall be continually sampled and tested via autosamplers at a location, frequency and duration acceptable to MoDOT, and may be continuously shipped direct from a marketing entity or generating station silo.

1018.6.4 Storage. All fly ash intended for use shall be sampled, tested, and placed in designated silos or bins.

1018.6.5 Coal Sources and Process. Fly ash from each coal source at each plant shall be qualified separately. Coals from different sources may be blended prior to burning, but the qualification shall be based on the blend. When the production procedure or fuel source is changed, or when any change is made by the manufacturer that alters the properties or characteristics of the qualified fly ash, requalification may be required.

1018.6.6 Acceptance. The marketing entity shall certify that the material complies with the specification requirements. When a qualified marketing entity or terminal is shipping fly ash for, or purchasing fly ash from, another qualified marketing entity, the bill of lading or delivery receipt shall be from the shipping company. The certification statement showing the actual manufacturer shall be prominently placed on the bill of lading or delivery receipt. A copy of the bill of lading or delivery receipt shall accompany each shipment and shall be furnished to MoDOT at the shipping and destination points.

1018.6.7 The bill of lading or delivery receipt for each shipment to MoDOT projects shall carry the following certification statement:
"This is to certify this Class ___ fly ash originated from a MoDOT qualified manufacturer, has been maintained to meet MoDOT specifications and was loaded from silo number _____."
_____ Name and Location of Manufacturer
_____ Name and Location of Shipping Facility
By_____ Signature and Name of Marketing Entity

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SECTION 1019
CEMENT

1019.1 Scope. This specification covers Portland cement, hydraulic cement and blended hydraulic cement.

1019.2 General. All Portland cement shall be in accordance with the following requirements. The basis of acceptance will be as described in Sec 1019.3.

1019.2.1 Portland Cement. All Portland cement shall be in accordance with AASHTO M 85 with the following modifications:

(a) Specific surface, fineness, for all Type I Portland cements shall not exceed 430 m2/kg using Air permeability test. Maximum fineness limits do not apply if the sum of C3S + 4.75C3A is less than or equal to 90.

(b) When slag cement is used as an inorganic processing addition, loss on ignition shall be corrected in accordance with ASTM C 114 and reported on mill test reports.

1019.2.2 Hydraulic Cement. All hydraulic cement shall be in accordance with ASTM C 1157.

1019.2.3 Blended Hydraulic Cement. All blended hydraulic cement shall be in accordance with Type IP, IS, IL or IT of AASHTO M 240 with the following modification that chemical composition shall be provided and tolerances checked in accordance with Section 7.1.1 of AASHTO M240 and allowable constituent amounts of Type IP, IS, IL and IT cements are within the specified limits listed below:

(a) Type IP cement shall have a pozzolan constituent up to 25 percent by mass of the blended cement. Type IP cements, in which the pozzolan constituent is metakaolin or silica fume, shall be a maximum of 15 or 8 percent, respectively.

(b) Type IS cement shall have a slag cement constituent up to 25 percent by mass of the blended cement.

(c) Type IL cement shall have a limestone constituent up to 15 percent by mass of blended cement.

(d) Type IT cement shall have a slag cement, limestone and pozzolan constituent up to 40 percent by mass of the ternary blended cement. The maximum constituent requirements shall be in accordance with Sec 1019.2.3 (a), (b) and (c) in some combination up to 40 percent.

1019.2.4 Other Cements. White Portland cement shall meet the requirements for Type I. Air-entraining Portland cement shall be used only when specified in the contract. Different types of cement shall not be mixed nor shall different types be used in the same unit of construction.

1019.2.5 Sack or Bag. A sack or bag of cement will be considered to be 94 pounds net.

1019.3 Sampling, Testing and Acceptance Procedures. All manufacturers and terminals furnishing cement to MoDOT projects shall be qualified as herein described. All cement will be subject to inspection and sampling by MoDOT at the source of manufacture, an intermediate shipping terminal or destination. MoDOT shall be allowed unlimited access to all facilities and records as required to conduct inspection and sampling.

1019.3.1 Manufacturer Qualification. In order to become qualified, a written request shall be sent by the manufacturer to Construction and Materials, along with a copy of the QC plan. In order to maintain qualification, the manufacturer shall submit additional information, as listed, to MoDOT. The plant may be inspected to verify the information and to establish personal contact with the QC personnel.

1019.3.1.1 The following information shall be included in the request for qualification:

(a) An outline of the QC program from the quarry to the point where the product is relinquished to the purchaser. The QC program shall cover all tests required by the specification and shall include the testing frequency for each test.

(b) A copy of the most recent Cement and Concrete Reference Laboratory (CCRL) inspection report and the latest CCRL proficiency sample report. The CCRL inspection shall cover all tests required by the specification. Documentation showing satisfactory resolution of all inspection deficiencies shall be included.

(c) The physical layout of the plant, including the number and capacity of finish mills and silos and the type of cement stored in each silo.

(d) A copy of a typical bill of lading with the required certification statement.

(e) A split sample of each type of cement proposed for use. Manufacturer test results for the split sample shall also be submitted.

1019.3.1.2 In order to maintain qualification, the following will be required:

(a) Monthly QC test results covering the production of cement types proposed for use in MoDOT projects, including the high, low and average results for each type shall be forwarded to MoDOT upon manufacturer completion.

(b) A copy of the most recent CCRL inspection and proficiency sample reports and any deficiency resolutions shall be forwarded promptly to MoDOT.

(c) Semi-annual split samples for each type of approved cement will be obtained by MoDOT for joint testing by the manufacturer. Manufacturer test results on the split samples shall be furnished to MoDOT when completed.

(d) All QC test results shall be available for a minimum of three years, for MoDOT review upon request.

(e) Only cement in compliance with these specifications shall be allowed into a silo destined for MoDOT projects.

1019.3.2 Terminal Qualification. In order to become a qualified terminal, a written request shall be sent from terminal personnel to Construction and Materials. The request shall be accompanied by a letter from each affected and qualified manufacturer, advising of the intent to ship through the respective terminal. Any changes in cement source shall be updated in the same manner. Terminals will be inspected to ensure adequacy to accept, retain and ship cement from qualified manufacturers.

1019.3.3 Failure to Comply. Failure to fulfill any of these requirements may result in disqualification of the cement manufacturer or a terminal. In cases of dispute, test results obtained by MoDOT will control.

1019.3.4 Disqualified Manufacturers. If a manufacturer has been disqualified, the manufacturer will be required to designate the silo, bin or storage facility from which they propose to furnish cement for MoDOT projects. Each silo, bin or storage facility designated shall be sampled, tested, sealed and approved by MoDOT prior to shipment. The manufacturer shall also sample, test and report the test results for each designated silo, bin or storage facility. This procedure shall continue until adequate QC has been established.

1019.3.5 Foreign Cement. All tests on foreign cement shall be performed by a qualified domestic manufacturer.

1019.4 Acceptance. The supplier shall certify that the material complies with the specification requirements. When a qualified manufacturer or terminal is shipping cement for, or purchasing cement from, another qualified manufacturer, the bill of lading or delivery receipt shall be from the shipping company. The certification statement showing the actual manufacturer shall be prominently placed on the bill of lading or delivery receipt. A copy of the bill of lading or delivery receipt shall accompany each shipment and shall be furnished to MoDOT at the shipping and destination points.

1019.4.1 Certification. The bill of lading or delivery receipt for each shipment to MoDOT projects shall carry the following certification statement:
"This is to certify this Type ___ cement originated from a MoDOT qualified manufacturer, has been maintained

to meet MoDOT specifications and was loaded from silo number _____."
_____ Name and Location of Manufacturer
_____ Name and Location of Shipping Facility
By_____
Signature and Name of Marketing Entity

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SECTION 1020
CORRUGATED METALLIC-COATED STEEL CULVERT PIPE, PIPE-ARCHES AND END SECTIONS

1020.1 Scope. This specification covers corrugated steel pipe, pipe-arches and flared end sections intended for use in the construction of culverts and similar uses. The steel used in fabrication shall have a protective metallic coating of zinc (galvanizing) or aluminum.

1020.2 Basis of Acceptance. Unless otherwise specified, the basis of acceptance will be in accordance with AASHTO M 36. Pipe shall be from an approved qualified plant and will be accepted based on certification, manufacturer quality control documentation and tests on samples as required by the engineer. Pipe may be fabricated using English units of measurement. Pipe fabricated using English measurements shall be in accordance with the dimensions and tolerances shown on the plans.

1020.3 Material.

1020.3.1 Steel Sheet. Steel sheet shall be certifiable in accordance with AASHTO M 218 or AASHTO M 274. Finished steel sheet shall be free from injurious defects such as blisters, flux and uncoated spots.

1020.3.2 Zinc Coating. Zinc for coating or galvanizing shall be prime western grade or better. Zinc-coated steel shall have a weight of zinc coating no less than 2.00 ounces psf of double exposed surface. If the average weight of zinc coating, as determined from the required samples, is less than 2.00 ounces psf, or if any one specimen has less than 1.80 ounces of zinc psf of double exposed surface, the lot sampled will be rejected or resampled, as determined by the engineer. If a retest is conducted, the weight of zinc coating of all of the original samples and the samples for retest shall average at least 2.00 ounces psf of double exposed surface, and no specimen shall have less than 1.80 ounces psf, or the entire lot sampled will be rejected. Adherence of coating shall be such that no peeling occurs while the material is being corrugated or formed into pipe.

1020.3.3 Aluminum Coating. Aluminum for coating shall be commercially pure aluminum. The bath analysis shall be in accordance with the Aluminum Bath Analysis table shown on the plans. Aluminum-coated steel shall have a weight of aluminum coating no less than 1.00 ounce psf of double exposed surface. If the average weight of aluminum coating, as determined from the required samples, is less than 1.00 ounce psf or if any one specimen has less than 0.90 ounce of aluminum psf of double exposed surface, the lot sampled will be rejected or resampled, as determined by the engineer. If a retest is conducted, the weight of aluminum coating of all of the original samples and the samples for retest shall average at least 1.00 ounce psf of double exposed surface and no specimen shall have less than 0.90 ounce psf or the entire lot sampled will be rejected.

1020.3.4 Documentation.

1020.3.4.1 Sheet Manufacturer's Certified Analysis. The manufacturer of each brand shall file with Construction and Materials a certificate setting forth the name or brand of metal to be furnished, the specified chemical composition and a typical or average analysis showing the percent of carbon, phosphorus, manganese, sulfur and silicon. The certificate shall be sworn to, for the manufacturer, by a person having legal authority to bind the company.

1020.3.4.2 Sheet Manufacturer's Guarantee. The manufacturer of the steel sheet shall submit with the certified analysis a guarantee providing that all metal furnished is in accordance with the specification requirements, shall bear a suitable identification brand or mark and shall be replaced without cost to the Commission when not in accordance with the specified analysis, sheet thickness or coating. The guarantee shall be so worded as to remain in effect as long as the manufacturer continues to furnish material. The manufacturer shall conduct such tests and measurements as necessary to ensure the material produced is in accordance with all specification requirements. These tests and measurements shall be identified by the identification symbols or code used on the sheet in a manner that will permit the manufacturer to produce specific reports showing test results representative of specific lots of steel sheet. Copies of reports of these tests shall be kept on file and shall be submitted to the engineer upon request. The brand shall be removed or obliterated by the manufacturer on all material where control tests, as outlined herein, do not show conformance to this specification.

1020.4 Fabrication.

1020.4.1 Riveted Seams. A longitudinal seam will not be permitted on the corner radius or invert of pipe-arch.

1020.4.2 Resistance Spot Welded Seams. A longitudinal seam will not be permitted on the corner radius or invert of pipe arch.

1020.4.3 Shop Elongation. If round pipe is required to be shop elongated, the vertical axis shall be five percent greater than the nominal diameter. A tolerance of one percentage point in elongation will be permitted. Approximately 2 feet at each end of an installation may be left round to accommodate connecting end treatments or extensions. A paint mark to indicate the top of the pipe shall be placed on each piece of shop elongated pipe, and round ends on an elongated pipe shall be clearly marked "Outside End-Round".

1020.4.4 Beveled Ends. Corrugated metal pipe requiring beveled ends to conform to the adjacent roadway slope shall be cut in such a manner as to leave smooth edges without damage to the coating away from the cut edge. Cut edges shall be completely covered with two coats of single component inorganic zinc or organic zinc-rich paint meeting the approval of the engineer. No other end finish will be required for pipe with beveled ends.

1020.4.5 End Sections. Metal end sections shall be in accordance with the requirements for base metal, coating, fabrication, sampling, accepted brands of metal, sheet manufacturer's certified analysis, sheet manufacturer's guarantee, sheet thickness, workmanship and repair of coating. The sections shall conform to the shape, dimensions and sheet thicknesses shown on the plans, and shall be manufactured as integral units or so the sections may be readily assembled in place.

1020.4.6 Bands. Formed bands may be used on pipe with annular corrugations and helically corrugated pipe with reformed ends. Bands shall be formed with a minimum of two corrugations matching the profile of the pipes being joined together. The corrugations shall be spaced to provide seating in the second corrugation of each pipe and without creating more than 1/2-inch annular space between the pipe ends when joined together.

1020.4.6.1 Circumferentially corrugated bands, bands with projections and helically corrugated bands shall be so constructed as to lap on an equal portion of each of the culvert sections and shall be connected at the ends by galvanized angles having minimum dimensions of 2 x 2 x 3/16 inch, fastened with galvanized bolts of 1/2-inch minimum diameter. Formed bands shall be fastened together by two 1/2-inch bolts through a bar, and strap welded to the band. Angles shall be secured to the coupling bands by riveting, welding, resistance spot welding or a method approved by the engineer at each corrugation. Rivets shall be placed such that the head of the rivet will be on the inside of the band. Welds, except for resistance spot welds, shall be painted with one coat of zinc dust-zinc oxide or zinc-rich paint meeting the approval of the engineer. The 7-inch and 10 1/2-inch bands shall have at least two fastening bolts, the 12-inch and 14-inch bands shall have at least three fastening bolts and the 16 1/4-inch or greater bands shall have at least four fastening bolts. Alternate methods of fastening the ends of coupling bands may be used if approved by the engineer. Coupling bands for pipe-arch and shop elongated pipe shall be shaped to fit the structure.

1020.4.6.2 As an alternate to coupling bands, a bell and spigot joint system may be used as approved by Construction and Materials.

1020.4.7 Special Fittings. Special fittings, angles and tees shown on the plans shall be fabricated by welding in such a manner as to avoid excessive damage to the coating away from the welded area. The welded area and adjacent damaged coating shall be repaired in accordance with Sec 1020.6.

1020.5 Sampling, Testing and Acceptance Procedures. All fabrication plants furnishing pipe for MoDOT projects shall be qualified as herein described. A pipe distributor, who does not fabricate pipe, may attain qualification as set forth for a pipe manufacturer or may furnish pipe for MoDOT projects that is marked and certified from an approved plant. All pipe will be subject to inspection by the engineer at the source of manufacture, at an intermediate shipping terminal or at destination. The engineer shall be allowed unlimited access to all facilities and records, as required, to conduct inspection and sampling in accordance with Sec 106.

1020.5.1 Application for Placement on the Qualified List. For a plant to become qualified, a written request shall be sent by the manufacturer to Construction and Materials with the following information:

(a) A QC Plan, in accordance with Sec 1020.5.2, for each plant from which pipe is to be fabricated for use on MoDOT projects.

(b) A certification statement from the manufacturer that the quality control procedures at the plant, at a

minimum, meet the requirements set forth in the manufacturer's QC Plan.

(c) Sources for each material to be used in the fabrication of pipe shall be provided.

(d) A guarantee that all material to be used in the fabrication of pipe will be in accordance with MoDOT specifications and that pre-approval for any source of material will be received prior to use.

(e) Units of measurement, English or metric, used to fabricate the pipe.

1020.5.2 Manufacturer's QC Plans. The QC Plan for each plant shall include the following:

(a) A list of personnel with corresponding authority and responsibility.

(b) Qualifications and training of QC personnel, current and proposed.

(c) A description of how the manufacturer proposes to control production in order to assure all material and workmanship incorporated into the fabrication of pipe meets the applicable specification requirements.

(d) Lot sizes, the specific tests to be performed during or after production, frequency of these tests, the point where samples or inspections will be obtained or performed, and the format for recording test data.

(e) A drawing, photograph or copy of the manufacturer's identification marking.

(f) A plan for resolving conflicts.

(g) Designate how the pipe will be identified as pipe for MoDOT projects if the pipe is stockpiled and not marked in accordance with Sec 1020.7.

1020.5.3 Maintaining Qualification. To maintain qualification, the manufacturer and plant shall perform and maintain quality control in accordance with the manufacturer's QC Plan approved by Construction and Materials. The manufacturer or plant shall conduct tests and inspections to verify that adequate quality control is maintained and that the pipe furnished is in accordance with Sec 1020. The manufacturer or plant shall maintain for three years a record of all test results and inspections for review by the engineer. The records shall show that each shipment of pipe has been inspected by the plant's QC personnel. The record shall indicate the purchase order number or the project number, route, county, date of inspection, size of corrugation, type of fabrication, quantity in lineal feet, number of bands and end sections, pipe diameter, sheet thickness, brand and heat number of the base metal, and the coating lot number. The manufacturer or plant shall notify the engineer responsible for inspection of that plant at least 24 hours prior to each shipment. Additional pipe may be considered part of the original shipment when the ordered quantity was underestimated or material was lost or damaged. A bill of lading in accordance with Sec 1020.10 shall be provided for each shipment of pipe. Each plant shall maintain a current list of QC personnel with corresponding authority and responsibility. All training provided to QC personnel shall be documented with a brief description of the training and shall be kept on file at the plant.

1020.5.4 Disqualification of a Manufacturer or Plant. A manufacturer or plant may be disqualified to provide pipe for use on MoDOT projects based on the discretion of Construction and Materials, for reasons including, but not limited to, noncompliance with the manufacturer's QC Plan, failure of pipe to consistently meet specifications, falsification of documentation, unsatisfactory performance in the field or for other reasons indicating lack of consistent material or workmanship quality.

1020.5.4.1 A manufacturer or plant will not be considered for reinstatement until after one year from the date of removal for falsification of documents.

1020.5.4.2 Three notices of failure to meet the specification requirements within a 12-month period will be cause for disqualification of a plant for one year, effective from the date of the third notice.

1020.5.4.3 A manufacturer having two or more plants disqualified will constitute disqualification of the manufacturer for one year.

1020.5.4.4 A manufacturer or plant disqualified within one year of the end of a disqualification may be subject to permanent removal, with no application to be reinstated for a period of three years.

1020.5.5 Reinstatement of a Manufacturer or Plant. Consideration of reinstatement of a manufacturer or a plant once disqualified will be no sooner than specified in Sec 1020.5.4, will require a written document from the manufacturer or plant stating the reasons for disqualification and the action taken to correct those deficiencies, written concurrence from Construction and Materials that the problem has been suitably addressed, and followed by an application in accordance with Sec 1020.5.1.

1020.5.6 Sampling of Material. Random sampling of the pipe or material used in the production of pipe will be conducted by the engineer to verify if the pipe and material are in accordance with the applicable specifications. Sampling size and frequency will be at the discretion of the engineer. In the event pipe materials certified by the manufacturer are not in accordance with Sec 1020 as determined by random sampling, testing and inspection, all pipe incorporating that material will be rejected.

1020.5.7 Mill and Factory Inspection. The engineer may have the material inspected and sampled in the rolling mill or in the shop where fabricated. The engineer may require from the mill the chemical analysis of any heat number. The inspection, either in the mill or in the shop, shall be under the direction of the engineer. The engineer shall have unlimited access to the mill or shop for inspection, and every facility shall be extended for the purpose of inspection. Any material or pipe that has been previously rejected at the mill or shop and included in a later lot will be considered sufficient cause for rejection of the entire lot.

1020.5.8 Inspection. Inspection by the engineer will include an examination of the pipe for deficiency in specified diameter, net length of finished pipe and any evidence of poor workmanship. The inspection may include taking samples for chemical analysis, mechanical properties and determination of weight of coating. The pipe making up the shipment shall meet all requirements of these specifications. If 10 percent of the pipe in any lot fails to meet these requirements, the entire lot may be rejected.

1020.5.9 Sampling of Coated Steel. Samples of coated steel sheet may be obtained from coils, flat or corrugated cut lengths or fabricated culverts. Samples shall be taken at a frequency determined by the manufacturer's QC Plan or as required by the engineer.

1020.5.9.1 For testing weight of coating of flat or corrugated cut lengths before fabrication, three specimens, each no less than 2 1/4 inches square or of an equivalent area, shall be taken from each test sheet selected to represent the lot. The specimens shall be taken such that no part includes metal closer than 2 inches from an edge or 4 inches from an end of the cut length. These specimens shall be obtained in any one of the following patterns:

(a) One specimen shall be obtained from the center of the cut length and the other two in a straight line diagonally at the opposite corners.

(b) Specimens shall be taken in a straight line from one end of the cut length, one from the middle portion and one from near each edge.

1020.5.9.2 For testing weight of coating of coils before fabrication, three specimens, each no less than 2 1/4 inches square or of an equivalent area, shall be taken, one from the middle of the width and one from each side. No specimen shall be taken closer than 2 inches from an edge or 4 inches from an end of the coil.

1020.5.9.3 For testing weight of coating of fabricated pipe or pipe-arch, at least one specimen 2 1/4 inches square or of equivalent area, shall be selected for each 20 pieces of pipe within a given lot selected to be tested, provided that no less than three specimens, each from a different piece, shall represent any one lot. The three specimens shall constitute one sample and shall be in accordance with Sec 1020.3.

1020.5.9.4 For chemical analysis of the base metal of flat or corrugated cut lengths before fabrication, a specimen, no less than 2 1/4 inches square or of an equivalent area, shall be taken from each of three different cut lengths for lots weighing 5 tons or less, from four cut lengths for lots weighing more than 5 tons and less than 10 tons and from five cut lengths for lots weighing 10 tons or more. Drillings or chips from the specimens shall be thoroughly mixed for analysis.

1020.5.9.5 For chemical analysis of the base metal of coils, three specimens, each no less than 2 1/4 inches

square or of an equivalent area, shall be taken from across the width of the coil, or if more than one mill lift or coil is involved, three specimens shall be selected from each of at least two different coils. Drillings or chips from the specimens shall be thoroughly mixed for analysis.

1020.5.9.6 When chemical analysis of base metal of fabricated pipe or pipe-arch is required, the analysis shall be performed on the same specimens taken for determination of weight of coating.

1020.5.9.7 For testing mechanical properties of the base metal, two specimens, each 4 x 14 inches, shall be taken from one end of a cut length or coil. The 14-inch dimension shall be in the longitudinal direction of the steel sheet. No specimen shall be taken closer than 2 inches from an edge or 4 inches from an end of a sheet.

1020.5.9.8 Samples for retest of weight of coating on cut lengths shall be taken in accordance with pattern (a) of Sec 1020.5.9.1. Samples for retest of mechanical properties or chemical composition of any base metal or retest of weight of coating on coils or fabricated pipe or pipe-arch shall be taken in the same manner as for the original test.

1020.5.10 Testing of Metallic-Coated Steel. Tests for weight of coating, chemical composition and mechanical properties of metallic-coated steel sheets shall be as herein specified.

1020.5.10.1 Test specimen size and method of test for determining weight of coating shall be in accordance with AASHTO T 65 for zinc coatings, and AASHTO T 213 for aluminum coatings. At the option of the engineer, material may be accepted on the basis of magnetic gauge determinations made in accordance with ASTM E 376.

1020.5.10.2 The method of test for chemical analysis shall be in accordance with ASTM E 30-68, exclusive of any later revisions or additions.

1020.5.10.3 Test specimen size and method of test for determining tensile strength, yield strength and elongation shall be in accordance with ASTM A 370 for sheet steel.

1020.5.11 Acceptance of Metallic-Coated Steel Sheet. Acceptance of metallic-coated steel sheet will be based on a satisfactory sheet manufacturer's certified analysis and guarantee and sheet identification markings, upon tests on samples of the material, or upon both. The frequency of sampling will be determined by the engineer. The fabricator shall provide the equipment and personnel required to obtain the samples as directed by the engineer.

1020.5.12 Accepted Brands of Metal. No metal will be accepted under these specifications until the sheet manufacturer's certified analysis and manufacturer's guarantee have been approved by the engineer. Misbranding or other misrepresentation and non-uniformity of product, will each be considered sufficient reason to discontinue the acceptance of any brand under these specifications, and notice sent to the sheet manufacturer of the discontinuance of acceptance of any brand will be considered to be notice to all culvert companies that handle that particular brand.

1020.5.13 Sampling and Testing of Continuous Lock Seam. Sampling and testing for continuous lock seam quality control shall be in accordance with AASHTO T 249.

1020.5.13.1 The pipe manufacturer or plant shall cut, log and retain quality control samples, which shall be retained for two years. Visual examination samples for quality control shall be cut during production. The manufacturer or plant shall sample a minimum of one lock per coil when the same diameter of pipe is being produced. The samples shall be taken from the beginning of the coil. If diameters are changed within a coil, at least one lock per diameter shall be taken. Quality control tension test specimens shall be taken from pipe representing each sheet thickness and diameter the first time that sheet thickness and diameter is produced. In addition, each sheet thickness thereafter shall be sampled on a monthly basis during production for tension testing of the seam. The manufacturer or plant shall record all tension test results and retain those records for two years.

1020.5.13.2 Inspection by the engineer will include random visual examination samples and tension test samples taken in the presence of the engineer. If visual examination samples indicate nonconformance, that length of the pipe will be rejected, and a resample will be taken from a different length of pipe of the same sheet thickness of the same diameter. If the resample fails, each shipment of that sheet thickness thereafter shall be sampled for visual examination and tension testing until the engineer determines that satisfactory quality control is

established. Pipe from which tension test specimens have been taken may be cut and the undamaged portion accepted for use.

1020.6 Repair of Damaged Coating. Damaged coating on pipe shall be repaired in accordance with AASHTO M 36, except as follows. Coating damaged in the field shall be repaired by recoating by the hot-dip process or by the metallizing process, except that in instances of minor damage to areas in the upper two-thirds of the perimeter as installed, the engineer may permit repair in the same manner as specified for repair during fabrication. The fabricated unit shall be thoroughly cleaned prior to recoating. The hot-dip process shall be in accordance with Sec 1020.3.

1020.7 Marking. Each section of pipe to be used on MoDOT projects shall be marked with an approved manufacturer's identification marking prior to shipment. The marking shall be permanent and located within 12 inches of the downstream end of the pipe.

1020.8 Handling. All pipe shall be handled with care to avoid damage. Pipe having damaged coating, localized bends in excess of 5 percent of the specified pipe diameter or any dent in excess of 1/2 inch will be rejected at the site of the work regardless of previous approvals. Rejected damaged pipe may be used if repaired to the satisfaction of the engineer.

1020.9 MoDOT Identification Number. When the manufacturer contacts the engineer in accordance with Sec 1020.5.3, the engineer will assign a specific MoDOT identification number for each size of pipe in the shipment.

1020.10 Bill of Lading. A bill of lading or delivery receipt for each shipment of pipe shall be furnished to the engineer at the shipping and destination points. The bill of lading shall contain an itemized statement of the sizes and lengths of pipe with the corresponding designated MoDOT identification number provided to the manufacturer for each size of pipe for that shipment. The bill of lading shall contain a certified statement. The certified statement shall be signed by an authorized representative of the manufacturer and shall state the following:
"This certifies that the pipe, bands and end sections in this shipment are in accordance with MoDOT specifications, were fabricated at an approved plant and were fabricated from the following brand names:"

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SECTION 1021
BITUMINOUS-COATED CORRUGATED METAL CULVERT PIPE AND PIPE ARCHES

1021.1 Scope. This specification covers bituminous-coated corrugated metal culvert pipe and pipe arches to be used for the construction of culverts.

1021.2 Basis of Acceptance. The basis of acceptance for pipe and pipe-arches will be in accordance with Sec 1020.2, Sec 1020.5 and as specified herein. The basis of acceptance for bituminous material will be in accordance with AASHTO M 190, except acceptance may be based on samples obtained from storage or from the dipping tanks.

1021.3 Material. The pipe shall be in accordance, as applicable, with Sec 1020 or Sec 1024. The bituminous material shall be in accordance with AASHTO M 190.

1021.4 Lift Hooks or Loops. Lift hooks or loops, if agreed upon by the engineer and manufacturer, may be attached to pipe and pipe-arches to facilitate handling.

1021.5 Repair of Damaged Bituminous Coating. Bituminous coating damaged or displaced during delivery or installation shall be repaired as directed by the engineer by application of hot bituminous material of the same type as that originally used. Care shall be taken to avoid damage to the bituminous material during heating.

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SECTION 1022
CORRUGATED METALLIC-COATED STEEL PIPE UNDERDRAIN

1022.1 Scope. This specification covers corrugated metallic-coated steel pipe underdrain.

1022.2 Basis of Acceptance. Basis of acceptance will be in accordance with Secs 1020.2, and 1020.5, as specified herein.

1022.3 Material. Corrugated metallic-coated steel underdrain shall be in accordance with Sec 1020 and AASHTO M 36, Type III pipe for zinc-coated or aluminum-coated, with the following modifications.

1022.3.1 Pipe 6 inches in diameter shall be fabricated of steel no less than 0.052 inch, 18 gage, specified thickness. Pipe with diameters 8 to 21 inches , inclusive, shall be fabricated of steel no less than 0.064 inch, 16 gage , of the specified thickness.

1022.3.2 Coupling bands shall be of the same base metal as the pipe.

1022.3.3 Mechanical requirements of the base metal shall not apply.

1022.3.4 Samples for determination of coating thickness may be taken from fabricated pipe.

1022.4 Perforations. Unless otherwise specified, all pipe shall be perforated in accordance with the requirements for Class 1 perforations AASHTO M 36.

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SECTION 1023
STRUCTURAL PLATE PIPE AND PIPE ARCHES

1023.1 Scope. This specification covers corrugated galvanized steel structural plates intended for use in construction of pipe and pipe arches. The plates shall consist of corrugated galvanized metal and shall be curved such that the plates can be bolted together to form a structure of the specified shape and size.

1023.2 Basis of Acceptance. The basis of acceptance will be in accordance with Sec 1020.2, Sec 1020.5, and as specified herein.

1023.3 Material. Corrugated galvanized steel structural plate for structural plate pipe and pipe arches shall be in accordance with AASHTO M 167, with the following modifications.

1023.3.1 Corrugations. The radii of curvature of the corrugations shall be at least one-half the depth of the corrugations. The corrugations shall have a depth of 2 inches and a pitch of 6 inches. The depth of corrugations shall not underrun the specified depth by more than 5 percent, and the pitch of the corrugations shall not deviate from the specified depth by more than 1/4 inch.

1023.3.2 Spelter Coating. The spelter coating shall be free from injurious defects such as blisters, flux and uncoated spots. For testing the weight of spelter coating and for chemical analysis, if required, the manufacturer shall take two samples for each 100 plates of each thickness of a shipment or fraction thereof. The samples may be obtained from a piece approximately 3 inches square, cut from a corner of a plate or from a coupon approximately
6 inches square attached to the center of one edge of the plate prior to galvanizing. The coupon shall be of the same thickness and base metal as the plate to which the coupon is attached. One sample shall be retained for the engineer for QA purposes and one sample shall be tested by the manufacturer. If the result of a test for weight of coating for any sample is not in accordance with AASHTO M 167, an additional sample shall be cut for tests from each of two other plates in the lot represented by the nonconforming sample. All original samples and samples for retest shall be in accordance with AASHTO M 167, or the entire shipment will be rejected. At the option of the engineer, the material may be accepted or rejected on the basis of magnetic gauge results, except at the request of the contractor or manufacturer, plates rejected by magnetic gauge results will be sampled as specified above.

1023.3.3 Accepted Brands of Metal. No metal will be accepted under these specifications until after the manufacturer's certificate and guarantee have been approved by the engineer.

1023.3.3.1 Manufacturer's Certificate. The manufacturer of the structural plate identified by the manufacturer's mark shall file with Construction and Materials, a certificate setting forth the name of the manufacturer, the base metal manufacturer, the specified chemical composition and a typical or average analysis showing the percent of sulfur, copper and any other elements specified in Table I of AASHTO M 167. The certificate shall be sworn to for the manufacturer by a person having legal authority to bind the company. Mismarking or other misrepresentation by the manufacturer will be considered sufficient reason to discontinue acceptance under these specifications. Notice sent to the manufacturer of the discontinuance of acceptance will be considered to be notice to all companies handling that particular manufacturer's product.

1023.3.3.2 Manufacturer's Guarantee. The manufacturer of the structural plate shall submit with the certificate a guarantee providing that all structural plate furnished is in accordance with the specifications, shall bear the manufacturer's identification mark and shall be replaced without cost when not in accordance with the specified analysis, sheet thickness or spelter coating. The guarantee shall be so worded as to remain in effect as long as the manufacturer continues to furnish the material.

1023.3.4 Bolts and Nuts for Connecting Plates.

1023.3.4.1 Bolts for connecting plates shall be 3/4 inch in diameter and shall be in accordance with ASTM A 449. Nuts shall be in accordance with ASTM A 563, Grade C. Bolts, nuts and washers shall be galvanized in accordance with AASHTO M 232, or the bolts, nuts and washers may be mechanically galvanized. If mechanically galvanized, the coating thickness, adherence and quality requirements shall be in accordance with AASHTO M 232, Class C. Except as specified herein, bolts and nuts shall meet the dimension requirements of ANSI B18.2.1 for heavy hex bolts and ANSI B18.2.2 for heavy hex nuts. The bearing surface of both bolts and

nuts shall be symmetrically shaped to a one-inch radius spherical surface. The maximum height of the wrench flats on bolts and thickness of nuts shall be within the limits specified in ANSI B18.2.1 and ANSI B18.2.2, respectively. Bolt lengths shall be such as to result in at least "full nuts" when tightened in place. The bolts and nuts may be sampled and tested before erection, or the bolts, nuts and washers may be accepted on certified mill tests by the manufacturer.

1023.3.4.2 Other fasteners may be used if the fasteners:

(a) Meet the chemical and mechanical requirements in Sec 1023.3.4.1.

(b) Have body diameter and bearing areas no less than those specified in Sec 1023.3.4.1.

(c) Provide a comparable fit with the corrugations.

1023.4 Manufacture. Plates shall be connected by bolts at longitudinal and circumferential seams. Joints shall be staggered such that no more than three plates come together at any one point. Plates shall be furnished in standard sizes to permit structure length increments of 2 feet. The size and shape of the plates shall be such that the finished structure will have the dimensions shown on the plans or as specified herein and the circumferential or peripheral transverse seams will be staggered at least one foot, except that the engineer may permit the seams in adjacent plates used for construction of beveled or skewed ends to be continuous. At least four bolts shall be used per foot of longitudinal seam, unless a greater number is specified on the plans, staggered in two rows 2 inches apart, with one row in the valleys and one row on the crests of the corrugations. Bolts along circumferential seams shall be spaced no more than 10 inches apart. The distance from the center of bolt hole to the edge of the plate shall be no less than 1.75 times the diameter of the bolt. The diameter of the bolt holes for the longitudinal seams, except holes at corners of plates, shall not exceed the diameter of the bolts by more than 1/4 inch. The major axis of the holes for transverse seams, including the holes at the corners of the plates, shall not exceed the diameter of the bolt by more than 1/2 inch and the average of the major and minor axis shall not exceed the diameter of the bolt by more than 1/4 inch.

1023.4.1 Circular Pipe. A manufacturing tolerance of 3 inches will be permitted in the diameter of the pipe. The thickness of metal to be used for each structure will be specified in the contract. The plates shall be prominently marked to show the position in which the plates are to be placed in the structure.

1023.4.2 Pipe-Arch. Plates for a pipe-arch shall form a cross-section made up of four circular arcs tangent to each other at the arcs' junctions and symmetrical about the vertical axis. The top shall be an arc of no more than 180 degrees or no less than 155 degrees. The bottom shall be an arc of no more than 50 degrees or no less than 10 degrees. The top shall be joined at each end to the bottom by an arc of no more than 87.5 degrees or no less than 75 degrees. The radius of corner arcs shall be between 16 and 21 inches for Type C-29 and smaller sizes, and between 29 and 33 inches for Type C-30 and larger sizes. The dimensions of structural plate pipe-arch shall be as specified below, subject to a manufacturing tolerance of two percent plus one inch. The thickness of metal to be used for each structure will be specified in the contract.

Structural Plate Pipe-Arch							
English							
Type	Area, Sq Ft	Span, Ft-In.	Height, Ft-In.	Type	Area, Sq Ft	Span, Ft-In.	Height, Ft-In.
C-1	22	6-1	4-7	C-28	105	14-10	9-1
C-2	24	6-4	4-9	C-29	109	15-4	9-3
C-3	26	6-9	4-11	C-30	98	13-3	9-4
C-4	28	7-0	5-1	C-31	102	13-6	9-6
C-5	31	7-3	5-3	C-32	106	14-0	9-8
C-6	33	7-8	5-5	C-33	110	14-2	9-10
C-7	35	7-11	5-7	C-34	115	14-5	10-0
C-8	38	8-2	5-9	C-35	119	14-11	10-2
C-9	40	8-7	5-11	C-36	124	15-4	10-4
C-10	43	8-10	6-1	C-37	129	15-7	10-6
C-11	46	9-4	6-3	C-38	133	15-10	10-8
C-12	49	9-6	6-5	C-39	138	16-3	10-10
C-13	52	9-9	6-7	C-40	143	16-6	11-0
C-14	55	10-3	6-9	C-41	148	17-0	11-2
C-15	58	10-8	6-11	C-42	153	17-2	11-4

C-16	61	10-11	7-1	C-43	158	17-5	11-6
C-17	64	11-5	7-3	C-44	163	17-11	11-8
C-18	67	11-7	7-5	C-45	168	18-1	11-10
C-19	71	11-10	7-7	C-46	174	18-7	12-0
C-20	74	12-4	7-9	C-47	179	18-9	12-2
C-21	78	12-6	7-11	C-48	185	19-3	12-4
C-22	81	12-8	8-1	C-49	190	19-6	12-6
C-23	85	12-10	8-4	C-50	196	19-8	12-8
C-24	89	13-5	8-5	C-51	202	19-11	12-10
C-25	93	13-11	8-7	C-52	208	20-5	13-0
C-26	97	14-1	8-9	C-53	214	20-7	13-2
C-27	101	14-3	8-11	….	….	….	….

1023.4.3 Beveled Ends. When specified on the plans, end plates for forming beveled ends shall be shaped to produce the specified slope in the finished structure. Burnt edges shall be free from oxide and burrs, and shall present a workmanlike finish. Any edges cut after galvanizing shall be completely covered with two coats of single component inorganic zinc or organic zinc-rich paint, meeting the approval of the engineer. Legible identification marks shall be placed on each part plate to designate the plate's proper position in the structure.

1023.5 Workmanship. All plates shall show careful and finished workmanship. Among others, the following defects are specified as constituting poor workmanship, and the presence of any or all of these defects in an individual plate or in general in any shipment, will be considered sufficient cause for rejection:

(a) Improper shape.

(b) Ragged edges.

(c) Unevenly aligned or spaced bolt holes.

(d) Illegible brands.

(e) Bruised, scaled or broken spelter coating.

(f) Dents in the metal.

(g) Bends in the metal not specified.

1023.6 Assembly Instructions and Drawings. The contractor shall provide the engineer with detailed assembly instructions and drawings for each structural plate pipe or pipe-arch prior to the installation of these structures.

1023.7 Repair of Galvanizing. Spelter coating damaged in the field shall be repaired by hot-dip galvanizing, the metallizing process as specified in Sec 1020 or by the zinc alloy stick method in accordance with Sec 1081, except that in instances of minor damage, the engineer may permit repair by painting with two coats of single component inorganic zinc or organic zinc-rich paint. The paint and application shall meet the approval of the engineer.

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SECTION 1024
CORRUGATED ALUMINUM ALLOY CULVERT PIPE AND CORRUGATED ALUMINUM ALLOY STRUCTURAL PLATE

1024.1 Scope. This specification covers corrugated aluminum alloy culvert pipe and corrugated aluminum alloy structural plate intended for use in construction of pipe and pipe arches.

1024.2 Basis of Acceptance. The basis of acceptance will be in accordance with Sec 1020.2, Sec 1020.5 and as specified herein.

1024.3 Material.

1024.3.1 Corrugated Aluminum Alloy Culvert Pipe. This pipe shall be in accordance with AASHTO M 196, Type I.

1024.3.2 Corrugated Aluminum Alloy Structural Plate. Plates, shapes and fasteners for aluminum alloy field bolted pipe and pipe arch shall be in accordance with AASHTO M 219.

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SECTION 1025
CORRUGATED ALUMINUM ALLOY PIPE UNDERDRAINS

1025.1 Scope. This specification covers corrugated aluminum alloy pipe underdrains.

1025.2 Basis of Acceptance. The basis of acceptance will be in accordance with Secs 1020.2 and 1020.5 as specified herein.

1025.3 Material. Pipe for corrugated aluminum alloy pipe underdrains shall be in accordance with AASHTO M 196, Type III, with the following modifications.

1025.3.1 Pipe 6 inches in diameter shall be fabricated of metal no less than 0.048 inch, 18 gage, specified thickness. Pipe with diameters 8 to 21 inches, inclusive, shall be fabricated of metal no less than 0.060 inch, 16 gage, specified thickness.

1025.3.2 Coupling bands shall be of the same aluminum alloy as the pipe.

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SECTION 1026
REINFORCED CONCRETE CULVERT PIPE

1026.1 Scope. This specification covers reinforced concrete pipe to be used for the conveyance of sewage, industrial wastes and storm water, and for the construction of culverts.

1026.2 Basis of Acceptance.

1026.2.1 The basis of acceptance will be in accordance with AASHTO M 170, unless otherwise specified. Pipe shall be from an approved qualified plant and accepted based on certification, manufacturer quality control documentation, and tests on samples as required by the engineer.

1026.2.2 The contractor for quality control purposes and the engineer for quality assurance purposes may select and apply the basis of acceptance in accordance with either Section 5.1.1 or 5.1.2 in AASHTO M 170.

1026.2.2.1 If cylinders are tested, the cylinders shall be tested in accordance with
AASHTO T 22. The average compressive strength of all cylinders tested shall be equal to or greater than the design concrete strength.

1026.2.2.2 If cores are cut from the wall of the pipe and tested, the cores shall be cut and tested in accordance with AASHTO T 280. If the compressive strength of each core tested is equal to or greater than the design concrete strength, the compressive strength of the concrete for the lot will be considered acceptable.

1026.2.2.2.1 If the compressive strength of a core tested is less than the design concrete strength, two additional cores shall be taken from that pipe section and tested. Concrete represented by these core tests will be considered acceptable if the average of the two additional cores is equal to or greater than the specified strength, and no single core is less than 85 percent of the specified strength.

1026.2.2.2.2 If the compressive strength of the three cores is not in accordance with Sec 1026.2.2.2.1, the pipe section from which the core was taken will be rejected. Two pipe sections from the remainder of the lot shall be selected at random and tested for conformance with either Sec 1026.2.2.2 or 1026.2.2.2.1. If both pipe sections meet the core strength requirements of either Sec 1026.2.2.2 or 1026.2.2.2.1, the concrete compressive strength of the remainder of the lot will be accepted. If the compressive strength of either of the two pipe sections tested does not meet the requirements, the remainder of the lot will be either rejected or, at the option of the manufacturer, each pipe section of the remaining lot shall be cored and will be accepted individually. Any pipe sections that have a core not meeting the requirements of either Sec 1026.2.2.2 or 1026.2.2.2.1 will be rejected.

1026.2.2.2.3 If the cores cut from a section of pipe meet the strength test requirements, the core holes shall be plugged and sealed by the manufacturer in a manner such that the pipe section will meet all requirements of these specifications. Pipe sections so sealed will be considered satisfactory for use.

1026.3 Material. Reinforced concrete pipe shall be in accordance with AASHTO M 170, except as specified otherwise herein.

1026.3.1 Reinforced Concrete. Reinforced concrete shall consist of a mixture of cement, mineral aggregate and water, in which steel has been embedded in such a manner that the steel and the concrete act together.

1026.3.2 Cement. Cement shall be in accordance with Sec 1019. Fly ash or GGBFS may be used to replace cement in accordance with Sec 501, except approved Class C or Class F fly ash may be used to replace a maximum of 25 percent of Type I or II cement on an equivalent weight basis. Fly ash shall not exceed 25 percent by weight of the total cementitious material, i.e., microsilica, steel slag or other pozzolanic material.

1026.3.3 Steel Reinforcement. All steel reinforcement shall be in accordance with Sec 1036.

1026.3.4 Aggregate. Fine and coarse aggregate shall be in accordance with Sec 1005, except that gradation requirements and percent passing the No. 200 sieve will not apply.

1026.3.5 Concrete Mixture. The proportion of cementious material in the mixture shall be no less than 470 pounds per cubic yard of concrete.

1026.3.6 Modified or Special Designs. The manufacturer may request approval of modified designs that differ from the designs in Section 7.1, AASHTO M 170; or special designs for sizes and loads beyond those shown in Tables I to V of AASHTO M 170; or special designs for pipe sizes that do not have steel reinforcement areas shown in Tables II to V of AASHTO M 170. Modified or special designs will not be permitted for pipe diameters greater than 36 inches under earth fills greater than 51 feet. Modified or special designs shall be in accordance with AASHTO M 242.

1026.3.6.1 Design Acceptance. The manufacturer shall submit to the engineer four copies of the pipe design, shop drawings and installation procedures all signed and sealed by a professional engineer registered in the State of Missouri. The pipe design, shop drawings and installation procedures shall be accepted in writing prior to the fabrication of the reinforced concrete pipe.

1026.3.6.1.1 Pipe designs may be based on either the indirect design method or direct design method and shall be in accordance with the current AASHTO LRFD Bridge Design Specifications.

1026.3.6.1.2 Designs shall provide all variables required to support computations. Designs based on the indirect design method shall provide test results in accordance with Section 9 of AASHTO M 242 with at least three specimens being tested under the three-edge-bearing method for both the D-Load to produce a 0.01-inch crack and the D-Load to produce the ultimate load. The computations of D-Load shall be included in the designs for both the indirect design method and direct design method.

1026.3.6.1.3 Shop drawings reflecting design and stress details shall include complete details required for reinforced concrete pipe fabrication including wall thickness, concrete design strength, the type, size and placement of reinforcement, and inside and outside dimensions.

1026.3.6.1.4 The installation procedure shall include bedding and compaction details.

1026.3.6.2 Pipe Acceptance. Acceptance of pipe designed by the indirect design method shall be in accordance with Section 4.1.2 of AASHTO M 242. Acceptance of pipe designed by the direct design method shall be in accordance with Section 4.1.1 of AASHTO M 242 by testing against the D-Load to produce the formation of a 0.01-inch crack, which was provided in the previously submitted and accepted design.

1026.3.7 Joints. If a rubber gasket-type joint is specified, joints shall be Type A rubber gaskets in accordance with AASHTO M 198. The manufacturer shall conduct tests in accordance with AASHTO M 198, Section 8, to demonstrate adequate performance, and shall furnish certification that the physical and chemical properties of the gasket are in accordance with this specification.

1026.3.8 Curing. A curing membrane in accordance with Sec 1055 may be applied, and if used, shall be left intact until the strength requirements are met.

1026.3.9 Lift Holes. If agreed upon by the engineer and the manufacturer, no more than two holes may be cast or drilled in the wall of each pipe for the purpose of handling at the construction site. The holes shall be no larger than 2 1/2 inches in diameter for pipe 60 inches in diameter or less, and no larger than 3 1/2 inches for pipe greater than 60 inches in diameter. Lift holes shall be carefully cast or drilled in a manner such that it will not be necessary to cut, bend or otherwise weaken the circumferential steel in the inner cage in pipe having two lines of reinforcement, or any of the circumferential steel in pipe having one line of reinforcement. Lift holes will be permitted for pipe specified with rubber gasketed joints only with written approval from the engineer.

1026.3.10 Marking. Each pipe shall be marked by the manufacturer with a "Q Cast" stamp to certify the pipe was produced by an American Concrete Pipe Association (ACPA) certified plant or the equivalent mark of another approved certification program.

1026.3.10.1 The following additional information shall be clearly marked on the inside of each section of pipe by indenting on the pipe section or by painting thereon with waterproof paint:

(a) Pipe class.

(b) Date of manufacture.

(c) Name or trade-mark of the manufacturer.

1026.3.10.2 One end of each section of pipe with elliptical reinforcement shall be clearly marked, during the process of manufacturing or immediately thereafter, on the inside and the outside of opposite walls along the minor axis of the elliptical reinforcement with the word "Top" or "Bottom" to designate the proper position when laid.

1026.4 Sampling, Testing and Acceptance Procedures. All manufacturers furnishing pipe for MoDOT projects shall be qualified as herein described. All pipe will be subject to inspection by the engineer at the source of manufacture, at an intermediate shipping terminal or at destination. The engineer shall be allowed unlimited access to all facilities and records as required to conduct inspection and sampling in accordance with Sec 106.

1026.4.1 Application for Placement on Qualified List. To become qualified, a written request shall be sent by the manufacturer to Construction and Materials with the following information:

(a) A statement certifying that the quality control procedures at the plant meet the requirements set forth by the American Concrete Pipe Association (ACPA) or National Precast Concrete Association (NCPA) Compliance Audit and Certification Program or an equivalent, MoDOT approved, nationally recognized program.

(b) Sources for each material to be used in the fabrication of pipe. For aggregate sources, the ledge the material is being taken from shall also be included.

(c) A guarantee that all material to be used in the fabrication of pipe will be in accordance with MoDOT specifications, and pre-approval for any source of material will be received prior to use.

(d) Units of measurement, English or metric, used to fabricate the pipe.

1026.4.2 Maintaining Qualification. To maintain qualification, the manufacturer shall perform and maintain a quality control program in accordance with the approved program, with the following modifications:

(a) The bill of lading for each shipment of material used in the production of pipe shall be kept on file for three years.

(b) For all aggregate, the aggregate producer shall provide a certificate of compliance to applicable MoDOT specifications and identify what ledges the aggregate is being produced from. The certificate of compliance shall be kept as long as that material from that source and ledge is being used.

(c) A sieve analysis for determination of aggregate gradations used in each concrete mix shall be conducted once per month, and when an aggregate source is changed.

(d) The percentage of deleterious substance for each aggregate fraction shall be determined once a month.

(e) Admixtures shall be from approved sources and the manufacturer's certification that the material meets MoDOT specifications shall be kept on file for one year.

(f) Mill test reports for reinforcing steel shall be kept on file for one year.

(g) Once a month, an absorption test shall be conducted for each mix used in the production of pipe. Test results shall be kept on file for one year.

(h) For pipe with diameters of 66 inches or larger, three edge bearing tests shall be performed once per 1000 feet of pipe manufactured, and at least once per year. Testing will not be required at plants where pipe of these diameters is not manufactured, nor will pipe of these diameters be required to be manufactured solely for the purpose of performing this testing.

(i) The manufacturer shall notify Construction and Materials at least 24 hours prior to each shipment.

1026.4.3 Plant Certification. Plants for concrete pipe production shall be certified by an approved program,

and the certification shall be maintained current.

1026.4.4 Disqualification of a Manufacturer. A manufacturer may be disqualified to provide pipe for use on MoDOT projects based on the discretion of Construction and Materials, for reasons including, but not limited to, not maintaining approved program certification, failure of material to consistently meet specifications, falsification of any documentation, misbranding of pipe, unsatisfactory performance in the field or for other reasons indicating lack of consistent material quality.

1026.4.4.1 In a case where a manufacturer loses ACPA certification and was not disqualified for any other reason, reinstatement will be considered when the manufacturer is recertified by the approved program.

1026.4.4.2 A manufacturer will not be considered for reinstatement until after one year from the date of removal for falsification of documents.

1026.4.4.3 Three notices of failure to meet specification requirements within a 12-month period will be cause for disqualification of the manufacturer for one year, effective from the date of the third notice.

1026.4.4.4 A manufacturer disqualified within one year of the end of a disqualification may be subject to permanent removal, with no application for reinstatement accepted for a period of three years.

1026.4.5 Reinstatement of a Manufacturer. Consideration of reinstatement of a manufacturer once disqualified will be no sooner than specified in Sec 1026.4.4, will require a written document from the manufacturer stating the reasons for disqualification and the action taken to correct those deficiencies, written concurrence from Construction and Materials that the problem has been suitably addressed, and followed by an application in accordance with Sec 1026.4.1.

1026.4.6 Sampling of Material. Random sampling of the pipe or material used in the production of pipe will be conducted by the engineer to verify the pipe and material are in compliance with applicable specifications. Sampling size and frequency will be at the discretion of the engineer.

1026.5 MoDOT Identification Number. When the manufacturer contacts the engineer in accordance with Sec 1026.4.2, the engineer will assign a specific MoDOT identification number for each size of pipe in the shipment.

1026.6 Bill of Lading. A bill of lading or delivery receipt for each shipment of pipe shall be furnished to the engineer at the shipping and destination points. The bill of lading shall contain an itemized statement of the sizes and lengths of pipe with the corresponding designated MoDOT identification number provided to the manufacturer for each size of pipe for that shipment. The bill of lading shall contain a certified statement. The certified statement shall be signed by an authorized representative of the manufacturer and shall state the following:
"This certifies that the pipe, bands and end sections in this shipment are in accordance with MoDOT specifications, were fabricated at an approved plant and were fabricated from the following brand names:"

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SECTION 1027
POLYMER COATED CORRUGATED METAL CULVERT PIPE AND PIPE ARCHES

1027.1 Scope. This specification covers polymer coated corrugated metal culvert pipe and pipe-arches to be used for the construction of culverts and storm sewers.

1027.2 Basis of Acceptance. Basis of acceptance for pipe and pipe-arches will be in accordance with Secs 1020.2, 1020.5 and the AASHTO specifications cited herein. The basis of acceptance for polymer material will be in accordance with AASHTO M 245. Pipe shall be from an approved qualified plant and will be accepted based on certification, manufacturer QC documentation and results from tests on samples as required by the engineer.

1027.3 Material. Polymer coated corrugated metal pipe and pipe-arches shall be in accordance with Sec 1020 and AASHTO M 245.

SECTION 1028
POLYVINYL CHLORIDE CULVERT PIPE

1028.1 Scope. This specification covers corrugated PVC culvert pipe intended for use in the construction of culverts, sewers and similar uses.

1028.2 Basis of Acceptance. Acceptance of corrugated PVC culvert pipe will be based upon the pipe being in accordance with this specification. Pipe shall be provided from an approved manufacturer, and will be accepted based on certification, identification markings and results from tests required by the engineer.

1028.3 Material. All corrugated PVC culvert pipe, couplings and fittings shall be in accordance with ASTM F 949 for 46 psi stiffness, except as follows.

1028.3.1 Section properties shall be within the following limits:

Minimum					
Nominal Size S (in.)	Effective Pipe Wall Area A_{eff} (in.^{2}/in.)	Pipe Wall Centroid to Inside Face y^c (in.)	Pipe Wall Moment of Inertia I (in.^{4}/in.)	Area Ratio[a] A_{eff}/A_g	Extreme Fiber Ratio[b] y_c/c
12	0.134	0.213	0.0059	0.814	0.622
15	0.149	0.257	0.0111		
18	0.195	0.309	0.0185		
24	0.235	0.406	0.0415		
30	0.284	0.523	0.0828		
36	0.347	0.634	0.1445		

[a] A_g equal gross area of pipe wall per unit length of pipe (in.^{2}/in.)

[b] c equals the distance from the pipe wall centroid to the outermost fiber (in.)

1028.3.2 The pipe shall not be perforated unless otherwise specified.

1028.3.3 Field joints of corrugated PVC pipe shall provide circumferential and longitudinal strength to maintain the pipe alignment, prevent separation of pipe and prevent infiltration of side fill material. Coupling bands, if used, shall be of the same base material as the pipe. Prior to use, the design of coupling bands and fastening devices shall be submitted to and approved by Construction and Materials. Final acceptance of coupling bands and fastening devices will be based on field performance.

1028.3.4 The manufacturer shall provide to the engineer an itemized statement of the sizes and lengths of pipe in each shipment.

1028.4 Sampling, Testing and Acceptance Procedures. Manufacturers furnishing pipe to MoDOT projects shall be qualified as herein described. All pipe will be subject to inspection by the engineer at the source of manufacture, at an intermediate shipping terminal or at the destination. The engineer shall be permitted free access to all facilities and records as required to conduct inspection and sampling in accordance with Sec 106.

1028.4.1 Application for Placement on Qualified List. To become qualified, a written request shall be sent by the manufacturer to Construction and Materials with the following:

(a) A QC plan for each plant from which pipe is to be fabricated for use on MoDOT projects. The QC plan shall be in accordance with Sec 1028.4.2, and shall provide that pipes be randomly selected for test by an independent testing laboratory, and that randomly selected pipes are representative of that manufacturer's pipe.

(b) A statement certifying that the quality control procedures at the plant, at a minimum, meet the requirements set forth in the manufacturer's QC plan.

(c) Sources for each material to be used in the fabrication of pipe.

(d) Certification that all pipe material to be used in the fabrication of pipe will be in accordance with

MoDOT specifications.

(e) Units of measurement, English or metric, used to fabricate the pipe.

1028.4.2 Manufacturer's QC Plans. The QC plan for each plant shall include the following:

(a) A list of personnel with corresponding authority and responsibility.

(b) Qualifications of QC personnel, to include training received or to be given.

(c) A description of how the manufacturer proposes to control production in order to assure all material and workmanship incorporated into the fabrication of pipe meets the applicable specification requirements.

(d) The specific tests to be performed during or after production, frequency of these tests, the point where samples or inspections will be obtained or performed, and the format for recording test data.

1028.4.3 Maintaining Qualification. To maintain qualification, the manufacturer shall perform and maintain a QC program in accordance with the manufacturer's QC plan approved by Construction and Materials. The manufacturer shall conduct tests and inspection to verify that adequate QC is maintained, and that the pipe furnished is in accordance with these specifications. The manufacturer shall maintain for three years a record of all test results and inspections for review by the engineer. The records shall show that each shipment of pipe has been inspected by the plant's QC personnel. The record shall indicate the purchase order number or the project number, the route, county and date of inspection. The manufacturer shall notify Construction and Materials at least 24 hours prior to each shipment of pipe to a MoDOT project. Additional pipe may be considered part of the original shipment when the ordered quantity was underestimated or material was lost or damaged. A bill of lading in accordance with Sec 1028.6 shall be provided for each shipment of pipe. Each plant shall maintain a current list of QC personnel with corresponding authority and responsibility. All training given to QC personnel shall be documented with a brief description of the training and shall be kept on file at the plant.

1028.4.4 Disqualification of a Manufacturer. A manufacturer may be disqualified from providing pipe for use on MoDOT projects based on the discretion of Construction and Materials, for reasons including, but not limited to, failure of material to consistently meet specifications, falsification of any documentation, misbranding of the pipe, unsatisfactory performance in the field or for other reasons indicating lack of consistent material quality.

1028.4.4.1 A manufacturer will not be considered for reinstatement until after one year from the date of removal for falsification of documents.

1028.4.4.2 Three notices of failure to meet specification requirements within a 12-month period will be cause for disqualification of the manufacturer for one year, effective from the date of the third notice.

1028.4.4.3 A plant disqualified twice for any reason in any two-year period will be subject for permanent removal, with a minimal suspension of three years.

1028.4.5 Reinstatement of a Manufacturer or Plant. Consideration of reinstatement of a manufacturer once disqualified will be no sooner than specified in Sec 1028.4.4, will require a written document from the manufacturer stating the reasons for disqualification and the action taken to correct those deficiencies, written concurrence from Construction and Materials that the problem has been suitably addressed, followed by an application in accordance with Sec 1028.4.1.

1028.4.6 Sampling of Material. Random sampling of the pipe will be conducted by the engineer to verify if the pipe and material are in accordance with these specifications. Samples of PVC pipe will be obtained from fabricated culvert sections in accordance with ASTM F 949 at a frequency determined by the engineer.

1028.4.7 Inspection. Inspection will include an examination of the pipe for markings, deficiency in specified diameter, net length of fabricated pipe and any evidence of poor workmanship. The inspection may include taking samples.

1028.4.8 Testing. Specimen testing size and method of tests shall be in accordance with ASTM F 949. The contractor or manufacturer shall provide the equipment and personnel to cut a sample from a section of pipe.

The sample shall include the markings or a record of the markings for that section of pipe.

1028.4.9 Rejection.

1028.4.9.1 Any individual section of pipe failing to meet the marking, diameter, length or workmanship requirements of these specifications will be rejected. If 10 percent of the pipe in any lot fails to meet these requirements, the entire shipment of that pipe size may be rejected.

1028.4.9.2 If a test specimen taken in accordance with Sec 1028.4.8 fails to meet the requirements of ASTM F 949, the pipe sampled will be rejected and the lot will be resampled. A resample will be of the same size as the original sample. The resample shall be in accordance with these specifications, or the entire shipment will be rejected.

1028.5 MoDOT Identification Number. When the manufacturer contacts the engineer in accordance with Sec 1028.4.3, the engineer will assign a specific MoDOT identification number for each size of pipe in the shipment.

1028.6 Bill of Lading. A bill of lading or delivery receipt for each shipment of pipe shall be furnished to the engineer at the shipping and destination points. The bill of lading shall contain an itemized statement of the sizes and lengths of pipe with the corresponding designated MoDOT identification number provided to the manufacturer for each size of pipe for that shipment. The bill of lading shall contain a certified statement. The certified statement shall be signed by an authorized representative of the manufacturer and shall state the following:

"This certifies that the pipe and bands in this shipment are in accordance with MoDOT specifications and were fabricated at an approved plant."

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SECTION 1029
FABRICATING PRESTRESSED CONCRETE MEMBERS FOR BRIDGES

1029.1 Scope. This specification covers the fabrication of prestressed concrete members for bridges. This specification covers both pretensioned and post-tensioned members.

1029.2 Acceptance. Unless otherwise specified in the contract, acceptance of prestressed units will be based on tests of the material and inspection of the completed product. Acceptability of all types of sections covered by these specifications will be determined by the material tests required in the referenced sections of Sec 1029.3, by crushing tests on concrete cores or cured concrete cylinders, and by inspection of the finished sections, including quantity and placement of reinforcement, and freedom from defect.

1029.3 Material.

1029.3.1 Cement. Cement shall be in accordance with Sec 1019.

1029.3.2 Aggregate. Fine and coarse aggregate shall be in accordance with Sec 1005, except that requirements for gradation and percent passing the No. 200 sieve will not apply.

1029.3.3 Steel Reinforcement. Reinforcement shall be in accordance with Sec 1036.

1029.3.4 Steel Strand. Steel strand shall be in accordance with AASHTO M 203.

1029.3.5 Structural Steel. Structural steel shall be in accordance with ASTM A 36. Structural steel for anchorage plates shall be in accordance with AASHTO M 270, Grade 50.

1029.3.6 Wire and Parallel Lay Wire Cables. Wire and parallel lay wire cables shall be in accordance with AASHTO M 203.

1029.3.7 High-Strength Steel Bars. High-Strength Steel Bars shall be in accordance with AASHTO M 275.

1029.3.8 Enclosures. Enclosures for post-tensioning tendons shall be mortar tight, semi-rigid metal tubes with an internal diameter at least 1/4 inch larger than the bar, cable, strand or wire group to be enclosed, and shall be provided with suitable entrance and discharge ports for grouting.

1029.3.9 Mortar. Mortar for grouting tendons in post-tensioned members shall consist of a mixture of cement and fine sand in the approximate proportions of four parts cement to three parts sand, by volume, with sufficient water to form a grout having the consistency of heavy paint.

1029.3.10 Concrete Mixture. Concrete material, proportioning, air-entraining, mixing, slump and transporting of concrete shall be in accordance with Sec 501, except as noted herein. Concrete for prestressed members shall conform to all requirements of Class A-1 concrete, except as noted herein. The contractor may use Type I, IP, I(PM), IS, I(SM), Type II or Type III cement. Alternate mix designs may be submitted to Construction and Materials for approval. Trial batches may be required. Independent laboratory testing may be required. Submissions shall include all mix design, testing and production detail requested by the engineer.

1029.4 Documentation. All wire, strand, bars and anchorage assemblies shall be assigned a lot number and tagged for identification. The contractor shall furnish one copy of the certified mill test report giving the chemical analysis and results of physical tests on the material furnished, except chemical analysis will not be required for steel strand in accordance with AASHTO M 203. The contractor shall also furnish one certified copy of the stress-strain curve representative of the lot to be used.

1029.5 Equipment.

1029.5.1 Prestressing. The contractor shall provide all equipment necessary for the construction and the prestressing of concrete members. Prestressing shall be done with approved jacking equipment. If hydraulic jacks are used, the jacks shall be equipped with accurate pressure gauges. All gauges, load cells, dynamometers and other devices for measuring the stressing load shall have an accuracy within two percent. The combination of jack and gauge shall be calibrated by a testing laboratory meeting the approval of the engineer. A certified graph or table showing the calibration shall be furnished to the engineer. The total load as determined from the

strand elongation shall check that indicated by the gauge within five percent of the total load required to achieve the designated elongation. If other types of jacks are used, proving rings or other devices calibrated by a testing laboratory meeting the approval of the engineer shall be furnished such that the jacking forces may be accurately determined. Calibration shall be repeated at intervals not exceeding one year and after each overhaul. While work is in progress, if any jack or gauge appears, in the judgment of the engineer, to be giving erratic results, or if gauge pressure and elongation indicate materially different stresses, recalibration may be required. The contractor shall furnish means of accurately measuring the elongation of the tendons to within 1/16 inch. Elongation upon completion of stressing operations shall be within five percent of that specified. No tensioning of strands shall be done when strand temperatures are below 30 F.

1029.5.2 End Anchorages. End anchorages and stressing blocks for pretensioned members shall be adequately designed to withstand the forces incidental to prestressing and to maintain the tension in all prestressed tendons of any member until the concrete has been placed and attained its specified transfer strength.

1029.5.3 Concrete Testing Equipment. Equipment for field determination of compressive strength of concrete shall be furnished by the contractor at the location of manufacture of prestressed concrete members. The testing machine may be of any mechanical or hydraulic type, shall be power operated in accordance with AASHTO T 22, Section 1.2.1, shall be capable of testing cylinders to failure, and shall comply with the accuracy tolerances and corrections specified in AASHTO T 67, Sections 16.1 and 17. Approximately the last one-half of the load shall be applied at a rate between 1,200 and 3,000 psi per minute. The contractor shall furnish a sufficient number of 6 x 12-inch or 4 x 8-inch compression test cylinder molds of a type meeting the approval of the engineer. The contractor shall furnish sufficient personnel for cleaning and preparing reusable molds. The contractor shall, at the option of the engineer, furnish technicians to assist the engineer with concrete testing and the making of test cylinders during the placing of concrete.

1029.5.4 Field Laboratory. When requested, a Type 1 field laboratory in accordance with Sec 601 shall be furnished.

1029.6 Construction Requirements.

1029.6.1 Shop Drawings. Shop drawings showing in detail the type, size, number of units, location of tendons, enclosures, method and sequence of releasing the strands, anchorage details and details of proposed lifting loops and lifting procedure shall be submitted to the engineer for approval. The contractor may select the method of prestressing, provided an approved specific method is used and the total prestressing force and the center of gravity of the prestressing tendons as shown on the plans are maintained. The shop drawings shall show a tabulation of the design computations and the total prestress force, size and spacing of all reinforcing steel and concrete compressive strengths for strand release and design. No inspection will be conducted until the plant inspector has received a copy of the approved shop drawings. Prior to making shop drawings, the contractor shall submit in writing for approval of the engineer any proposed tack welding in lieu of tying of the reinforcing bars of prestressed members. If approved by the engineer, the location of tack welding of reinforcing bars shall be shown on the shop drawings submitted for approval. No heat or welding will be permitted in the proximity of prestressing tendons in the members. Shop drawings for the prestressed concrete solid, voided slab and box girder beams shall be required to include the alignment of the holes for the tie rods. The holes shall be aligned in such a way as to prevent damage to the precast units during the placement of the precast units on the beam caps and the installation and tensioning of the tie rods through the precast units.

1029.6.2 Forms and Formwork. Forms and formwork, placing and tying of reinforcing bars and placing and vibrating of concrete shall be in accordance with Secs 703 and 706, with the following additions:

(a) Clamps, bolts or other devices connecting the bulk-head to the side forms, inserts and blockouts shall be capable of being removed or loosened before steam curing is applied.

(b) The casting bed shall have a concrete deck on which the form grillage and soffit plates may be adequately centered, aligned and leveled to the same plane.

(c) Exterior forms for prestressed members shall be metal other than aluminum, mortar-tight and of adequate design to produce members within the tolerances specified. Supplemental forms, such as those used to form steps or to establish slopes, may be made of a material other than metal, so long as dimensional tolerances and mortar-tightness are maintained.

(d) The temperature of the mixed concrete when placed shall be no higher than 90 F. The forms and

reinforcing steel shall be cooled by acceptable methods to an ambient temperature of 90 F or lower.

(e) Fabricating plants with demonstrated facilities for protection of the concrete during cold weather may, with the approval of the engineer, cast prestressed units when the ambient temperature is below 40 F. When the ambient temperature is below 40 F, the forms or enclosures and reinforcing steel shall be heated to attain and maintain a temperature of at least 40 F. No concrete shall be placed when the concrete temperature is below 60 F.

(f) Concrete for girders shall be placed in a minimum of two continuous lifts. No more than 30 minutes shall elapse between the placing of contiguous lifts of concrete. The thickness of the first layer for I-girder beam sections shall be such that the top of the concrete is slightly above the top of the bottom fillet. The casting procedure shall be modified if the length of girders and placement conditions are such that an initial set of concrete may result if each lift is continued full length before another lift is placed.

1029.6.3 Prestressing Tendons. Prestressing tendons for pretensioned members, and metal enclosures for post-tensioned members, shall be accurately placed and securely held during placing and curing of the concrete. Strand chucks for pretensioning shall anchor the strand positively without slippage after seating. Strand chuck components shall be cleaned and inspected between each use and lubricated as necessary. All strands shall be free of contaminants such as dirt, oil, paint, wax, corrosion or other foreign material that may prevent a bond between the strands and the concrete. The use of prestressing strands having kinks, bends, nicks or other defects shall not be permitted. A light coating of rust will not be cause for rejection, provided that the loose rust is removed and the surface of the strands is not visibly damaged. Tensioned strands shall be protected against excessive temperatures such as those produced by torches, welding equipment or sparks. Strands from more than one source shall not be used in any one tensioning operation.

1029.6.4 Strand Splices. One approved splice per strand will be permitted provided the splices are located outside of the prestressed member. For single strand tensioning, the number of strands per bed that may be spliced is not restricted. If multi-strand jacking is used, either all strands shall be spliced or no more than 10 percent of the strands shall be spliced. Spliced strands shall be similar in physical properties, from the same source, and have the same twist or lay. Previously tensioned strands may be reused one time provided the strands meet all requirements of these specifications.

1029.6.5 Wire Failures. Wire failures may be accepted, provided no more than one wire in any strand is broken and the area of broken wires does not exceed two percent of the total area of the strands.

1029.6.6 Stressing Requirements. The contractor shall provide a technician skilled in the use of the system of prestressing to supervise the prestressing operations.

1029.6.7 Elongation. The contractor shall compute the required elongation. Two copies of the computations shall be submitted to the engineer. The length of the strand to be used in calculating elongations shall be the actual length of the strand along the strand's trajectory between the fixed anchorage and the reference point at jacking end of the strand. Stress losses due to slippage of strand anchorages, splice chucks and movement of anchorage abutments shall be included in the elongation computations.

1029.6.8 Pretensioned Members. Prestressing tendons shall be uncoated seven-wire low relaxation strands in accordance with AASHTO M 203, Grade 270. Several pretensioned members may be cast in one continuous line. The time intervening between the casting of the first and last member on a bed shall not exceed four days unless otherwise permitted by the engineer. When the temperature at the time of tensioning is such that correction must be made to compensate for change in strand stresses, all members on the bed shall be cast in a continuous pour. The tension in the strand as determined from the elongation at the time of placing concrete shall be within five percent of that specified. The stress to be given each strand shall be as shown on the plans. Pretensioning shall be by either the single strand or multi-strand jacking method. Each strand shall be brought to a uniform initial tension. The initial tension of each strand shall be accurately measured by a dynamometer or other approved means. The initial tension shall be within 50 pounds or two percent of that required, whichever is the larger. The same jack used for single strand tensioning may be used for initial tensioning provided the jack is equipped with a proper gauging system for measuring the initial tension. Measurement of elongation shall not begin until initial tensioning has been completed. Strands tensioned as a group shall have the same initial tension, be from the same source, and have essentially the same modulus of elasticity. Coil ties shall be held in place in the forms by setting studs projecting through the forms. Studs shall be left in place until girders are

erected and then replaced by coil tie rods. Alternate methods may be used, provided acceptable results are achieved. Coil ties shall have a concrete pull-out strength of at least 9,000 pounds in 3,000 psi concrete.

1029.6.9 Post-Tensioned Members. Post-tensioned members shall be stressed in such a manner that the tension being applied and the elongation of the tendon may be measured at all times. The contractor shall furnish a certified record of gauge pressures and elongations to the engineer. Friction losses in the enclosures, elastic shortening and anchorage set shall be included in the computations for the required elongation of the tendon. In cases of discrepancies between gauge readings and the stress indicated by the elongation of the tendon, the elongation method of stress determination shall govern. Loads shall not be applied to the concrete until the concrete has attained the design compressive strength shown on the plans. Tendons shall be stressed in a sequence to produce the least eccentricity of the load. Post-tensioning elements shall be placed in metal enclosures and after stressing shall be bonded by pressure grouting the space between the enclosure and the tendon. Enclosures shall be thoroughly cleaned of all foreign material prior to grouting. The discharge ports shall be closed after all air has been forced out of the enclosure, as evidenced by the steady discharge of grout at the grout's proper consistency, and a pump pressure of at least 50 psi maintained on the grout for a sufficient length of time to ensure completely filling all voids in the enclosure. Post-tensioned members shall not be removed from their supports for at least 24 hours after grouting.

1029.6.10 Strand Release. Strands shall not be released until the concrete has attained the required compressive strength shown on the approved shop drawings. The compressive strength shall be determined by tests of standard cylinders made of concrete from the same batches and cured in the same manner as the members. The strands or prestressing elements shall be cut or released in a sequence that produces the least eccentricity of the load. If steam curing is used, strand release shall be performed while the members are still warm. Forms, hold down devices, or other appurtenances that may restrict movement of the members shall be removed or loosened prior to strand release. The sequence of release for hold down devices and strands shall be indicated on the shop drawings. Release shall be in accordance with the approved shop drawings.

1029.6.11 Curing. Concrete members shall be kept continuously wet until the conclusion of the curing period. Curing shall be accomplished by covering with burlap or jute mats kept continuously wet by moist air, live steam or any combination of these methods. Other moist curing methods that will keep the member moist may be used provided the details of the proposed method are submitted to the engineer and approved. As soon as the concrete has set sufficiently that no marring of the surface or distortion will result, wet burlap or jute mats shall be applied, covering the exposed surface. Curing shall be continued until the concrete has attained the design compressive strength shown on the plans. The concrete shall not be exposed to temperatures below freezing until the curing has been completed.

1029.6.11.1 Steam Curing. A preset period of no less than four hours shall be allowed before steam cure is applied. When the ambient temperature is below 50 F, steam shall be applied also during the preset period, but only at a rate sufficient to keep the air surrounding the member at a temperature between 50 and 70 F. After the preset period, steam shall be applied at a rate that will not increase the temperature of the air surrounding the members more than 40 F per hour. The maximum curing temperature shall not exceed 160 F, and the difference in temperature adjacent to the concrete at different locations within the enclosure shall not exceed 30 F at any time. Fluctuations of the temperature adjacent to the concrete during the curing period at any one location shall vary no more than 30 F. The contractor shall furnish and place, at the direction of the engineer, a minimum of two portable recording thermometers and no less than one for each 150 feet of enclosure, for use in determining the magnitude and degree of uniformity of temperatures within the enclosure. The temperature recording system shall be capable of automatically producing a temperature record during the entire curing period. The temperature record shall show the temperature at each location at intervals of no more than 15 minutes and have a range of approximately zero to 200 F. The temperature recording system shall be accurate within plus or minus 5 F. Steam shall be applied from pipes with perforations at suitable intervals laid along each side of the member, or by other approved arrangements. Jets of steam will not be permitted to impinge directly against the member, forms or test specimens. Provisions shall be made for effective circulation of the steam around all portions of the members. The concrete shall be kept continuously moist during the steam curing period. Steam curing shall continue until the required strength for transfer of load has developed. Steam or other curing methods shall continue until the concrete has attained the design compressive strength shown on the plans. After the expiration of the steam curing period, the temperature inside the chamber shall be reduced at a rate of no more than 40 F per hour until a temperature has been reached approximately 40 F above the temperature of the air to which the concrete will be exposed.

1029.6.12 Form Removal. Forms shall not be stripped from prestressed concrete members sooner than 12 hours

after casting. If strand release strength has then been attained, forms may be removed and members moved without unnecessary delay to a curing area. If forms are removed before the concrete has attained the strength which will permit the units to be moved or stressed, only the minimum area of the curing enclosure that is necessary to remove each individual form section shall be removed at any one time. The open area in the enclosure shall immediately be closed as each form section is removed. When the surrounding air temperature is below 30 F, no portion of the enclosure shall be removed before the unit has attained the required transfer strength. Forms of test specimens shall be stripped at the same time the forms are removed from the members.

1029.6.13 Handling. Handling and storage of prestressed members shall be performed with the members in an upright position and with points of support in approximately the same position as designated for the final position of the members in the structure. Members shall not be transported nor erected until the concrete has attained the design compressive strength shown on the plans. In storage, the members shall be fully supported across their width on battens that are no less than 4 inches wide. During transportation, the ends of I-beams shall not extend a distance of more than the depth of the beam beyond the bolsters or other supports on the transporting vehicle. Other beams shall not extend more than 1 1/2 times their depth beyond the supports on the transporting vehicle. During storage, the supports shall maintain the members in essentially a level position without twisting. Stacking of members in storage shall be done only with the approval of the engineer. If such permission is granted, the supports of all members shall be in the same vertical planes and shall be of adequate thickness to prevent damage to the lifting devices.

1029.6.14 Surface Finish, I-Girders. Surface finish shall be in accordance with Sec 703.3.5.8, except that no cracks of any kind in post-tensioned members shall be filled before the stressing is completed. The engineer will determine the kind, type and extent of cracks and surface defects, such as honeycomb and chipped edges or corners, that will be tolerated. Repairs may be permitted with mortar in accordance with Sec 703.3.2.9. Commercially available patching material may be used if approved by the engineer. The top surface of members shall be scored transversely to a depth of approximately 1/4 inch with a wire brush, stiff broom or other approved method. A 3-inch wide strip across the top flange of the member shall be smooth finished to accurate top flange depth at each camber point designated on the plans. No laitance shall remain on surfaces to be embedded in concrete. After removal of hold-down devices, holes shall be plugged. If the method for plugging these holes is not shown on the shop drawings, written approval of the proposed method shall be obtained from the engineer. Exposed reinforcing steel shall be thoroughly cleaned of all concrete before delivery of members. The portions of girders to be embedded in the diaphragms at supports shall be roughened by sandblasting or other approved methods to provide suitable bond between girder and diaphragm. Mechanical benders, without the use of heat, shall be used to bend the strands on girders.

1029.6.15 Surface Finish, Tee Girders. Surface finish shall be in accordance with Sec 703.3.5.8, except that no cracks of any kind in post-tensioned members shall be filled before the stressing is completed. The engineer will determine the kind, type and extent of cracks and surface defects, such as honeycomb and chipped edges or corners, that will be tolerated. Repairs may be permitted with mortar in accordance with Sec 703.3.2.9. Commercially available patching material may be used if approved by the engineer. The top surface of members shall be scored transversely to a depth of approximately 1/8 inch. A 6-inch square area at each end and at each camber point designated on the plans, centered on each stem, shall be smooth finished to accurate top flange depth. Laitance on surfaces to be embedded in concrete shall be removed by sandblasting, waterblasting or other approved methods. After removal of hold down devices, holes shall be plugged. If the method for plugging these holes is not shown on the shop drawings, written approval of the proposed method shall be obtained from the engineer. Exposed reinforcing steel shall be thoroughly cleaned of all concrete before delivery of members. The portion of girders to be embedded in the diaphragms at supports shall be roughened by sandblasting or other approved methods to provide suitable bond between girder and diaphragm. Mechanical benders, without the use of heat, shall be used to bend the strands on girders.

1029.6.16 Surface Finish, Deck Panels. The top surface of the panel shall be scored to facilitate bond with the cast-in-place deck. The scoring shall be perpendicular to the prestressing strands in the panel and shall be approximately 1/8 inch in depth.

1029.7 Dimensional Tolerances. The dimensional tolerances shall be as shown in Table I, II or III.

1029.8 Marking. Each precast unit shall be identified with the date, manufacturer and identification number. Markings may be indented on the unit or painted thereon with waterproof paint, and shall be located as shown on the plans or as directed by the engineer.

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Table I Dimensional Tolerances – I–Girders, Solid Slab Beams, Voided Slab Beams,Box Girder Beams and Miscellaneous Prestress Units	
Length of Beam	±1/8 inch per 10 feet of beam length, but no greater than 3/4 inch
Width (Flanges, Web and Fillets)	+3/8 inch, -1/4 inch
Depth (Flanges, Web and Fillets)	±1/4 inch
Depth (Overall)	+1/2 inch, -1/4 inch
Horizontal Alignment - I-Girders and Miscellaneous Prestressed Units (Deviation from a straight line to face of web at mid depth)	Length/8 in tenths of an inch max., all lengths
Horizontal Alignment - Solid Slab, Voided Slab and Box Girder Beams (Deviation from a straight line to face of slab/web)	1/4 inch max., to 40-foot lengths 3/8 inch max., 40 to 60-foot lengths 1/2 inch max., 60 to 80-foot or greater lengths 5/8 inch max, 80 to 100-foot lengths
Camber (Deviation from design camber within 7 days of strand release)	±1/2 inch, to 80-foot lengths ±1 inch, greater than 80-foot lengths ±1 1/2 inch, greater than 120-foot lengths
Stirrup Bars (Projection above top of beam)	±3/4 inch
Stirrup Bars (Longitudinal spacing)	±2 inches
Tendon Position- I-Girders and Miscellaneous Prestressed Units	±1/4 inch center of gravity of strand group and individual tendons
Tendon Position - Solid Slab, Voided Slab and Box Girder Beams	±1/8 inch center of gravity of strand group and individual tendons
Position of Deflection Points for Deflected Strands	±6 inches, longitudinal
Position of Lifting Devices	±6 inches, longitudinal
Side Inserts (Centerline to centerline and centerline to end)	±1/2 inch
Coil Inserts (Centerline to centerline and centerline to end)	±2 inches horizontal, except must be 3 inches or more from end of beam and within reinforcement cage of bent, ±1 inch vertical
Slab Drain Inserts	±1/2 inch from designated location, engineer may approve location ±6 inches from design, multiple inserts for single drain must be within ±1/2 inch of vertical line
Exposed Beam Ends (Deviation from square or designated skew)	±1/4 inch horizontal, ±1/8 inch vertical per foot of beam height
Bearing Area (Deviation from plane)	+±1/8 inch
Bearing Plates (Centerline to centerline)	±1/8 inch per 10 feet of beam length, but no greater than 3/4 inch
Bearing Plates (Centerline to end of beam)	+±1/2 inch
Diaphragm Hole Location	+±1 1/2 inches for centerline of group ±1/2 inch within group
Scupper holes, blockouts and voids	Placed as close as possible to design location after reinforcement steel and strands are properly located

Table II Dimensional Tolerances – Tee Girders	
Length of Beam	±1/8 inch per 10 feet of beam length, but not greater than 1/2 inch
Width (Overall)	±1/4 inch
Depth (Overall)	±1/4 inch
Flange Thickness and Stem Thickness	±1/8 inch
Horizontal Alignment (Deviation from a straight line to face of each web)	1/4 inch max., to 40-foot lengths 3/8 inch max., 40 to 60-foot lengths 1/2 inch max., 60-foot or greater lengths
Camber (Deviation from design camber within 7 days of strand release)	±1/2 inch, to 80-foot lengths ±1 inch, greater than 80-foot lengths
Stirrup Bars (Projection above top of beam)	±3/4 inch
Stirrup Bars (Longitudinal spacing)	±2 inches
Tendon Position	±1/8 inch center of gravity of strand group and individual tendons
Strand Projection	±1 inch
Diagonal Tolerance	±1/4 inch
Position of Deflection Points	±6 inches, longitudinal

for Deflected Strands	±6 inches, longitudinal
Position of Lifting Devices	±6 inches, longitudinal
Side Inserts (Centerline to centerline and centerline to end)	±1/2 inch
Coil Inserts (Centerline to centerline and centerline to end)	±2 inches horizontal, except must be 3 inches or more from end of beam and within reinforcement cage of bent, ±1 inch vertical
Exposed Beam Ends (Deviation from square or designated skew)	±1/4 inch horizontal, ±1/8 inch vertical per foot of beam height
Bearing Area (Deviation from plane)	±1/8 inch
Bearing Plates (Centerline to centerline)	±1/8 inch per 10 feet of beam length, but not greater than 3/4 inch
Bearing Plates (Centerline to end of beam)	±1/2 inch
Center of Stem to Outside Edge of Top Flange	±1/8 inch
Center to Center Distance Between Stems	±1/8 inch
Stem End to End of Top Flange	±1/4 inch
Diaphragm Hole Location	±1 1/2 inches for centerline of group ±1/2 inch within group
Scupper holes, blockouts and voids	Placed as close as possible to design location after reinforcement steel and strands are properly located

Table III Dimensional Tolerances – Deck Panels	
Length	+ 1/8 inch, -1/2 inch
Width	±1/4 inch
Depth	±1/8 inch
Stirrup Bars (Projection above top of panel)	±1/4 inch
Stirrup Bars (Longitudinal spacing)	±1 inch
Tendon Position	±1/8 inch center of gravity of strand group and individual tendons
Strand Projection	±1 inch
Diagonal Tolerance	±1/4 inch
Scupper holes, blockouts and voids	Placed as close as possible to design location after reinforcement steel and strands are properly located
Warpage of corner (one corner out of plane of other three)	Be 1/16 in./ft times the distance from the nearest adjacent corner
Bowing or camber, concave or convex, of any part of a flat surface	Shall not exceed length of bow in inches divided by 360, with maximum of 3/4 inch; and differential bowing or camber between the adjacent members of the same design shall not exceed 1/4 inch
Scupper holes, blockouts and voids	Placed as close as possible to design location after reinforcement steel and strands are properly located

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SECTION 1030
VITRIFIED CLAY SEWER AND CULVERT PIPE

1030.1 Scope. This specification covers vitrified clay sewer and culvert pipe for use on MoDOT projects.

1030.2 Vitrified Clay Sewer and Culvert Pipe. This specification covers two classes of vitrified clay pipe: Standard Strength Clay Pipe for conveyance of sewage, industrial wastes and storm waters, and Extra Strength Clay Pipe for constructing culverts or where high strength pipe is desired. Vitrified clay pipe of these classes shall be in accordance with ASTM C 700. Pipe may be of bell and spigot construction or plain-end.

1030.3 Joints. Pipe shall be provided with compression joints in accordance with ASTM C 425. The contractor shall furnish a manufacturer's certification showing typical chemical resistance results of the joint material, physical test results representative of the joint performance, and certification that the joints are in accordance with ASTM C 425.

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SECTION 1031
CLAY DRAIN TILE

1031.1 Scope. This specification covers clay drain tile.

1031.2 Clay Drain Tile. Clay drain tile shall be in accordance with AASHTO M 179, except paragraphs 6.3, 6.5 and 7.4 will not apply. Unless otherwise specified in the contract, only Type II, Extra-Quality or Type III, Heavy-Duty Drain Tile, shall be furnished.

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SECTION 1032
PRECAST CONCRETE FLARED END SECTIONS

1032.1 Scope. This specification covers reinforced precast concrete flared end sections for use at inlets and outlets of rigid pipe culverts.

1032.2 Material. All material shall be in accordance with Sec 1026.3, except that marking required by Sec 1026.3.10 will be limited to Sec 1026.3.10.1.

1032.2.1 Steel Fibers. Steel fibers shall be in accordance with ASTM A820. The PAL process as outlined in Sec 106 shall apply to steel fibers used in flared end sections.

1032.3 Design.

1032.3.1 Standard Reinforcement. Flared end sections, utilizing rebar or cold drawn steel wire shall be in accordance with the Missouri Standard Plans for Highway Construction.

1032.3.2 Steel Fibers. Steel fibers may be used exclusively or in combination with standard reinforcement. When steel fibers are used, the amount of steel fibers and standard reinforcement required shall be determined through proof of design testing accordance with ASTM C1765, Section 9, for Class III pipe of the same diameter. Proof of design testing shall be performed every three years and the results provided to the engineer upon request. Additional proof of design testing shall be performed when the type of steel fiber is changed or when the dosage rate of the steel fibers is changed.

1032.4 Basis of Acceptance.

1032.4.1 Acceptance Criteria. Acceptability of end sections for all diameters will be determined by the results of such material tests as required in Sec 1026.3, by crushing tests on concrete cores or cured concrete cylinders, and by inspection of the finished end sections, including quantity and placement of reinforcement, to determine the conformance with the design and the freedom from defects.

1032.4.2 Workmanship. All protruding steel fibers shall be removed from the flared end prior to shipping.

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SECTION 1033
PRECAST DRAINAGE UNITS

1033.1 Scope. This specification covers precast reinforced concrete manhole and drop inlet sections and appurtenances, such as grade rings, tops and special sections.

1033.2 Acceptance. Unless otherwise specified, the basis for acceptance shall be in accordance with Sec 1001.14 and AASHTO M 199.

1033.2.1 Lot Size Definition. A lot is defined as one day's production.

1033.2.2 Quality Control. The producer QM plan shall define quality control testing and inspection frequencies and shall include the following minimum requirements.

1033.2.2.1 Compressive strength of cylinders or cores shall be taken at a minimum of once per lot in accordance with AASHTO M 199. Compressive strength testing may also be performed to control handling and curing operations. Cylinders shall be cured in accordance with AASHTO T23 field curing procedures.

1033.2.2.2 Air and slump of fresh concrete shall be taken a minimum of once per lot.

1033.2.2.3 Aggregate gradation, absorption and deleterious shall be checked a minimum of once per month per aggregate source in accordance with Sec 1005.

1033.2.2.4 Absorption samples shall be taken and tested in accordance with AASHTO M199 a minimum of once every four months. Each sample shall be a piece broken, core drilled from the wall, having a thickness equal to the wall and free of visible cracks.

1033.2.2.5 Steel placement shall be checked and documented for each unit.

1033.2.2.6 Finished dimensions shall be checked and documented for each unit.

1033.2.2.7 Pull out testing of steps and ladders shall be checked in accordance with AASHTO M199.

1033.2.2.8 All equipment used for testing shall be maintained and calibrated in accordance with AASHTO R18 or equivalent program.

1033.2.2.9 Concrete plant(s) shall be calibrated and monitored in accordance with producer's QMP.

1033.2.3 Quality Assurance. The QMP shall reference an industry organization or define independent QA testing frequencies including the following:

Tested Property[a]	Test Method	Independent QA
Air	T152	Twice a year
Slump	T119	Twice a year
Coarse Aggregate Deleterious	TM71	Twice a year
Coarse Aggregate Absorption	T85	Twice a year
Compressive Strength	T22	Twice a year
Absorption (per mix)	T280	Once a year

[a] All samples shall be taken at the precast plant

1033.2.4 MoDOT Hold Points

1033.2.4.1 Prior to shipping, producers shall notify MoDOT and obtain a MoDOT identification number(s).

1033.2.4.2 Repair methods and completion of repairs for non-conforming work shall be approved by the engineer and contractor.

1033.2.5 MoDOT Quality Assurance and Auditing. The engineer may perform MoDOT Quality Assurance testing or audit the producer's QMP, documentation and production at any time, which may include coring of

the precast units and the producer's expense.

1033.2.6 Deficient Work. A procedure addressing deficient work shall be in accordance with Sec 1001.14.

1033.2.6.1 Filling of form tie cavities and repair of other defects shall be in accordance with Sec 703.

1033.2.7 Non-Conforming Work. A procedure addressing non-conforming work shall be in accordance with Sec 1001.14.

1033.3 Material.

1033.3.1 Cement. Cement shall be in accordance with Sec 1019. Fly ash or Ground Granulated Blast Furnace Slag (GGBFS) may be substituted for cement in accordance with Sec 501.

1033.3.2 Fly Ash. Fly ash shall be in accordance with Sec 1018.

1033.3.3 Ground Granulated Blast Furnace Slag. GGBFS shall be in accordance with Sec 1017.

1033.3.4 Aggregate. Fine and coarse aggregate shall be in accordance with Sec 1005, except that requirements for gradation and percent passing the No. 200 sieve shall not apply.

1033.3.5 Steel Reinforcement. Reinforcement shall be in accordance with Sec 1036.

1033.3.6 Concrete Mixture. The manufacturer may designate the mixture proportions, but in no case shall the proportion of cement in the mixture be less than 470 pounds per cubic yard of concrete. Admixtures or blends may be used with the approval from the engineer. At the option of the manufacturer, Class B or B-1 concrete may be used. If Class B or B-1 concrete is used, material, proportioning, mixing, slump and transporting of concrete shall be in accordance with Sec 501.

1033.4 Design.

1033.4.1 Precast Drainage Units. The design of precast drainage units shall be in accordance with AASHTO M 199 with the following modifications.

1033.4.1.1 Wall thickness for rectangular drop inlets shall be as shown on the plans.

1033.4.1.2 The quantity of steel reinforcement for rectangular drop inlets shall be as shown on the plans.

1033.4.2 Modified or Special Designs. The manufacturer may request approval of designs, prior to manufacture, other than those specified in the contract documents. Special or modified designs shall be submitted to the engineer, in writing and shall fully describe any deviations from the contract documents. The description shall also include the wall thickness, all other dimensions, concrete compressive strength and the area, type, placement and strength of the steel reinforcement. Such sections shall meet all of the test and performance requirements specified by the engineer in accordance with Sec 1033.2.

1033.4.3 Reinforcement in Rectangular Drop Inlets. Placement of reinforcement in rectangular drop inlets shall be as shown on the plans.

1033.4.4 Manhole Risers and Conical Tops. Each line of circumferential reinforcement shall be assembled into a cage that shall contain sufficient spacer bars or members, extending through the wall of the manhole risers and conical tops, to maintain the reinforcement rigidly in shape and correct position within the form. The exposure of the ends of stirrups or spacers that have been used to position the cages during the placement of the concrete will not be cause for rejection.

1033.5 Joints. The reinforced concrete riser sections, except grade rings, shall be formed such that the risers and top when assembled will make a continuous and uniform structure compatible with the tolerances specified for risers in AASHTO M 199. The joints shall be designed to permit placement without appreciable irregularities in the interior wall surface.

1033.6 Manufacture.

1033.6.1 Placement of Concrete. The transporting and placing of concrete shall be by methods that will prevent the segregation of the concrete material and the displacement of the reinforcing steel from the proper position in the form.

1033.6.2 Curing.

1033.6.2.1 Precast units shall be cured in accordance with Sec 1026. Precast sections shall not be transported or erected until the design compressive strength has been reached.

1033.6.2.2 If Class B or B-1 concrete is used, the sections shall be cured with wet burlap for 72 hours or by covering with transparent membrane applied in accordance with Sec 502. Precast units constructed with Class B or B-1 concrete shall not be transported or erected until at least seven days after casting. If forms are removed before the expiration of the curing period, the parts of the structure exposed shall be cured as directed by the engineer.

1033.6.3 Lift Holes. Lift holes shall be in accordance with Sec 1026. If approved by the engineer, lifting hooks or bars may be cast into the sections.

1033.6.4 Forms. Forms shall be mortar-tight and of sound material adequate to prevent distortion during placing and curing of the concrete. Forms shall be reasonably smooth and free of loose knots, holes and other defects.

1033.6.5 Cold Weather Concreting. Concrete placed in cold weather shall be protected from freezing during the curing period by the use of a heated, weatherproof enclosure. Concrete shall not be placed on or against reinforcing steel or other surfaces with temperatures lower than 35 F. No concrete shall be placed when the ambient temperature is below 35 F.

1033.7 Physical Test Requirements.

1033.7.1 Concrete Test Requirements. The basis for concrete test requirements shall be AASHTO M 199. The specified number of specimens required for the tests shall be furnished without charge by the manufacturer and shall be selected at random by the engineer. The cores for compression tests shall be taken from manhole or drop inlet sections that would not otherwise be rejected under this specification. The selection shall be made at the point or points designated by the engineer.

1033.7.2 Compression Tests. Compression tests for satisfying the design concrete strength requirement may be made on either standard rodded concrete cylinders or cylinders compacted and cured in a similar manner to the manhole or drop inlet sections or, at the option of the manufacturer, on cores drilled from the wall of the section. If compression test cylinders are being used, the manufacturer shall furnish a sufficient number of molds of a type meeting the approval from the engineer. The compressive strength of each core tested shall be equal to or greater than the design strength of the concrete. If a core does not meet the required strength, another core from the same section may be tested. If this core does not meet the required strength, that section will be rejected. Additional tests shall be made on other sections to determine the acceptability of the lot.

1033.7.3 Absorption Test Requirements. The engineer may require samples for absorption tests if concrete other than Class B or B-1 is used. Each sample shall be a piece broken from the wall or a core drilled from the wall, have a minimum area of 9 square inches as measured on one surface of the wall, have a thickness equal to the wall and be free of visible cracks.

1033.8 Permissible Variations in Dimensions.

1033.8.1 The basis for permissible variations in dimensions shall be AASHTO M 199.

1033.8.2 The internal dimensions of precast units shall not vary more than one percent or 3/8 inch, whichever is greater.

1033.8.3 The vertical spacing and vertical alignment between adjacent manhole steps and horizontal distance from the inside wall to the centerline of a manhole step shall not vary more than one inch from the design dimensions.

1033.9 Steps. Steps for precast manholes and drop inlets shall be in accordance with Sec 604 and as shown on the plans.

1033.10 Repairs. Filling of form tie cavities and repair of other defects shall be in accordance with Sec 703.

1033.11 Inspection. The quality of material, the process of manufacture and the finished precast units shall be subject to inspection and approval by the engineer.

1033.12 Marking. Marking shall be indented into the section or shall be painted thereon with waterproof paint. The following information shall be clearly marked on the inside of each precast unit:

(a) MH for manholes or DI for drop inlets. Other units do not need a designation.

(b) Date of manufacture.

(c) Name or trademark of the manufacturer.

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SECTION 1034
REINFORCED CONCRETE ELLIPTICAL CULVERT PIPE

1034.1 Scope. This specification covers reinforced concrete elliptical culvert, storm drain and sewer pipe for use on MoDOT projects.

1034.2 Reinforced Concrete Elliptical Culvert, Storm Drain and Sewer Pipe. Reinforced concrete elliptical culvert, storm drain and sewer pipe shall be in accordance with AASHTO M 207, except material shall be in accordance with Sec 1026.

1034.3 Class and Type. The class of the pipe and type, whether Horizontal Elliptical or Vertical Elliptical, shall be as specified in the contract.

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SECTION 1035
REINFORCED CONCRETE ARCH CULVERT

1035.1 Scope. This specification covers reinforced concrete arch culvert, storm drain and sewer pipe for use on MoDOT projects.

1035.2 Reinforced Concrete Arch Culvert, Storm Drain and Sewer Pipe. Reinforced concrete arch culvert, storm drain and sewer pipe shall be in accordance with AASHTO M 206, except material shall be in accordance with Sec 1026.

1035.3 Class and Size. The class and size of the arch pipe shall be as specified in the contract.

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SECTION 1036
REINFORCING STEEL FOR CONCRETE

1036.1 Scope. This specification covers reinforcing steel to be used in concrete.

1036.2 Acceptance.

1036.2.1 All material shall be obtained from a source identified on the PAL designated for this specification. The source shall be listed on the PAL at the time the material is incorporated into the project.

1036.2.2 All material will be inspected and accepted in accordance with Sec 106.

1036.2.3 AASHTO specifications, when referenced, will control only the physical properties, chemical properties and handling and storage of the material, except as otherwise specified herein or shown on the plans.

1036.3 Reinforcing Steel for Concrete Structures.

1036.3.1 Unless otherwise specified, reinforcement shall be deformed bars in accordance with AASHTO M 31.

1036.3.2 Spiral reinforcement shall be in accordance with Sec 1036.3.1, except that the reinforcement may be plain or deformed or shall be cold drawn steel wire in accordance with AASHTO M 32 or deformed steel wire in accordance with AASHTO M 225.

1036.3.3 Steel welded wire reinforcement shall be in accordance with AASHTO M 55 or AASHTO M 221.

1036.4 Epoxy Coated Reinforcing Steel.

1036.4.1 Epoxy coated reinforcing steel shall be in accordance with ASTM A 775/A 775M except as otherwise specified herein or shown on the plans.

1036.4.1.1 Only steel in accordance with Sec 1036.3.1 shall be used.

1036.4.1.2 Coated bars shall not be spliced except as shown on the plans.

1036.4.1.3 Organic coatings, other than epoxy, shall not be used.

1036.4.1.4 Patching or repair material shall be compatible with the coating, inert in concrete and in accordance with the epoxy resin manufacturer’s recommendations. The material shall be epoxy and be suitable for application at the plant or in the field to uncoated areas and damaged areas of the coating.

1036.5 Documentation.

1036.5.1 Documentation of uncoated steel shall include the steel manufacturer’s certified mill test report showing complete chemical and physical test results for each heat.

1036.5.2 Documentation of coated steel shall include the coating applicator's certification that all material used, the preparation of the bars, coating and curing are in accordance with these specifications, and that no bar contains more than one holiday per linear foot. The certification shall include or have attached specific results of tests of coating thickness and flexibility of coating.

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SECTION 1037
SHEAR CONNECTORS

1037.1 Scope. This specification covers the requirements for stud-type shear connectors and weldability qualification.

1037.2 Material. Studs shall be in accordance with AASHTO M 169 for cold drawn carbon steel bars Grades 1015, 1017 or 1020, either semi- or fully-killed. If flux retaining caps are used, the steel for the caps shall be of a low carbon grade suitable for welding and shall be in accordance with ASTM A 109. The flux for welding shall be self-contained either in the base of the stud or in the ferrule and automatically applied in the welding operation. A ferrule of heat resistant ceramic or other suitable material shall be used with each stud, and the ferrule shall be composed of material, which is not detrimental to the welds, does not cause excessive slag and has sufficient strength to withstand thermal or structural shock.

1037.3 Qualification Procedure. The procedure for weldability tests to qualify shear connector studs for welding under shop or field conditions shall be as follows. Such tests may be performed by a university, independent laboratory or by other approved testing agencies. The tests shall be made on each type and size of stud. The agency performing the tests shall submit to the manufacturer of the stud a certified report giving procedures and results for all tests, including the information listed under Sec 1037.9.

1037.4 Duration of Qualification. Qualifications will be considered valid until the manufacturer makes a change in the base of the stud, the flux or the arc shield, which affects the welding characteristics.

1037.5 Preparation of Specimens.

1037.5.1 Test specimens shall be prepared by welding representative studs to the center of square specimen plates, 1/2 to 3/4 inch thick, in accordance with ASTM A 36. At the option of the manufacturer, several studs may be welded to a large plate and the specimen plates cut of a size suitable for test equipment used. Studs shall be welded with power source, welding gun and control equipment as recommended by the manufacturer. Welding voltage, current and time shall be measured by suitable instrumentation and recorded for each specimen. Lift and plunge shall be at the optimum setting as recommended by the manufacturer.

1037.5.2 Studs shall be of uniform quality and condition, free from laps, fins, seams, cracks, twists, bends or other injurious defects. The finish shall be as produced by cold drawing, cold rolling or machining. The overall height after welding will be shown on the plans. The size of studs with allowable tolerance shall be as follows.

Stud Size - Inches				
Shank Diameter	**Shank Diameter Tolerances**	**Overall Height (Tolerance After Welding)**	**Head Diameter**	**Head Thickness, Min.**
3/4	+ 0.000 - 0.010	+ 0.062 - 0.125	1 1/4 ± 1/64	3/8
7/8	+ 0.000 - 0.010	+ 0.062 - 0.125	1 3/8 ± 1/64	3/8

1037.5.3 Thirty test specimens shall be welded consecutively with optimum current and time. Optimum current and time shall be the midpoint of the range normally recommended by the manufacturer for production welding.

1037.5.4 Thirty test specimens shall be welded consecutively with time held constant at optimum, but with current 10 percent below optimum.

1037.5.5 Thirty test specimens shall be welded consecutively with time held constant at optimum, but with current 10 percent above optimum.

1037.6 Qualification Tests.

1037.6.1 Tensile Tests. Ten of the specimens welded in accordance with Sec 1037.5.3, ten in accordance with Sec 1037.5.4 and ten in accordance with Sec 1037.5.5, shall be subjected to a tensile test. Tensile properties shall be determined in accordance with the applicable sections of AASHTO T 244. If a fracture occurs outside the middle half of the gage length, the test shall be repeated. A stud will be considered as qualified if all test specimens meet the following requirements:

Property	Requirement
Tensile Strength, min	60,000 psi
Yield Strength,as determined by a 0.2% offset method, min	50,000 psi
Elongation, min	20% in 2 inches
Reduction of Area, min	50%

1037.6.2 Bend Tests. Twenty of the specimens welded in accordance with Sec 1037.5.3, 20 in accordance with Sec 1037.5.4 and 20 in accordance with Sec 1037.5.5, shall be bent alternately 30 degrees in opposite directions until failure occurs. A stud will be considered as qualified if, on all test specimens, fracture occurs in the shank of the stud and not in the weld.

1037.7 Retests. If a weld failure occurs in any of the tensile or bend test groups, another test group may be prepared and tested. If weld failure repeats, the stud shall fail to qualify.

1037.8 Qualification. For a manufacturer's studs and arc shields to be qualified, each group of thirty studs shall, by test or retest, meet the requirements specified in Sec 1037.6.

1037.9 Report of Tests. The report of the testing laboratory to the manufacturer shall include the following:

(a) Drawings which show shapes and dimensions with tolerances of studs, arc shields and flux.

(b) A complete description of material used in the studs and arc shields, including the quantity and analysis of the flux.

(c) A certification that the studs and arc shields described in the report are qualified in accordance with Sec 1037.8.

1037.10 Certification. Prior to inspection, the contractor shall submit to the engineer the following information:

(a) The name of the manufacturer.

(b) A detailed description of the studs to be furnished.

(c) A certification from the manufacturer that the studs delivered are qualified in accordance with Sec 1037.8.

(d) A copy of the qualification test results as certified by the testing laboratory unless the source and manufacturing process for these studs has been previously approved.

(e) Certified copies of in-plant quality control test results.

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SECTION 1038
BEARING PADS FOR STRUCTURES

1038.1 Scope. These specifications cover elastomeric bearing pads of neoprene, of rubber and fabric and of rubber and fiber. Elastomeric bearing pads shall include plain bearings, consisting of elastomer only, and laminated bearings, consisting of layers of elastomer restrained at their interfaces by bonded laminates.

1038.2 Acceptance. All material will be accepted on the basis of the required certification and testing required by the engineer.

1038.3 Elastomeric Bearing Pads.

1038.3.1 Material. The elastomer shall be 100 percent virgin chloroprene (neoprene) compound meeting the requirements shown below. The pads shall be of the Durometer Grade specified on the plans. If test specimens are cut from the finished product, a 10 percent variation in "Physical Properties" will be allowed.

ASTM Standard	Property	Durometer Grade		
		50	60	70
D 2240	Hardness	50 ± 5	60 ± 5	70 ± 5
D 412	Tensile Strength, psi, minimum	2500	2500	2500
D 412	Ultimate Elongation, percent, min	400	350	300
D 573 70 hrs @ 212 F	Heat Resistance Change in Durometer Hardness, points, max Change in Tensile Strength, percent, max Change in Ultimate Elongation, percent, max	 +15 -15 -40	 +15 -15 -40	 +15 -15 -40
D 395, Method B	Compressive Set 22 hrs at 212 F, %, max	35	35	35
D 1149	Ozone 100 pphm ozone in air by volume, 20 % strain 100 ± 2 F, 100 hrs, mounting procedure ASTM D 518 Procedure A	No Cracks	No Cracks	No Cracks
D 429, Method B	Adhesion Bond made during vulcanization, lbs/inch	40	40	40
D 746, Procedure B	Low Temperature Test Brittleness at -40 F	No Failure	No Failure	No Failure

1038.3.2 Laminates. Laminates shall be cold rolled sheets in accordance with ASTM A 1008 or hot rolled steel sheets in accordance with ASTM A 1011 with a minimum grade of 36.

1038.3.3 Manufacturing Requirements. Shop drawings for laminated neoprene bearings pad assemblies shall be prepared and submitted to Bridge for approval in accordance with Sec 1080.3.2. Shop drawings will not be required for plain neoprene bearing pads or laminated neoprene bearing pads without a steel sole plate. Cut edges shall be at least as smooth as ANSI 250 finish. Unless otherwise shown on the plans, all components of a laminated bearing shall be molded together into an integral unit, and all edges of the laminations shall be covered by a minimum of 1/8 inch of elastomer except at laminate restraining devices and around holes that will be entirely closed on the finished structure. The laminated neoprene bearings pad assembly steel sole plate shall be bonded by vulcanization to the laminated neoprene pad to provide a homogenous bond free of air and moisture pockets. The following values shall be met under laboratory testing conditions of full size bearings:

(a) Compressive strain of any layer of an elastomeric bearing shall not exceed seven percent at 800 psi average unit pressure or at the design dead load plus live load pressure, if so indicated on the plans.

(b) Shear resistance of the bearing shall not exceed 50 psi for 50 durometer, 75 psi for 60 durometer or 110 psi for 70 durometer compounds at 25 percent strain of the total effective elastomer thickness after an extended 4-day ambient temperature of -20 F.

1038.3.4 The manufacturer shall proof load each laminated neoprene bearing with a compressive load of 1,500 psi on the bearing area. The bulging pattern shall not indicate improper laminate placement or poor laminate

bond. No more than two separate surface cracks with a width of 0.08 inches and a depth of 0.08 inches will be permitted.

1038.4 Type "N" Polytetrafluoroethylene (PTFE) Bearings.

1038.4.1 Type "N" PTFE bearings shall be either fixed units or expansion units having sliding surfaces of mirror stainless steel against PTFE material. Shop drawings for type "N" PTFE bearings shall be prepared and submitted to Bridge for approval in accordance with Sec 1080.3.2 The PTFE sliding bearings shall consist of a steel sole plate with a welded upper element of stainless steel bearing on a lower element consisting of a layer of PTFE material bonded to a stainless steel plate that shall be bonded to the neoprene elastomeric pad. The surface of the stainless steel plate shall be protected from weld splatter during the welding procedure.

1038.4.2 The stainless steel sheet for the top and bottom elements of sliding bearings shall be Type 304 in accordance with ASTM A 240. The finished stainless surface of the top element shall be a plane within a tolerance of 1/32 inch, polished sufficiently to meet the friction requirement in Sec 1038.4.6.1, and shall be comparable to a No. 8 mirror finish as established by the American Iron and Steel Institute Committee of Stainless Steel Producers "Finishes for Stainless Steel" at the completion of fabrication.

1038.4.3 Neoprene elastomeric pads shall be in accordance with Sec 1038.3.

1038.4.4 The PTFE material shall be 100 percent virgin PTFE fluorocarbon resin, unfilled or filled with fiberglass reinforcement to minimize the cold flow tendencies while maintaining the friction properties of the PTFE fluorocarbon resin. The amount of filler by weight of filled PTFE sheet shall be no more than 15 percent. The finished material shall exhibit the following physical properties:

Requirement	Test Method	Filled Value	Unfilled Value
Tensile Strength, psi	ASTM D 638	2000, min	-
	ASTM D 2256	-	2800, min
Elongation, Percent	ASTM D 638	150, min	-
	ASTM D 2256	-	200, min
Melting Point	ASTM D 4895	621 ± 18 F	623 ± 2 F
Specific Gravity	ASTM D 4895	2.20 ± 0.03	2.16 ± 0.03

1038.4.5 The PTFE sheet shall be bonded to the stainless steel with epoxy bonding material designated by the manufacture as compatible with the PTFE sheet and stainless steel and be able to withstand the temperatures of vulcanization. The stainless steel shall then be bonded by vulcanization to the neoprene elastomer to provide a homogenous bond free of air and moisture pockets.

1038.4.6 One load specimen from the sliding bearing, consisting of a bottom element and a compatible top element no less than the smaller of the bearing area or 7 x 7 inches shall be tested by the manufacturer.

1038.4.6.1 The specimen shall be loaded to 800 psi compression at 68 F ± 2 F and subjected to 100 cycles of one inch of horizontal movement each way from center at a rate of 2.5 inches per minute. The breakaway friction coefficient shall be computed for each direction of each cycle, and the breakaway friction coefficient mean and standard deviation shall be computed for the sixth through twelfth cycles. The initial static breakaway coefficient of friction for the first cycle shall not exceed twice the design coefficient of friction. The maximum coefficient of friction for all subsequent cycles shall not exceed the design coefficient of friction. Failure of a single sample shall result in rejection of the entire lot. Following the test, the breakaway coefficient of friction shall be determined again and shall not exceed the initial value. The bearing shall show no signs of bond failure or other defect.

1038.4.6.2 A minimum of one test for sliding bearings shall be performed for each lot of bearings.

1038.5 Rubber and Fabric Pads.

1038.5.1 Rubber and fabric bearings pads shall be manufactured of new material and be composed of multiple layers of prestressed cotton duck material weighing no less than 8.1 ounces per square yard. The duck warp count shall be 50 threads plus or minus one thread per inch and filing count 40 threads plus or minus two threads per inch, each with two yarns per thread. The finished pads shall have 64 plies per inch of thickness. The duck

material shall be impregnated and bound with a high quality rubber compound containing rot and mildew inhibitors and anti-oxidants, compounded into resilient pads of uniform thickness.

1038.5.2 The pads shall withstand compressive loads perpendicular to the plane of laminations of no less than 10,000 psi without separation of bond or detrimental deformation. Load deflection properties, determined in accordance with procedures of Military Specifications MIL-C-882B, shall not exceed 10 percent of total pad thickness at 1,000 psi and 15 percent of total pad thickness at 2,000 psi. When loaded to 1,500 psi, permanent set as load shall be removed in accordance with procedures of MIL-C-882B and shall be no more than 2.5 percent of the original "zero point" thickness. Type A Durometer hardness shall be 87 to 95. The ratio of lateral expansion to vertical deflection shall not exceed 0.25 when loaded to 1,500 psi. The material shall not lose effectiveness throughout a temperature range of -65 F to 150 F. The thickness shall vary no more than five percent from that shown on the plans. There shall be no visible evidence of damage or deterioration resulting from environmental effects of sunshine, humidity, salt spray, fungus or dust in accordance with MIL-E-5272.

1038.6 Rubber and Fiber Pads.

1038.6.1 Rubber and fiber bearing pads shall consist of a rubber body and fabric fibers for insulation under aluminum rail posts. The bearing pads shall be made from new unvulcanized rubber and unused fabric fibers. Fibers and rubber shall be in proper proportion to maintain specified strength and stability.

1038.6.2 Type A durometer surface hardness of the pads shall be 70 to 90. Pads of the specified thickness shall be capable of withstanding compressive loads of no less than
7,000 psi without excessive extrusion or detrimental reduction in thickness.

1038.7 Tolerances. For both plain and laminated bearings, the permissible variation from the dimensions and configuration shown on the plans shall be as follows:

	Inch
Overall Vertical Dimensions Average total thickness 1 1/4 inches or less Average total thickness over 1 1/4 inches	 -0, +1/8 -0, +1/4
Overall Horizontal Dimensions 36 inches and less Over 36 inches	 -0, +1/4-0, +1/2
Thickness of Individual Layers of Elastomer (Laminated bearings only)	± 1/8
Variation from a Plane Parallel to the Theoretical Surface (as determined by measurements at the edges of bearings) Top Sides Individual non-elastic laminates	 1/8, 1/4 1/8
Position of Exposed Connection Members	1/8
Edge Cover of Embedded Laminates or Connection Members	-0, +1/8
Size of Holes, Slots or Inserts	-0, +1/8
Position of Holes, Slots or Inserts	± 1/8

1038.8 Certification. The manufacturer shall furnish certification of all material. The certification shall indicate that the components are in accordance with this specification and shall include typical test results representative of the material, except for bearings meeting 1038.3 and 1038.4 which will require test results for the material actually used in the bearing. The certification shall indicate the results of the proof loading, when required.

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SECTION 1039
EPOXY RESIN MATERIAL

SECTION 1039.10 TYPE II EPOXY.

1039.10.1 Scope. This specification covers epoxy resin to be used to bond plastic concrete or mortar to hardened concrete or mortar.

1039.10.2 General Requirements. The epoxy shall be furnished as a system in accordance with the requirements of ASTM C 881, Type II, Grade 2, Class B or C.

1039.10.3 Manufacturer and Brand Name Approval. Prior to approval and use of this material, the manufacturer shall submit to Construction and Materials a certified test report showing specific test results from an independent laboratory in accordance with all requirements of these specifications. The certified test report shall contain the manufacturer's name, brand name of material, lot tested, date of manufacture and ratio of components. In addition, the manufacturer shall submit a one-quart sample of each component, A and B, for laboratory testing accompanied by a technical data sheet and an MSDS. With approval from the engineer of the certified test report and satisfactory results of tests performed on the sample submitted, the brand name and manufacturer will be placed on a qualified list of concrete bonding compounds. New certified test results and samples shall be submitted any time the manufacturing process or the material formulation is changed and may be required when random sampling and testing of material offered for use indicates nonconformity with any of the requirements herein specified.

1039.10.4 Acceptance. To obtain final acceptance of this material, the manufacturer shall furnish certification to the engineer at the destination that the material supplied is in accordance with all requirements specified and stating that the material is the same system and is identically formulated to the material tested for manufacturer and brand name approval.

SECTION 1039.20 TYPE III EPOXY.

1039.20.1 Scope. This specification covers epoxy to be used in the grouting of dry cracks, in epoxy mortar for patching concrete and in epoxy mortar surface leveling.

1039.20.2 General Requirements. The epoxy shall be furnished as a system in accordance with the requirements of ASTM C 881, Type III, Grade 1, Class B or C.

1039.20.3 Manufacturer and Brand Name Approval. Prior to approval and use of this material, the manufacturer shall submit to Construction and Materials a certified test report showing specific test results from an independent laboratory in accordance with all requirements of these specifications. The certified test report shall contain the manufacturer's name, brand name of material, lot tested, date of manufacture and ratio of components. In addition, the manufacturer shall submit a one-quart sample of each component, A and B, for laboratory testing accompanied by a technical data sheet and an MSDS. With approval from the engineer of the certified test report and satisfactory results of tests performed on the sample submitted, the brand name and manufacturer will be placed on a qualified list of concrete bonding compounds. New certified test results and samples shall be submitted any time the manufacturing process or the material formulation is changed and may be required when random sampling and testing of material offered for use indicates nonconformity with any of the requirements herein specified.

1039.20.4 Acceptance. To obtain final acceptance of this material, the manufacturer shall furnish a certification to the engineer at destination certifying that the material supplied is in accordance with all requirements specified and stating that the material is the same system and is identically formulated to the material tested for manufacturer and brand name approval.

SECTION 1039.30 EPOXY OR POLYESTER BONDING AGENTS FOR DOWELS.

1039.30.1 Scope. This specification covers a multi-component epoxy or polyester bonding agent to be used in anchoring epoxy coated dowel bars in concrete for pavement repair.

1039.30.2 General Requirements. Epoxy or polyester bonding agents for anchoring epoxy coated dowel bars shall be furnished as a multi-component system. The system shall include automatic mixing, whether in

cartridge or bulk form. The component ratios shall be shown on the label of each cartridge or bulk container.

1039.30.3 Properties. The epoxy or polyester bonding agent shall exhibit good bonding properties between the epoxy coated dowel bar and the existing concrete and shall cure in accordance with the manufacturer's recommendation. Bonding agents, when initially mixed, shall have a viscosity, which prevents flow from a horizontal hole. When tested in accordance with MoDOT Test Method TM 49, the minimum pull-out load shall be 8,100 pounds.

1039.30.4 Manufacturer and Brand Name Approval. Prior to approval and use of this material, the manufacturer shall submit to Construction and Materials a certified test report from an independent laboratory showing specific test results in accordance with all requirements of this specification. The certified test report shall contain the manufacturer's name, brand name of material, lot tested, date of manufacture, ratio of components by volume and system tested. In addition, the manufacturer shall submit to Construction and Materials a sample representing the system for laboratory testing accompanied by a technical data sheet, an MSDS and any special installation instructions relative to the system being submitted, including recommended curing time. With approval from the engineer of the certified test report and satisfactory results of tests performed on the sample submitted, the brand name and manufacturer will be placed on a qualified list of bonding agents for dowels. New certified test results and samples shall be submitted any time the manufacturing process or the material formulation is changed and may be required when random sampling and testing of material offered for use indicates nonconformity with any of the requirements herein specified.

1039.30.5 Acceptance. To obtain final acceptance of this material, the manufacturer shall furnish certification to the engineer at the destination that the material supplied is in accordance with all requirements specified and stating that the material supplied is the same system and is identically formulated to the material tested for manufacturer and brand name approval.

SECTION 1039.40 EPOXY BONDING AGENTS FOR RESIN ANCHOR SYSTEMS.

1039.40.1 Scope. This specification covers a multi-component epoxy bonding agents to be used in anchoring steel components in concrete for structures.

1039.40.2 General Requirements. The epoxy shall be furnished as a system in accordance with the requirements of ASTM C 881, Type IV, and Grade 3 and as described herein. When a cartridge dispensing system is used the epoxy shall have a gel time as stated in ASTM C 881 paragraph 5.2.

1039.40.3 Pull Test. The epoxy bonding agent shall exhibit good bonding properties between the anchored product and the existing concrete and shall cure in less than 24 hours or manufacturer's recommendation. For acceptance on the qualified list, Resin Anchor Systems shall be tested in accordance with MoDOT Test Method TM 74. The ultimate minimum pull-out load shall be in accordance with the following table. When tested in accordance with ASTM E 488 the minimum embedment for each size anchor shall be determined and the minimum ultimate pullout loads shall be in accordance with the following table:

Pull-Out Specification Requirements	
Diameter of Threaded Rod or Reinforcing Bar	**Minimum Ultimate Pullout Strength**
1/2"	9,800 lbs
5/8"	15,500 lbs
3/4"	20,400 lbs
7/8"	27,500 lbs
1"	33,600 lbs

1039.40.4 Manufacturer and Brand Name Approval. Prior to approval and use of this material, the manufacturer shall submit to Construction and Materials a certified test report from an independent laboratory showing specific test results in accordance with all requirements of this specification. The certified test report shall contain the manufacturer's name, brand name of material, lot tested, date of manufacture, bar or rod size tested, embedment depth and ratio of components. In addition, the manufacturer shall submit a one- quart sample of each component, A and B, for laboratory testing accompanied by a technical data sheet and a material safety data sheet. With approval from the engineer of the certified test report and satisfactory results of tests performed on the sample submitted, the brand name and manufacturer will be placed on a qualified list of Epoxy Bonding Agents for Resin Anchor Systems. New certified test results and samples shall be submitted any time

the manufacturing process or the material formulation is changed and may be required when random sampling and testing of material offered for use indicates nonconformity with any of the requirements herein specified.

1039.40.5 Acceptance. To obtain final acceptance of this material, the manufacturer shall furnish certification to the engineer at the destination that the material supplied is in accordance with all requirements specified and stating that the material is the same system and is identically formulated to the material tested for manufacturer and brand name approval.

SECTION 1039.50 SAND FOR EPOXY MORTAR.

1039.50.1 Scope. This specification covers sand for use in epoxy mortar for the repairing of concrete surfaces. The epoxy material used in epoxy mortar shall be Type III epoxy in accordance with Sec 1039.20.

1039.50.2 Properties. Sand for mortar shall be a quartzite sand, Ottawa sand or equal. The sand shall be clean and dust free. The maximum moisture content shall be 2 percent. The gradation shall be in accordance with the following requirements:

Gradation Requirements	
Sieve Size	**Percent Passing by Weight**
No. 16	100
No. 30	97-100
No. 50	5-35
No. 100	0-2
No. 200	0-0.4

1039.50.3 Acceptance. The manufacturer shall furnish certification to the engineer at the destination that the material supplied is in accordance with all requirements of this specification. Acceptance will be based on certification and testing.

SECTION 1039.60 EPOXY POLYMER CONCRETE OVERLAY.

1039.60.1 Scope. This specification covers an epoxy concrete overlay system consisting of an epoxy resin material and aggregate for use on bridge deck surfaces.

1039.60.2 Epoxy Resin Material. The infrared spectrum for each component of the epoxy-resin material shall essentially match that of the standard infrared spectrum for the particular component as specified in AASHTO T 237, Sections 4 and 5. The epoxide equivalent for Component A shall not exceed 270. The mixed epoxy shall meet the following requirements:

Epoxy Resin Requirements	
Property	**Specific Value**
Pot life, 75 F, minutes	10 - 55
Tensile strength, 75 F, 7 Days, psi, min.	1500
Tensile elongation, 75 F, percent, min.	20
Water absorption, percent, max.	0.8
Compressive strength, 4 hr., psi, min.	1000
Compressive strength, 48 hr. wet, psi, min.	4000
Ash content, percent, max	0.5
Rotational Viscosity, 75 F, Spindle 3, 60 rpm, Poise	7 - 25
Volatile Content, percent, max.	3.0
Thermal Shear	No shearing, shrinkage, expansion or scaling.

1039.60.2.1 Classes. Epoxy resin shall be formulated for use at specific temperatures as specified in ASTM C 881. The controlling temperature shall be that of the hardened concrete surface to which the overlay is applied. Where unusual curing rates are desired and upon the approval from the engineer, a class of epoxy may be used at a temperature other than that for which the epoxy is normally intended.

1039.60.2.2 Packaging. Containers shall be identified as "Component A--Contains Epoxy Resin" and

"Component B--Contains Hardener" and shall show the type, class and mixing directions. Each container shall be marked with the name of the manufacturer, class, batch, or lot number, date of packaging, date of shelf life expiration, pigmentation, if any, manufacturer, and the quantity contained in pounds and gallons.

1039.60.3 Aggregate for Epoxy Polymer Concrete Overlay. Aggregate shall be bauxite, crushed porphyry, aluminum oxide, flint chat or other similarly hard, durable, dry aggregates with less than 0.2 percent moisture. Aggregate shall be in accordance with the following gradation:

Aggregate Requirements	
Sieve Size	**% Passing By Weight**
# 4	100
# 20	0-5
# 200	0-1.0

1039.60.3.1 Lead Content. Aggregate produced as a by-product from lead or zinc mining operations shall not have a total lead content greater than 4,500 ppm, as determined by EPA Method 3050A, “Acid Digestion of Sediments, Sludges and Soils. Suppliers of this aggregate shall provide certification to the engineer for each shipment that the total lead content of the aggregate does not exceed this value, and attach a typical test report from the same source no older than 12 months prior to the shipment.

1039.60.3.2 Aggregate Recommendation. For each contract, the epoxy supplier shall supply a letter to the engineer specifically recommending the use of a designated aggregate and source, which has been previously approved by Construction and Materials.

1039.60.4 Overlay System. The overlay system shall not exhibit shearing, shrinkage, expansion or scaling.

1039.60.5 Test Methods. Tests will be performed in accordance with the following methods:

Test Methods	
Rotational Viscosity	ASTM D 2393 Model LVT Brookfield viscometer
Epoxy equivalent	MoDOT Test Method TM 73
Volatile content[a]	ASTM D 1259, Method B, for mixed system
Filler content	MoDOT Test Method TM 73
Ash content	ASTM D 482
Pot life	AASHTO T 237
Tensile strength	ASTM D 638
Compressive strength	ASTM C 881
Water absorption	ASTM D 570
Thermal Shear	MoDOT Test Method TM 72

[a]Sample cured 4 days at room temperature and weighed on a previously weighed metal foil.

1039.60.6 Manufacturer and Brand Name Approval. Prior to approval and use of this material, the manufacturer shall submit to Construction and Materials a certified test report showing specific test results in accordance with all requirements of this specification. The certified test report shall include the manufacturer's name, brand name of material, lot tested, date of manufacture, ratio of components by volume and system tested. In addition, the manufacturer shall submit to Construction and Materials a sample representing the system for laboratory testing accompanied by a technical data sheet, an MSDS and any special installation instructions relative to the system being submitted. Upon approval of the certified test report and satisfactory results of tests performed on the sample submitted, the brand name and manufacturer will be placed on a qualified list of epoxy resin material for polymer concrete overlay. New certified test results and samples shall be submitted any time the manufacturing process or the material formulation is changed and may be required when random sampling and testing of material offered for use indicates non-conformity with any of the requirements herein specified.

1039.60.7 Product History. The overlay system shall have a proven record of a minimum of two years on similar bridge decks within the United States. A list including the location, the name of the agency involved with the project, and a name and phone number of a contact person with that agency, shall be provided for each location used as evidence of satisfactory use.

1039.60.8 Acceptance. The manufacturer shall furnish certification to the engineer at the destination that the material supplied is in accordance with all requirements specified and stating that the material supplied is the same system and is identically formulated to the material tested for manufacturer and brand name approval. Acceptance will be based on certification and testing.

SECTION 1039.70 POLYMER CONCRETE.

1039.70.1 Scope. This specification covers polymer concrete consisting of a fast setting epoxy based solid that may contain aggregate for use at bridge expansion joints.

1039.70.2 General Requirements. The polymer concrete shall be resilient, self-adhering, water tight and shall withstand and remain bonded to the surrounding material under repeated impact and thermal cycling. The polymer concrete shall not flow or become tacky at temperatures up to 130 F, shall be resistant to ultraviolet radiation, petroleum products and abrasion, and shall be capable of curing at all temperatures above 50 F. Mixing and placement shall be in accordance with the manufacturer's recommendations.

1039.70.2.1 The combined liquid components with no aggregate added shall be in accordance with the following requirements:

Epoxy Requirements	
Property	**Specific Value**
Mixing Ratio, by Volume	1:1
Viscosity (ASTM D 2393), Poises, Spindle 2, 30 rpm, 25 C ± 2 C	9-20
Color	Black
Gel Time (AASHTO M-200-73), minutes	25-50
Elongation (ASTM D 638[a]), percent	45-55
Tensile Strength (ASTM D 638[a]), psi , min.	900
Shore D Hardness (ASTM D 2240), 77 F	45-75

[a]Test Method Type 1, Molded Specimens, 0.25 inches thickness

1039.70.2.2 The cured polymer concrete including aggregate, which shall be supplied by the manufacturer, shall be in accordance with the following requirements:

Polymer Concrete Requirements	
Property	**Specific Value**
Compression strength (ASTM C 579), psi min. at 24 hours	2,500
Bond Shear Strength (ASTM C 882), psi	700
Abrasion Resistance (ASTM C 501), Wear Index (Taber H-22), max.	1.0
Compressive Stress (OK/OHD L-6), psi	350
Resilience (OK/OHD L-6), percent	70

1039.70.3 Manufacturer and Brand Name Approval. Prior to approval and use of this material, the manufacturer shall submit to Construction and Materials a certified test report from an independent laboratory showing specific test results in accordance with all requirements of this specification. The certified test report shall contain the manufacturer's name, brand name of material, lot tested, date of manufacture and ratio of components. In addition, the manufacturer shall submit a one-quart sample of each component, A and B, for laboratory testing accompanied by a technical data sheet and a material safety data sheet. With approval from the engineer of the certified test report and satisfactory results of tests performed on the sample submitted, the brand name and manufacturer will be placed on a qualified list of polymer concretes. New certified test results and samples shall be submitted any time the manufacturing process or the material formulation is changed and may be required when random sampling and testing of material offered for use indicates nonconformity with any of the requirements herein specified.

1039.70.4 Acceptance. To obtain final acceptance of this material, the manufacturer shall furnish certification to the engineer at destination certifying that the material supplied is in accordance with all requirements specified and stating that the material is identically formulated to the material tested for manufacturer and brand name approval.

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SECTION 1040
GUARDRAIL, END TERMINALS, ONE-STRAND ACCESS RESTRAINT CABLE AND THREE-STRAND GUARD CABLE MATERIAL

1040.1 Scope. This specification covers guardrail, end terminals, one-strand access restraint cable, three-strand guard cable, and all appurtenances required for installation.

1040.2 Basis of Acceptance. The basis of acceptance will be in accordance with specification compliance and from an approved qualified plant and accepted based on certification, quality control documentation, and tests on samples required by the engineer.

1040.2.1 Sampling, Testing and Acceptance Procedures. All suppliers furnishing components for MoDOT projects shall be qualified as herein described. All components will be subject to inspection by the engineer at the source, intermediate shipping terminal, or at destination. The engineer shall be allowed unlimited access to all facilities and records as required to conduct inspection and sampling in accordance with Sec 106 unless specified below.

1040.2.2 Application for Placement on Qualified List. To become qualified, a written request shall be sent by the supplier to Construction and Materials. The request shall include a "Pre-Qualified Section 1040, 1043, and 1044 Supplier Inclusion Certificate and Guarantee Statement" and a guarantee that all material to be used in fabrication will be in accordance with MoDOT specifications and pre-approval for any source of material will be received prior to use.

1040.2.3 Maintaining Qualification. To maintain qualification, the supplier shall maintain quality control documentation. The required documentation for each shipment of material used in production shall be kept on file for three years. The supplier shall notify Construction and Materials at least 24 hours prior to each shipment.

1040.2.4 Disqualification of a Supplier. A supplier may be disqualified to provide components for use on MoDOT projects based on the discretion of Construction and Materials, for reasons including, but not limited to, not maintaining required documentation, failure of material to consistently meet specifications, falsification of any documentation, misbranding of components, unsatisfactory performance in the field, or for other reasons indicating lack of consistent material quality.

1040.2.4.1 A supplier will not be considered for reinstatement until after one year from the date of removal for falsification of documents.

1040.2.4.2 Three notices of failure to meet specification requirements within a 12-month period will be cause for disqualification of the supplier for one year, effective from the date of the third notice.

1040.2.4.3 A supplier disqualified within one year of the end of a disqualification may be subject to permanent removal, with no application for reinstatement accepted for a period of three years.

1040.2.5 Reinstatement of a Supplier. Consideration of reinstatement of a supplier once disqualified will be no sooner than specified in Sec 1040.2.4, will require a written document from the supplier stating the reasons for disqualification and the action taken to correct those deficiencies, written concurrence from Construction and Materials that the problem has been suitably addressed, and followed by an application in accordance with Sec 1040.2.2.

1040.2.6 Sampling of Material. Random sampling of the material used in production will be conducted by the engineer to verify the material is in compliance with applicable specifications. Sampling size and frequency will be at the discretion of the engineer.

1040.2.7 MoDOT Identification Number. When the supplier contacts the engineer in accordance with Sec 1040.2.3, the engineer will assign a specific MoDOT identification number for each component. A Shippers form must accompany the products to the job site.

1040.3 Posts and Blocks. The same type of posts and blocks shall be used in a given run, except as shown on the plans or as approved by the engineer.

1040.3.1 Wood Posts and Blocks. Wood posts and blocks for guardrail and one-strand access restraint cable

shall be in accordance with Sec 1050.

1040.3.2 Steel Posts, Plates and Rails. Steel posts, anchor plates, bearing plates, soil plates, plate washers and channel rail shall be structural steel in accordance with AASHTO M 270, Grade 36, shall be of the dimensions and weights shown on the plans and shall be galvanized in accordance with AASHTO M 111. Bolts, nuts and washers shall be in accordance with the dimensions shown on the plans and shall be galvanized in accordance with AASHTO M 232, or may be mechanically galvanized. If mechanically galvanized, the coating thickness, adherence and quality requirements shall be in accordance with AASHTO M 232, Class C. Any dimensional defects and structural discontinuities will be cause for rejection. The material to be welded shall be preheated in accordance with good welding practice, and welds shall be full-section and sound throughout. All welds shall be mechanically cleaned before galvanizing. No punching, drilling, cutting or welding will be permitted after galvanizing.

1040.3.3 Plastic Blocks. Plastic guardrail blocks shall meet the dimensional requirements shown on the plans. The blocks shall be a homogeneous product with a uniform texture, and shall have no cracking, chipping, flaking, peeling or splintering after fabrication. The blocks will not be considered homogeneous if there are more than five voids larger than 5/8 inch or any voids larger than 3/4 inch on any cut face. The blocks shall be of new stock, shall meet all applicable requirements of NCHRP 350 for NCHRP 350 compliant installations or MASH for MASH complaint installations, and shall meet the approval of Construction and Materials.

1040.3.3.1 Approval. Prior to approval and use of the plastic guardrail blocks, the manufacturer shall submit to Construction and Materials, the manufacturer's name, the product brand name or model number, a copy of the NCHRP 350 or MASH test results, a copy of the FHWA eligibility letter, an MSDS and a sample block.

1040.3.3.2 Acceptance. Acceptance of the material will be based on the manufacturer's certification and upon the results of such tests as may be performed by the engineer.

1040.4 Steel Beam Guardrail. Guardrail beams shall be of the class and type shown on the plans. Guardrail beams shall be in accordance with AASHTO M 180, Type 1 or Type 2.

1040.4.1 Test Specimens. Test specimens for mechanical properties, irrespective of the galvanization method, shall be prepared and tested in accordance with ASTM A 653.

1040.4.2 End Sections. End sections and terminal connectors shall be of a class and type the same as or superior to that used for the beam to which the end sections and terminal connectors are attached. The physical properties shall be in accordance with AASHTO M 180.

1040.4.3 Fabrication. The beams, end sections and terminal connectors shall be shaped and punched as shown on the plans and ready for assembly when delivered. Only drilling or cutting necessary for special connections and for sampling will be permitted in the field. Warped or deformed beams will be rejected. Beams to be erected on a radius of 150 feet or less shall be shop curved to the approximate curvature of the installation.

1040.4.4 Markings.

1040.4.4.1 Beams. Beam markings shall be in accordance with AASHTO M 180, except the AASHTO specification number may be omitted if another designation for Class and Type is used.

1040.4.4.2 Transition Sections and Terminal Connectors. Transition sections and terminal connectors shall be marked in accordance with Sec 1040.4.4.1, except as follows. Durable tags securely attached to each section or connector may be used. If the transition section or terminal connector is Class B, the Class indicator will not be required. If the transition section or terminal connector is Type 2, the Type indicator will not be required. Heat numbers and coating designations will not be required.

1040.4.4.3 End Sections. No markings or tags will be required for end sections.

1040.4.4.4 Posts. Posts shall be marked such that the marking is exposed after installation, in such a manner as to indicate the manufacturer.

1040.4.5 Brand Registration and Guarantee. The manufacturer shall submit a brand registration and guarantee, and current test results indicating compliance with this specification prior to delivery of any material.

Once the brand registration and guarantee is approved, the manufacturer's name will be added to the qualified list of guardrail fabricators. For Type I coated material, the brand registration and guarantee shall certify the material as being produced by the continuous galvanizing method.

1040.4.6 Acceptance. Acceptance will be by brand registration and guarantee, and any sampling deemed necessary by the engineer. The contractor or supplier shall provide equipment and personnel required to obtain samples as directed by the engineer.

1040.5 Crashworthy End Terminals.

1040.5.1 Material. Only new material shall be used in the fabrication of end terminals. The major items of the installations shall be the best standard products of a manufacturer regularly engaged in the production of that type of end terminal and shall be of the manufacturer's latest approved design. After installation, the end terminal shall redirect traffic face side vehicle impacts within the prescribed performance crash test criteria ranges.

1040.5.2 Manufacture's Approval. Prior to approval and use of a end terminal, the manufacturer shall submit to MoDOT the manufacturer's name, the product brand name or model number, a copy of the MASH test results, a copy of the FHWA eligibility letter, and shop drawings.

1040.5.3 Acceptance. Acceptance of the material will be based on the manufacturer's certification and upon satisfactory field performance.

1040.5.4 Contractor's Certification. Prior to installation, the contractor shall furnish to the engineer a manufacturer's certification that the units furnished are identical in material and design to successfully tested units.

1040.6 End Anchors, Bridge Anchors, and Approach Transitions.

1040.6.1 Steel Tube and Tube Block. Steel tubes for end anchors shall consist of structural steel tubing in accordance with ASTM A 500, Grade B, or ASTM A 501 and shall be galvanized in accordance with AASHTO M 111. Structural steel tubing blocks for guardrail shall consist of steel tubing in accordance with ASTM A 500, Grade B, and shall be galvanized in accordance with AASHTO M 111.

1040.6.2 Cable. Cable shall be 3/4 inch in diameter, Type II, Class A in accordance with AASHTO M 30.

1040.6.3 Transition Cap Rail. The transition cap rail shall be in accordance with AASHTO M 270, Grade 36.

1040.6.4 Thrie Beam Rail and Transition Section. The thrie beam rail and transition section shall be galvanized in accordance with AASHTO M 180, Type 2.

1040.6.5 Approval. The cable assembly and anchor plate will be subject to approval by the engineer and shall have a minimum breaking strength of 20 tons.

1040.6.6 Markings. Thrie beam rail and transition sections shall be marked in accordance with Sec 1040.4.4.

1040.7 Cable and Fittings.

1040.7.1 One-Strand Access Restraint Cable.

1040.7.1.1 Cable. Cable shall be zinc-coated steel wire strand; 1/2-inch diameter; seven wire strand; Common, Siemens-Martin or High Strength grade; Class A coating; and shall be in accordance with ASTM A 475.

1040.7.1.2 Hardware. Eyebolts, turnbuckles and clips for cable connections and end anchors shall be steel forgings in accordance with AASHTO M 102 or pearlitic malleable iron in accordance with ASTM A 220. All miscellaneous parts, comprising of cable connections, fasteners and end anchors, shall be galvanized in accordance with AASHTO M 232.

1040.7.2 Three-Strand Guard Cable.

1040.7.2.1 Cable and Connecting Hardware. The cable and connecting hardware shall be in accordance with AASHTO M 30 and AASHTO M 269. The wire rope shall be Type 1, 3/4-inch diameter, 3 by 7 construction with a Class A coating. The rope, with connecting hardware, shall develop the breaking strength of a 25,000-pound single cable. Connecting hardware shall be galvanized in accordance with AASHTO M 232 or may be mechanically galvanized. If mechanically galvanized, the coating, thickness, adherence and quality requirements shall be in accordance with AASHTO M 232, Class C. Cast Steel components shall be in accordance with AASHTO M 103, Grade 70-40, Class 1. Malleable iron castings shall be in accordance with ASTM A 47. Compensating devices shall have a spring constant of 0.46 psi, plus or minus 0.06 pound per inch, and permit 6 inches of travel, plus or minus one inch. All threaded parts on compensating cable end assemblies shall be in accordance with ASTM F 568, Class 4.6, 3/4-10 threads. Socket baskets shall be designed for use with the cable anchor wedge as shown on the plans. Guard cable anchor brackets shall be manufactured from an AASHTO M 270, Grade 250 steel plate, and zinc-coated in accordance with AASHTO M 111. Dimensional tolerances not shown on the plans shall be consistent with the proper functioning of the part, including the part's appearance and accepted manufacturing process.

1040.7.2.2 Cable Brackets. Steel used in the fabrication of the bracket shall be in accordance with ASTM A 36. The bracket shall be galvanized after fabrication in accordance with AASHTO M 111. All fittings, including splices, shall be designed to use the wedge detail, and shall be of such section as to develop the full strength of the 3/4-inch, 25,000-pound round cable. Designs for a combination or single-unit compensating device and turnbuckle assembly shall be submitted for approval. Compensating devices shall have a spring rate of 0.46 ± 0.03 pound per inch, and shall permit 6 inches ± one inch of travel. All parts, except cable wedge, shall be hot-dip zinc coated in accordance with AASHTO M 232 or AASHTO M 298.

1040.7.2.3 Hook Bolts, Hex Bolts, Nuts and Washers. Hook bolts, hex bolts and washers shall be in accordance with ASTM A 307. Cable hook nuts shall be 5/16-18 threads and in accordance with ASTM A 563. Hook bolts, as installed, shall develop an ultimate pull open strength of 450 to 1,000 pounds applied in a direction normal to the axis of the post. Hooked anchor studs shall be in accordance with AASHTO M 314, except the threads and nominal diameter shall be 3/4-10 and in accordance with ASTM F 568, Class 4.6. All items shall be galvanized in accordance with AASHTO M 232 or may be mechanically galvanized in accordance with AASHTO M 232, Class C.

1040.8 Certification. The contractor shall furnish the manufacturer's certification for all material governed by this specification. Specifically, each certification shall indicate compliance with the requirements of each applicable section and as set forth in Table I.

1040.9 Repair of Galvanizing. Galvanized material shall be handled in a manner to avoid damage to the surface. No field punching, drilling, cutting or welding will be permitted after galvanizing. Any galvanized material on which the spelter coating has been damaged will be rejected or may be repaired in accordance with Sec 1081, with approval from the engineer.

Table I - Certification Requirements

Item	Galvanizing Standard	Steel Grade	Other
Wood Post and Blocks	-	-	a
Steel Posts, Plates and Brackets	AASHTO M 111	AASHTO M 270, Grade 36	b
Plastic Blocks	-	-	g
Guardrail Beam	Sec 1040.4	Sec 1040.4	b, c
Bolts, Nuts and Washers	AASHTO M 232	ASTM A 307	
End Terminals Systems	-	-	f
End Anchors - Tubes - Transition Cap Rail	 AASHTO M 111 AASHTO M 111	 ASTM A 500/ASTM A 501 AASHTO M 270, Grade 36	 b b
One-Strand Access Restraint Cable - Cable - Hardware	 AASHTO M 30 AASHTO M 232	 AASHTO M 30 AASHTO M 102/ ASTM A 220	 b b
Three Strand Guard Cable - Cable - Hardware - Cast Steel Components - Malleable Iron Castings - Anchor Brackets - Cable Brackets - Hook and Hex Bolts	 AASHTO M30 AASHTO M 232 AASHTO M 232 AASHTO M 232 AASHTO M 111 AASHTO M 111 AASHTO M 232	AASHTO M 30 & AASHTO M 269 AASHTO M 102/ASTM A 220 AASHTO M 103 ASTM A 47 AASHTO M 270 AASHTO M 270, Grade 36 ASTM A 307	b d d e d

- Hook Nuts	AASHTO M 232	ASTM A 563	
- Hooked Anchor Studs	AASHTO M 232	AASHTO M 314	

(a) Certification shall state that the material is in accordance with Sec 1050 and shall include a listing of the material supplied and a certified test report as detailed in Section 7.2 of AWPA, Standard M2, attesting to complete compliance with this specification.

(b) Certification shall include, or have attached, specific results of laboratory tests for physical and chemical properties from samples representative of the material.

(c) Shall have Brand Registration and Guarantee on file, including certification indicating the coating is either Type 1 by Continuous Galvanizing Method or Type 2.

(d) All threaded parts of compensating cable end assemblies and hooked anchor studs shall be in accordance with ASTM F 568.

(e) All fittings for cable bracket, except the cable wedge, shall be in accordance with AASHTO M 232 or AASHTO M 298.

(f) Certification shall state the name of the manufacturer and that the units furnished are identical in material and design as those tested for performance in accordance with Sec 606.30.

(g) Certification shall state that the materials furnished are identical in chemistry, mechanical properties and geometry as those that passed the NCHRP 350 crash test, and as those that were approved by the Missouri Department of Transportation.

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SECTION 1041
POLYPROPYLENE CULVERT PIPE

1041.1 Scope. This specification covers polypropylene culvert pipe intended for use in the construction of culverts, sewers and similar uses.

1041.2 Basis of Acceptance. Acceptance of polypropylene culvert pipe will be based upon the pipe being in accordance with this specification. Pipe shall be provided from an approved manufacturer, and will be accepted based on certification, identification markings and results from tests required by the engineer.

1041.3 Material. All polypropylene culvert pipe, couplings and fittings shall be in accordance with ASTM F 2736 for double wall and ASTM F 2764 for triple wall, except as follows.

1041.3.1 Section properties shall be within the following limits:

		Minimum						Maximum
	Nominal Size S (in.)	Effective Pipe Wall Area A_{eff} (in.^{2}/in.)	Pipe Wall Centroid to Inside Face y_c (in.)	Pipe Wall Moment of Inertia I (in.^{4}/in.)	Area Ratio[a] A_{eff}/A_g	Extreme Fiber Ratio[b] yc / c	Inside Diameter D_i (in.)	Outside Diameter D_o (in.)
Double Wall	12	0.168	0.445	0.0314	0.803	0.586	11.97	14.65
	15	0.216	0.537	0.0538	0.821	0.687	14.85	17.81
	18	0.217	0.569	0.0747	0.777	0.549	17.82	21.42
	24	0.241	0.710	0.1318	0.723	0.558	23.85	28.34
	30	0.248	0.882	0.2732	0.661	0.475	29.70	35.81
Triple Wall	30	0.324	1.107	0.4416	0.676	0.681	29.70	35.81
	36	0.315	1.363	0.4808	0.653	1.000	35.39	41.62
	42	0.452	1.208	0.5554	0.817	0.797	41.38	47.72
	48	0.348	1.535	0.9460	0.542	0.980	46.92	54.14
	60	0.541	1.627	1.2088	0.739	0.812	58.65	67.17

[a] A_g equals gross area of pipe wall per unit length of pipe (in^2/in.).

[b] c equals the distance from the pipe wall centroid to the outermost fiber (in.).

1041.3.2 The pipe shall not be perforated unless otherwise specified.

1041.3.3 Field joints of polypropylene pipe shall provide circumferential and longitudinal strength to maintain the pipe alignment, prevent separation of pipe and prevent infiltration of fill material. Coupling bands, if used, shall be of the same base material as the pipe. Prior to use, the design of coupling bands and fastening devices shall be submitted to and approved by Construction and Materials. Final acceptance of coupling bands and fastening devices will be based on field performance.

1041.3.4 The manufacturer shall provide to the engineer an itemized statement of the sizes, section properties and lengths of pipe in each shipment.

1041.4 Sampling, Testing and Acceptance Procedures. Manufacturers furnishing pipe to MoDOT projects shall be qualified as herein described. All pipe will be subject to inspection by the engineer at the source of manufacture, at an intermediate shipping terminal or at the destination. The engineer shall be permitted free access to all facilities and records as required to conduct inspection and sampling in accordance with Sec 106.

1041.4.1 Application for Placement on Qualified List. To become qualified, a written request shall be sent by the manufacturer to Construction and Materials with the following:

(a) A QC plan for each plant from which pipe is to be fabricated for use on MoDOT projects. The QC plan shall be in accordance with Sec 1041.4.2, and shall provide that pipes be randomly selected for test by an independent testing laboratory, and that randomly selected pipes are representative of that manufacturer's pipe.

(b) A statement certifying that the quality control procedures at the plant, at a minimum, meet the requirements set forth in the manufacturer's QC plan.

(c) Sources for each material to be used in the fabrication of pipe.

(d) Certification that all pipe material to be used in the fabrication of pipe will be in accordance with MoDOT specifications.

(e) Units of measurement, English or metric, used to fabricate the pipe.

1041.4.2 Manufacturer's QC Plans. The QC plan for each plant shall include the following:

(a) A list of personnel with corresponding authority and responsibility.

(b) Qualifications of QC personnel, to include training received or to be given.

(c) A description of how the manufacturer proposes to control production in order to assure all material and workmanship incorporated into the fabrication of pipe meets the applicable specification requirements.

(d) The specific tests to be performed during or after production, frequency of these tests, the point where samples or inspections will be obtained or performed, and the format for recording test data.

1041.4.3 Maintaining Qualification. To maintain qualification, the manufacturer shall perform and maintain a QC program in accordance with the manufacturer's QC plan approved by Construction and Materials. The manufacturer shall conduct tests and inspection to verify that adequate QC is maintained, and that the pipe furnished is in accordance with these specifications. The manufacturer shall maintain for three years a record of all test results and inspections for review by the engineer. The records shall show that each shipment of pipe has been inspected by the plant's QC personnel. The record shall indicate the purchase order number or the project number, the route, county and date of inspection. The manufacturer shall notify Construction and Materials at least 24 hours prior to each shipment of pipe to a MoDOT project. Additional pipe may be considered part of the original shipment when the ordered quantity was underestimated or material was lost or damaged. A bill of lading in accordance with Sec 1041.6 shall be provided for each shipment of pipe. Each plant shall maintain a current list of QC personnel with corresponding authority and responsibility. All training given to QC personnel shall be documented with a brief description of the training and shall be kept on file at the plant.

1041.4.4 Disqualification of a Manufacturer. A manufacturer may be disqualified from providing pipe for use on MoDOT projects based on the discretion of Construction and Materials, for reasons including, but not limited to, failure of material to consistently meet specifications, falsification of any documentation, misbranding of the pipe, unsatisfactory performance in the field or for other reasons indicating lack of consistent material quality.

1041.4.4.1 A manufacturer will not be considered for reinstatement until after one year from the date of removal for falsification of documents.

1041.4.4.2 Three notices of failure to meet specification requirements within a 12-month period will be cause for disqualification of the manufacturer for one year, effective from the date of the third notice.

1041.4.4.3 A plant disqualified twice for any reason in any two-year period will be subject for permanent removal, with a minimal suspension of three years.

1041.4.5 Reinstatement of a Manufacturer or Plant. Consideration of reinstatement of a manufacturer once disqualified will be no sooner than specified in Sec 1041.4.4, will require a written document from the manufacturer stating the reasons for disqualification and the action taken to correct those deficiencies, written concurrence from Construction and Materials that the problem has been suitably addressed, followed by an application in accordance with Sec 1041.4.1.

1041.4.6 Sampling of Material. Random sampling of the pipe will be conducted by the engineer to verify if the pipe and material are in accordance with these specifications. Samples of polypropylene pipe will be obtained from fabricated culvert sections in accordance with ASTM F 2736 or ASTM F 2764 at a frequency determined by the engineer.

1041.4.7 Inspection. Inspection will include an examination of the pipe for markings, deficiency in specified

diameter, net length of fabricated pipe and any evidence of poor workmanship. The inspection may include taking samples.

1041.4.8 Testing. Specimen testing size and method of tests shall be in accordance with ASTM F 2736 or ASTM F 2764. The contractor or manufacturer shall provide the equipment and personnel to cut a sample from a section of pipe. The sample shall include the markings or a record of the markings for that section of pipe.

1041.4.9 Unacceptable Material.

1041.4.9.1 Any individual section of pipe failing to meet the marking, diameter, length or workmanship requirements of these specifications will be unacceptable. If 10 percent of the pipe in any lot fails to meet these requirements, the entire shipment of that pipe size may be rejected.

1041.4.9.2 If a test specimen taken in accordance with Sec 1041.4.8 fails to meet the requirements of ASTM F 2736 or ASTM F 2764, the pipe sampled will be rejected and the lot will be resampled. A resample will be of the same size as the original sample. The resample shall be in accordance with these specifications, or the entire shipment will be rejected.

1041.5 MoDOT Identification Number. When the manufacturer contacts the engineer in accordance with Sec 1041.4.3, the engineer will assign a specific MoDOT identification number for each size of pipe in the shipment.

1041.6 Bill of Lading. A bill of lading or delivery receipt for each shipment of pipe shall be furnished to the engineer at the shipping and destination points. The bill of lading shall contain an itemized statement of the sizes and lengths of pipe with the corresponding designated MoDOT identification number provided to the manufacturer for each size of pipe for that shipment. The bill of lading shall contain a certified statement. The certified statement shall be signed by an authorized representative of the manufacturer and shall state the following:
"This certifies that the pipe and bands in this shipment are in accordance with MoDOT specifications and were fabricated at an approved plant."

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SECTION 1042
HIGHWAY SIGN MATERIAL

1042.1 Scope. This specification covers the material used in signs and fastening devices, and the fabrication of signs.

1042.2 Material. Material shall be of new stock and shall be in accordance with the following, unless otherwise shown on the plans.

1042.2.1 Signs.

Item	Specification
Aluminum Flat Sheets	ASTM B 209, 6061-T6 or 5052-H38
Aluminum Extruded Sign Panels	ASTM B221, 6063-T6

1042.2.2 Sign Appurtenances.

Item	Specification
Aluminum Post Clip	ASTM B 108, 356-T6
Aluminum Bolts	ASTM B 211, 2024-T4 or 6061-T6
Aluminum Nuts	ASTM B 211, 2024-T4, 6061-T6, 6262-T9 or 2017-T4
Aluminum Flat Washers	ASTM B 209, or Alclad 2024-T4 or 2024-T4
Aluminum Lock Washers	ASTM B 211, 7075-T6
Aluminum Lock Nuts (Nylon Insert)	ASTM B 211, 2017-T4
Aluminum Edge Molding	ASTM B 221,6063-T6
Stainless Steel Bolts, Nuts, Screws and Washers	ASTM A 320 or SAE J405D, Austenitic Steel, Min. Yield 30,000 psi

1042.2.3 Certification. A manufacturer or supplier's Certification of Metal used for signing material listed above shall be furnished to the engineer at the fabrication plant at the time of material inspection. The contractor shall furnish to the engineer the fabricator's certification in accordance with Sec 903.3.5.2.

1042.2.4 Structural Signs. Structural signs shall be fabricated of 0.081-inch minimum extruded aluminum panels and mounted as shown on the plans. The maximum allowable deviation from flatness shall not exceed 0.010 inch per inch width of the panel. Shop drawings for approval from the engineer will be required for any variation in the assembly or mounting details.

1042.2.5 Sheet Signs. Flat sheet signs shall be fabricated as shown on the plans from sheet aluminum of the specified thickness. Flat sheet signs shall not have holes except those drilled or punched for proper mounting.

1042.2.6 Washers. Nylon washers recommended by the sign sheeting manufacturer shall be used between the bolt heads and sign faces on flat sheet aluminum signs. The washers shall be for use with 3/8-inch bolts and shall have a minimum outside diameter of 3/4 inch, and a nominal thickness of 1/16 inch.

1042.2.7 Retroreflective Sheeting. Retroreflective sheeting shall be in accordance with latest versions or ASTM D 4956 and AASHTO M 268, except as noted herein. Color and luminance values for all MoDOT types of reflective sheeting shall be in accordance with ASTM D 4956. Retroreflective sheeting shall have sufficient adhesion, strength and flexibility such that the sheeting can be handled, processed and applied according to the manufacturer's recommendations without appreciable stretching, tearing, cracking or other damage. Adhesive performance for retroreflective sheeting shall be in accordance with ASTM D 4956. The sheeting surface shall be in condition to be readily screen processed and compatible with transparent overlay films, plus recommended transparent and opaque screen process colors. The retroreflective sheeting manufacturer shall furnish information as to the type of solvent or solvents that may be used to clean the surface of the sheeting without detrimental loss of performance and durability. Retroreflective sheeting having a datum mark on the surface shall be oriented vertically. ASTM D 4956 Type IX, XI or AASHTO M 268 Type C or D retroreflective sheeting applied as legend and border for specific signing applications, without a datum mark on the surface of the sheeting, shall be evaluated for rotational sensitivity per AASHTO M 268, Section 3.3. Retroreflective

sheeting products that do not meet the rotational sensitivity requirements of Section 3.3 shall follow guidelines detailed in AASHTO M 268 Section 3.3.1 and fabricated per AASHTO M 268 Section 3.3.2.

1042.2.7.1 ASTM D 4956 Type I, Class 1 retroreflective sheeting shall be enclosed lens glass-bead or prismatic sheeting.

1042.2.7.2 Sign Sheeting. Background sheeting applied to flat sheet and extruded panel signs shall be in accordance with ASTM D 4956 Type IV, Class 1. All yellow, orange and yellow green sheeted signs shall be fabricated with ASTM D 4956 Type IX, XI or AASHTO M 268 Type C or D fluorescent yellow, fluorescent orange and fluorescent yellow green sheeting respectively. Retroreflective sheeting shall be high intensity that is an unmetallized micro prismatic reflective material.

1042.2.7.3 Channelizers. All reflective sheeting for channelizers and drum-like channelizers shall be in accordance with ASTM D 4956 Type IX or XI for fluorescent orange sheeting and in accordance with ASTM D 4956 Type IV for orange or white sheeting. All retroreflective marking on channelizers shall be in accordance with ASTM D 4956, Supplemental Requirements, and Section S2. Reflective sheeting applied to channelizers shall be reboundable in accordance with ASTM D 4956. Retroreflective marking on cones will not be required.

1042.2.7.4 Advanced Warning Rails. All reflective sheeting for advanced warning rails shall be in accordance with ASTM D 4956 Type IV.

1042.2.7.5 Delineators. All retroreflective sheeting for delineators shall be in accordance with ASTM D 4956 Type IX or XI requirements, except permanent and temporary tubular delineators, which shall be ASTM D 4956 Type IV requirements. All permanent and temporary tubular delineators' reflective sheeting shall be reboundable in accordance with ASTM D 4956.

1042.2.7.6 Retroreflective sheeting applied as legend and border shall be in accordance with ASTM D 4956, Type IX, XI or AASHTO Type C or D, Class 1.Retroreflective sheeting shall be an unmetallized cube corner microprismatic reflective material.

1042.2.7.7 Screen Print and Overlay. For screen printed transparent colored areas or transparent colored overlay films on white sheeting, the coefficient of retroreflection (RA) shall be no less than 70 percent of the original values for the corresponding color.

1042.2.8 Outdoor Exposure. Retroreflective sheeting, except for work zone signs, shall be submitted by the manufacturer to NTPEP for two years of 45-degree south-facing outdoor exposure. Retroreflective sheeting for work zone signs shall be submitted by the manufacturer to NTPEP for an exposure time of one year. Results shall be published by NTPEP and available for MoDOT review. For all NTPEP test decks, retroreflective sheeting shall have a coefficient of retroreflection at least 50 percent of the specified value for ASTM D 4956 Type I or 80 percent of the original reading for ASTM D 4956 Type IV, IX or XI.

1042.2.9 Manufacturer and Brand Name Approval. The manufacturer shall make available, upon request, NTPEP test results from all test decks, and certification to Construction and Materials, showing reflective material is in accordance with ASTM D 4956 specification. In addition, the manufacture shall, upon request, submit samples representing the retroreflective sheeting tested by NTPEP, and with compatible inks. These samples shall be accompanied by a product data sheet, an MSDS, technical bulletins on sign fabrication and any special fabrication instructions relative to the retroreflective sheeting submitted. Samples of retroreflective sheeting shall 10 x 10 inches and applied to an aluminum substrate.

1042.2.9.1 Materials that fail to provide satisfactory field performance will be evaluated and may be disqualified from future use on fabricated signs for MoDOT. All corrective actions made by MoDOT will control.

1042.2.10 Type of Characters. Letters, numerals, arrows, symbols, borders and other features of the sign message shall be of the type, size and series shown on the plans or as specified by the engineer. Completed letters, numerals and other units shall be formed to provide a continuous stroke width with smooth edges, and shall yield a flat surface free of air bubbles, wrinkles or other blemishes as determined by the engineer. Units of the sign message shown on the plans shall meet the requirements for the specified type.

1042.2.10.1 Screen Print, Transparent Overlay and Opaque Black Film.

1042.2.10.1.1 The letters, numerals, arrows, symbols and borders shall be applied to the background of the sign by the direct or reverse screen process. Messages and borders of a color darker than the sign field shall be applied to the retroreflective sheeting by the direct process. Messages and borders of a color lighter than the sign field shall be produced by the reverse screen process. Inks used in the silkscreen process shall be of the type to produce the desired color and durability when applied on retroreflective sheeting. Silkscreen inks shall be used in accordance with the manufacturer's recommendations. The ink shall produce the desired color when applied on retroreflective sheeting background and shall dry to a good film without running, streaking or sagging. The screening shall be done in a manner that results in a uniform color and tone, with sharply defined edges of legend and border without blemishes on the sign field that will affect the intended use. Signs after screening shall be dried in accordance with the manufacturer's recommendations to provide a smooth hard finish. Any signs on which blisters appear during the drying process will be rejected.

1042.2.10.1.2 Transparent overlay films may be used as a replacement for the reverse screen process, as recommended by the sheeting manufacturer.

1042.2.10.2 Direct Applied Characters. The letters, numerals, symbols, borders and other features of the sign message shall be cut from the color and type of sheeting shown on the plans, and applied to the sign field in accordance with the sheeting manufacturer’s recommendations.

1042.2.10.3 Allowable Variations. The design height of rounded letters or numerals shall be 1/64 inch of height greater than normal height, both on top and bottom of letter or numeral, where rounded. The loop portion of letters such as f, g and y, shall conform to the dimensions shown on the plans with the allowable tolerance. The following variations in dimensions of letters and numerals, regardless of character type, will be acceptable with all measurements made to the nearest 1/8 inch.

Allowable Variation		
Nominal Height, inches	**Variation in Height, inches**	**Variation in Width, inches**
4 thru 12	-1/8 to +3/8	-1/4 to +1/4
Over 12	-1/8 to +3/8	-3/8 to +3/8

1042.3 Sign Fabrication. A sign shall consist of aluminum flat sheets or extruded panels retroreflectorized on the face side with all letters, numerals, symbols, borders, corners and route shields mounted on the face, and shall include all necessary mounting devices shown on the plans. Signs equal to or greater in width than six feet are considered structural (ST) and shall be fabricated on extruded panels. Signs less than six feet in width will be considered sheet (SH) signs and shall be fabricated with flat sheet. Any exceptions to these fabrication standards will be indicated on the plans.

1042.3.1 All signs shall be of the highest quality with consistent daytime and nighttime color and retroreflectivity throughout the sign and produced as follows.

1042.3.1.1 All aluminum substrate shall be given a chromate conversion coating in accordance with ASTM B 449, Class 2, and shall be prepared by one of the Treatment Sequence Options described in ASTM B 449, Appendix X2. The chemicals and solvents shall be applied in strict accordance with the manufacturer’s recommendations. Sufficient laboratory facilities to test and control the concentration of the solutions used shall be maintained at the treating plant. A log of the concentration of treating solutions shall be maintained. Treated panels shall be handled in such a manner as to prevent contamination. Panels shall be stored in a dry, clean area free from dust, acid fumes or vapors. When aluminum is shipped to a secondary location for retroreflectorizing, adequate precautions shall be taken to ensure that the material arrives at the destination uncontaminated.

1042.3.1.2 All materials used to fabricate a sign legend, including retroreflective and non-retroreflective sheeting, used for background, letters, numerals, arrows, symbols, borders and other features of the sign message shall be from a single manufacturer.

1042.3.1.3 Retroreflective sheeting splices on structural signs shall be kept to a minimum. Rolled overlap splices in accordance with the sheeting manufacturer’s recommendations may be used, with no more than one allowed per panel. Retroreflective sheeting shall be placed on the individual extruded panels in accordance with the manufacturer’s recommendations. The sign panels may be clear coated or edge sealed after application of the retroreflective sheeting, if recommended by the sheeting manufacturer. If edge sealer is used, the sealer shall be applied to all splices and edges. The completed sign shall have good color matching of retroreflective

sheeting and shall be free from air bubbles, wrinkles or other blemishes.

1042.3.1.4 Retroreflective sheeting applied to standard flat sheet signs shall not have splices on signs where the smallest dimension is less than 4 feet. One vertical overlap splice approximately 1/4 inch wide will be allowed on standard flat sheet signs where the smallest dimension is greater than 4 feet. Any special flat sheet signs requiring splicing other than noted for the standard flat sheet signs shall be as approved by the engineer. The sign panels may be clear coated or edge sealed after application of the retroreflective sheeting if recommended by the sheeting manufacturer. If clear finish is used, the finish shall be applied after screening of messages and borders. If edge sealer is used, the sealer shall be applied to all splices and edges. The completed sign face shall be free from air bubbles, wrinkles or other blemishes.

1042.3.2 Nuts on panel bolts used to connect extruded panels together to form a structural sign shall be torqued to 220 - 230 inch-pounds.

1042.3.3 Signs will be accepted on certification from the manufacture assuring all fabrication and sheeting specifications are in compliance with all applicable requirements specified herein. Periodic shop inspections of sign fabrication will be made at the discretion of MoDOT, to include contractor furnished signs for MoDOT projects. Routine shop inspections will include inspection and sampling of materials, inspection of treatment and fabrication processes, and of any signs completed at time of inspection. Inspections on delivered signs for maintenance operations will be conducted for quality assurance purposes by the appropriate district inspectors. Signs may be rejected at the fabrication shop and/or upon delivery based on unsatisfactory workmanship and/or material applications or based on any aspect of the product that is not in accordance with the specifications. The contractor will be charged with the transportation costs of sign inspectors for trips from Jefferson City, Missouri to which the inspectors must travel for signs provided to MoDOT projects. Transportation costs will be deducted by the Commission from monies due the contractor.

1042.3.4 Signs shall be packaged and shipped according to the reflective sheeting manufacture's recommendations. Signs fabricated and shipped to MoDOT for maintenance operations shall be shipped in accordance with manufacture's recommendations and in a manner that meets the requirements of the engineer. All signs shall include decals indicating sign production date, lot number of reflective sheeting used in the production of sign and other information necessary for proper sign fabrication. Upon shipment of signs to MoDOT, certifications shall be submitted thereafter to Construction and Materials. Required paperwork shall include a certification statement indicating signs meet all applicable requirements herein to include aluminum standard and extruded panel, reflective sheeting (manufacturer, series and color), and hardware certifications. Material quantities, such as square foot of flat sheet, extruded panels, if produced, reflective sheeting and a shipping list of all signs shall be included in the certification packet.

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SECTION 1043
FENCE MATERIAL

1043.1 Scope. This specification covers the material required in the construction of chain-link fence and woven wire fence.

1043.2 Basis of Acceptance. The basis of acceptance shall be in accordance with Sec 1040.2.

1043.3 Chain Link Fence Material. Material used in the construction of fences and gates shall consist of chain-link fence fabric, posts, rails, ties, bands, bars, rods, tension wire and other fittings and hardware designed to support the fabric in a vertical, taut position.

1043.3.1 Zinc Coated Steel Fabric. Zinc coated steel fabric shall be in accordance with AASHTO M 181, Type 1, Class D, with the following exceptions. The weight of zinc coating shall be at least 2.0 ounces per square foot of uncoated wire surface, determined from the average of all specimens representing the lot and no less than 1.8 ounces per square foot on an individual specimen. Sections of fencing with excessive lumps, beads and drops of zinc will be removed before determining weight of coating.

1043.3.2 Aluminum Coated Steel Fabric. Aluminum coated steel fabric shall be in accordance with AASHTO M 181, Type 2, with the following exceptions. An individual specimen shall have at least 0.30 ounce per square foot of uncoated wire surface on 0.148 or 0.192-inch specified diameter wire and no less than 0.25 ounce per square foot on 0.120-inch specified diameter wire.

1043.3.3 Vinyl Coated Steel Fabric. Vinyl coated steel fabric shall be in accordance with AASHTO M 181, Type IV, Class A or Class B. In addition to the referenced colors, brown will also be acceptable.

1043.3.4 Aluminum Alloy Fabric. Aluminum alloy fabric shall be in accordance with AASHTO M 181, Type III.

1043.3.5 Posts, Braces, Rails and Gate Frames. These members shall be in accordance with AASHTO M 181, Grade 1 or Grade 2, and of the shape and dimension shown on the plans. These members may be used with either Type I, Type II, Type III or Type IV fabric.

1043.3.5.1 Zinc Coated Steel Members. Zinc coated steel members shall be in accordance with ASTM F 1043, heavy industrial fence Group IA, with Type A interior and exterior coating, and the plans.

1043.3.5.2 Zinc Plus Organic Coated Steel Members. Zinc plus organic coated steel members shall be in accordance with ASTM F 1043, heavy industrial fence Group IC, with Type B or D interior coating and Type B exterior coating, and the plans.

1043.3.5.3 Aluminum Alloy Members. Aluminum alloy members shall be in accordance with ASTM F 1043, heavy industrial fence Group IB, and the plans.

1043.3.6 Tension Wire. Tension wire shall be in accordance with AASHTO M 181 Type I, Class I.

1043.3.7 Fabric Fasteners. Fabric fasteners shall consist of wire ties, hog rings and C-clips. Fasteners for use with zinc or aluminum coated steel fabric shall be in accordance with Sec 1043.3.7.1 or Sec 1043.3.7.2; those for use with aluminum alloy fabric shall be in accordance with Sec 1043.3.7.2; and those for use with vinyl coated steel fabric shall be in accordance with Sec 1043.3.7.3. Fasteners shall be capable of withstanding a 180-degree bend over the fasteners own diameter without fracture of the wire or loss of adherence of coating. The wire shall have a finished or coated diameter of no less than 0.143 inch, except C-clips for attaching fabric to H section posts shall have a finished or coated diameter of no less than 0.187 inch. Aluminum alloy C-clips will not be permitted for fastening fabric to H section posts.

1043.3.7.1 Zinc or Aluminum Coated Fabric Fasteners. Wire shall be zinc coated at a rate of no less than 0.70 ounce per square foot or aluminum coated at a rate of no less than 0.30 ounce per square foot.

1043.3.7.2 Aluminum Alloy Fabric Fasteners. Wire shall be of aluminum alloy having a minimum tensile strength of 16,000 psi.

1043.3.7.3 Vinyl Coated Fabric Fasteners. Wire may be of steel or aluminum alloy and shall be uniformly coated with the same vinyl material as used to coat the fence fabric. Vinyl coating thickness shall be a minimum of 0.010 inch. Aluminum alloy wire shall have a minimum tensile strength of 16,000 psi.

1043.3.8 Miscellaneous Fittings and Hardware. Miscellaneous fittings and hardware shall be in accordance with AASHTO M 181. Aluminum alloy fittings shall not be used with zinc coated steel posts, rails or gate frames.

1043.3.9 Gates. Frames shall be fastened at the corners by clamps and braces, or by welding. If corners are to be welded, the ends of the vertical members shall be hemispherically notched to fit snugly to the horizontal members. The joint shall be uniformly and continuously fillet welded. The welded area and adjacent damaged coating shall be recoated by the hot-dip process or metallizing process; or covered with two coats of zinc-rich paint. The material for repair of welded areas and applications shall meet the approval of the engineer. Each gate frame shall be cross-braced with no less than two 3/8-inch adjustable truss rods. The filler for gates shall be chain-link fabric of the same kind used for the fence. This filler shall be attached to the frame with stretcher bars and wire ties or clamps. Gates 6 feet high or less shall be equipped with two hinges, and gates more than 6 feet high shall have three hinges. All gates, walks and drives, shall be equipped with a latch and locking attachment. Gatekeepers and center rests of an approved design shall be installed for double drive gates.

1043.3.10 Barbed Wire. Barbed wire for use with chain-link fence shall be zinc-coated steel, aluminum-coated steel or aluminum alloy, and shall be in accordance with AASHT0 M 280, with the following exceptions. Zinc-coated barbed wire shall consist of two No. 12 1/2, 13 1/2 or 15 1/2 gage line wires twisted with 4-point barbs uniformly spaced approximately 4 or 5 inches apart in accordance with and the minimum weight of coating shall be 0.80 ounce per square foot of uncoated wire surface for all gages. Aluminum-coated barbed wire shall be in accordance with the requirements for zinc-coated barbed wire, except that the coating shall be aluminum alloy. The weight of coating per square foot of surface shall be no less than 0.25 ounce for both line wires and barbs. However, barbs of suitable aluminum alloy will be permitted. Aluminum alloy barbed wire shall be aluminum alloy 5052-H38, ASTM B 211. Aluminum alloy barbed wire shall consist of two 0.110-inch line wires twisted with 4-point 0.080-inch diameter wire barbs spaced 5 inches apart.

1043.4 Woven Wire Fence Material. Woven wire fence shall be composed of woven wire, barbed wire, brace wire, posts, ties, fittings and hardware.

1043.4.1 Fabric. Fabric shall be made of zinc-coated or aluminum-coated steel wire. Zinc coated fabric shall be in accordance with AASHTO M 279, for Design Number 939-6-11, Grade 60 or 939-6-12.5, Grade 125. The minimum weight of zinc coating shall be Class 3 for all gages. Line wires shall have tension curves. Aluminum-coated fabric shall be in accordance with the requirements for zinc-coated fabric, except that the coating shall be aluminum alloy applied at the rate of no less than 0.25 ounce per square foot of uncoated wire surface.

1043.4.2 Barbed Wire. Barbed wire for use with zinc-coated steel fabric or aluminum- coated steel fabric shall be in accordance with Sec 1043.3.10.

1043.4.3 Wood Posts. Wood posts and braces shall be in accordance with Sec 1050.

1043.4.4 Steel Posts. Steel posts and braces shall be in accordance with Sec 1043.3.5. Corner, end and pull posts shall be pipe of the sizes and weights shown on the plans. Line posts shall be of the lengths and shapes shown on the plans. Posts shall have a nominal weight of 1.33 pounds per linear foot and a minimum weight of 1.28 pounds per linear foot, exclusive of anchor plate.

1043.4.5 Post Tops and Miscellaneous Hardware. Post tops and miscellaneous fittings and hardware shall be in accordance AASHTO M 181.

1043.4.6 Brace Wire. Brace wire shall be no less than 0.143 inch in diameter and shall be of material in accordance with Sec 1043.4.1.

1043.4.7 Staples. Staples shall be of the screw shank-type or equivalent, a minimum of 1 1/4 inches long, galvanized, and of good commercial quality.

1043.4.8 Wire Ties. Wire used for ties shall be in accordance with Sec 1043.3.7, except that the wire may have a minimum diameter of 0.115 inch.

1043.4.9 Gates. Gates for woven wire fence shall be in accordance with Sec 1043.3.9, except that the filler shall be woven wire fabric meeting these specifications.

1043.5 Workmanship and Finish. Fabrication of chain-link or woven wire fencing material furnished under these specifications shall be in accordance with the sizes, shapes and dimensions shown on the plans. Excessive roughness, blisters, sal-ammoniac spots, bruises, flaking, voids in coating, frozen knuckles or other defects, if present to any considerable extent, will be considered cause for rejection. Polyvinyl chloride coating shall be without voids, tears, cracks or cuts that reveal the substrate. Welded seam pipe shall have smooth welds, without skips or gaps. Non-uniform or damaged organic topcoats will be considered cause for rejection whether caused by fabrication, shipping or handling on the job. All burrs at the ends of posts and rails shall be removed.

1043.6 Sampling and Testing.

1043.6.1 Sampling. Sampling of material shall be in accordance with the MoDOT's *EPG 106.3.1*.

1043.6.2 Testing. When fencing material is tested, tests shall be in accordance with the following methods.

1043.6.2.1 Weight. Weight of hot-dip zinc coatings shall be determined in accordance with AASHTO T 65 or, at the option of the engineer, material may be accepted on the basis of magnetic gauge determinations conducted in accordance with ASTM E 376. Weight of aluminum coating shall be determined in accordance with AASHTO T 213 or, at the option of the engineer, material may be accepted on the basis of magnetic gauge determinations conducted in accordance with ASTM E 376.

1043.6.2.2 Thickness. Thickness of zinc-rich organic coating shall be determined by magnetic gauge determinations conducted in accordance with ASTM E 376. Thickness of organic topcoat shall be determined by first determining the total thickness of the organic topcoat and exterior hot-dip zinc coating by magnetic gauge determinations conducted in accordance with ASTM E 376, then chemically stripping the organic topcoat and determining the thickness of only the exterior hot-dip zinc in accordance with AASHTO T 65 or ASTM E 376. The difference between the two measurements shall be the thickness of the organic topcoat.

1043.6.2.3 Tensile Strength. Tensile strength or breaking load shall be in accordance with AASHTO T 68.

1043.7 Inspection. The engineer shall have access at all times to all parts of the manufacturer's or fabricator's works that concern the manufacture or fabrication of material furnished under this specification. Each product or article furnished under this specification will be subject to inspection at the factory, fabricating plant, in laboratories of the engineer's choosing, or at the point of delivery. The engineer reserves the right to sample and test each product or article subsequent to acceptance at the place of manufacture or fabrication to determine conformance with the requirements of this specification or to verify certification.

1043.8 Certification. Certifications will be required as follows.

1043.8.1 Vinyl Coated Material. The contractor shall submit to the engineer certification that the vinyl material and vinyl coated fabric meet the requirements of these specifications. If vinyl coated items other than chain-link fabric are furnished, certification will also be required.

1043.8.2 Aluminum Alloy Material. The contractor shall submit to the engineer certification that the material is in accordance with the requirements specified. The certificate shall include or have attached a list or description of typical physical properties representative of the material.

1043.8.3 Organic Topcoated Material. The contractor shall submit to the engineer certification that the material is in accordance with the requirements specified and that the material is the same as prequalified by the engineer.

1043.9 Packaging and Marking. Packaging and marking of the material shall provide ease of handling, storage and identification.

1043.9.1 Each length of chain-link fabric, woven wire fabric or barbed wire shall be tightly rolled and firmly tied. Each roll shall carry a tag showing, as applicable to the product, the length, kind of base metal, type of coating, specified wire size, mesh size, design (style), height or width of fabric, and the producer name, brand or

trademark of the manufacturer.

1043.9.8.2 Each bundle or container of posts, hardware and fittings shall be marked with the name, brand or trademark of the manufacturer, type of material (steel, cast iron, aluminum alloy number, etc.), type of coating and any additional data required for proper identification or to determine apparent conformance to specified quality requirements.

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SECTION 1044
POSTS FOR MARKERS AND DELINEATORS

1044.1 Scope. This specification covers galvanized steel and flexible posts used for mounting mile and object markers, delineators, drain and right of way markers signs and other similar purposes.

1044.2 Steel Posts. Posts shall be rerolled rail steel, in accordance with the mechanical requirements of ASTM A 499, Grade 60, and to the chemical requirements of ASTM A 1.

1044.2.1 Shape and Dimensions. Posts shall be of a channel or modified channel section. Posts for mile markers, object markers and delineators shall be of the dimensions and weights (masses) shown on the plans.

1044.2.2 Drainage and Right of Way Markers. Posts for drainage and right of way markers shall weigh no less than 1.80 or more than 2.25 pounds per foot, all tolerances included, and shall be of the lengths shown on the plans. Permissible variations in length will be a maximum of one inch under and 2 inches over that shown on the plans. Posts shall have no less than five drilled or punched 3/8-inch holes along the centerline of the web. Holes shall be on 2-inch centers, beginning one inch from the top of posts. Anchors or pointed ends on posts will not be required.

1044.2.3 Fiberglass Composite Right of Way Markers. Fiberglass reinforced polymer composite posts for right of way markers shall be 3 and 3/4 inches wide of a multi rib design weighing no less than 0.35 pounds per foot and shall be of the color and length as shown on the plans. The markers shall have a right of way decal meeting the description as shown on the plans. The markers shall be pointed on one end for installation into the ground to the depth as shown on the plans.

1044.2.4 Galvanizing. Posts shall be galvanized after fabrication in accordance with AASHTO M 111.

1044.3 Channel Post Delineator. Channel post for delineators shall be manufactured from ductile ASTM A 36 or ASTM A 1011 Gr 60 and as shown on the plans. Posts shall be hot dipped galvanized after manufacture in accordance with Sec 1080. Damaged coating shall be repaired in accordance with Sec 1081. The contractor shall furnish to the engineer three copies of the fabricator's certification that the material supplied is in accordance with the requirements specified.

1044.4 Square Steel Perforated Posts.

1044.4.1 Material.

1044.4.1.1 Steel. Steel shall be in accordance with ASTM A 1011, Grade 50, for hot rolled carbon sheet steel, structural quality. The average minimum yield strength after cold-forming shall be a minimum of 50,000 psi.

1044.4.1.2 Coating. Posts shall be galvanized in accordance with ASTM A 653, G90. The corner weld shall be zinc coated after the scarfing operation. The steel shall also be coated with a chromate conversion coating and a clear organic polymer topcoat. Both the interior and the exterior of the post shall be galvanized.

1044.4.2 Dimensions.

1044.4.2.1 Dimensional Tolerances. All dimensional tolerances shall be in accordance with ASTM A 513, excepted as noted.

1044.4.2.2 Length. The length of each post shall be as shown on the plans.

1044.4.2.3 Weight Per Foot. The weight per foot shall be in accordance with the following or as specified:

Square Steel Perforated Post Requirements			
Size	**Thickness**	**Weight**	**Tolerance**
2 in. x 2 in.	12 Gage	2.42 lbs/ft	±0.12 lbs/ft

1044.4.3 Cross Section. The cross section of the post shall be square tube formed of 12 gage steel, carefully rolled to size and shall be welded directly in the corner by high frequency resistance welding and externally scarfed to agree with corner radii.

1044.4.4 Hole Punching. All holes shall be 7/16 ± 1/64 inch in diameter on one-inch centers on all four sides down the entire length of the post. The holes shall be on the centerline of each side in true alignment and opposite each other directly and diagonally.

1044.4.5 Telescoping Properties. Finished posts for telescoping post systems shall be in accordance with the general dimensional requirements and shall permit consecutive square tubes to telescope freely, for no less than 10 feet without the necessity of matching any particular face to any other face. The finished posts shall be straight, and shall have a smooth, uniform finish. All holes and ends shall be free from burrs, and ends shall be cut square.

1044.4.6 Bases. If bases are specified on the plans, one of the following FHWA accepted "Breakaway Anchor" systems shall be used.

a) Single. The anchor shall be one size larger than the signpost and driven using an appropriate sized drive cap. All anchors shall be driven into the ground leaving one to two holes exposed for signpost connection.

b) Two-Piece. An additional 18-inch outer sleeve, one size larger than the anchor, shall be used to double the anchor wall thickness at the critical bending area.

1044.4.7 Connecting Bolts and Nuts. Bolts used to connect posts to bases shall be 5/16 inch, 18NC threads, bent-truss head bolts in accordance with ASTM A 307, Grade A. The bolts shall be mechanically zinc galvanized in accordance with ASTM B 695, Class 25. The nuts shall be 5/16 inch, 18NC threads, serrated flange nuts in accordance with ASTM A 194 and zinc electroplated in accordance with ASTM B 633.

1044.4.8 Certification. The fabricator shall furnish to the engineer, a certification stating that the posts furnished comply with all requirements of this specification. The certification shall include or have attached specific results of tests of the mechanical and chemical properties. The certification shall accompany each shipment of the material to the destination.

1044.5 Acceptance. Acceptance of posts furnished under this specification will be based on Sec 1040.2 and on the results of any tests deemed necessary by the engineer at destination to ascertain compliance with these specifications. If requested, two posts shall be furnished for testing purposes from such lots as the engineer may determine.

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SECTION 1045
PAINT FOR STRUCTURAL STEEL

1045.1 Scope. This specification covers paint, paint material and coating systems for use on structural steel.

1045.2 Paint and Paint Material.

1045.2.1 General. All single component paints shall be ready-mixed at the factory to comply with the specification formula for the type of paint ordered; shall be well ground to a uniform consistency and smooth texture; shall be free from dirt, water and other foreign matter; shall be of such consistency to have good application, covering and leveling properties; and shall dry within the specified period to a good film without running, streaking or sagging.

1045.2.1.1 Any paint that has livered or hardened or thickened to any extent in the container, or in which the pigment has settled such that the paint cannot be readily broken up with a paddle to a smooth uniform paint of good application consistency, will be rejected.

1045.2.1.2 All percentages and proportions shall be on a weight basis unless otherwise stated.

1045.2.1.3 All VOC content requirements specified shall be a maximum when thinned for application.

1045.2.2 Sampling. Each batch or lot of paint shall be sampled and approved prior to use. Each batch or lot of each component of multiple-component paints shall be sampled and approved prior to use.

1045.2.3 Packaging and Labeling. The lining of the containers shall not react with the paint. All components shall bear a label on which shall be clearly shown the name of the manufacturer, the kind of paint, lot number, shelf life, date of manufacture and net weight of contents. The lot number and date of manufacture shall be stamped, stenciled or painted directly onto the container using a weatherproof, durable material.

1045.2.4 Determination of Quantities. Quantities of paint shall be determined by volume. One gallon shall equal 231 cubic inches at 77 F.

1045.3 High Solids Inorganic Zinc Silicate Coating.

1045.3.1 Description. High solids inorganic zinc coating shall be a solvent base multiple-component material which, when mixed and applied in accordance with Sec 1081, cures without the use of a separate curing solution. High solids inorganic zinc coating shall be in accordance with AASHTO M 300, Type IA. The VOC content shall not exceed 3.50 pounds per gallon. If thinning is necessary for application, the maximum VOC content after thinning shall not exceed 3.50 pounds per gallon.

1045.3.2 Manufacturer and Brand Name Approval. Prior to approval and use of high solids inorganic zinc, the manufacturer shall submit to Construction and Materials a certified test report from an approved testing laboratory showing specific test results conforming to all quantitative and resistance test requirements of these specifications. The certified test report shall also contain the exact ratio, by weight, of each component of the coating used for the tests, the lot tested, the manufacturer's name, brand name of coating and date of manufacture. Upon approval from the engineer of this certified test report, further resistance tests will not be required, except as hereinafter noted, of that manufacturer for that brand name of coating. New certified test results shall be submitted any time the manufacturing process or the coating formulation is changed, and may be required by the engineer when sampling and testing of material offered for use indicates nonconformance to any of the requirements herein specified. All resistance testing shall be performed on duplicate sets of test panels, and upon completion of the prescribed exposure testing, the manufacturer shall submit one set of the exposed panels to Construction and Materials.

1045.3.3 Alternate Approval. If approved by Construction and Materials, compliance with all specified requirements for the system under NTPEP or Northeast Protective Coating Committee (NEPCOAT), in addition to the physical property requirements of this specification, may be substituted for the manufacturer and brand name approval requirements of Sec 1045.3.2. The manufacturer shall provide documentation identifying specific products evaluated, along with the manufacturer’s code numbers and/or report code numbers.

1045.4 High Solids Epoxy System G Intermediate Coating.

1045.4.1 Description. The coating shall be a multiple-component, modified epoxy primer with an amine/amide-type curing system compatible as an intermediate coat over high solids inorganic zinc primer and suitable for topcoating with polyurethane.

1045.4.2 Mixed Coating. The color shall be gray (Federal Standard 595b No. 26373) or brown (Federal Standard 595b No. 30045) unless otherwise specified. The color of the intermediate coat shall match the color of the finish coat, unless otherwise approved by the engineer. The physical properties of the mixed paint shall be as follows:

High Solids Epoxy System G Intermediate Coating	
Item	**Requirement**
Viscosity, Krebs-Stormer, 77 F KU	80-130
VOC Content, max., lb/gal	3.50
Fineness of Grind, Hegeman Gage, min.	4
Sag Resistance, Leneta Anti-Sag Meter, mils wet, min.	8
Dry to Touch, hours, max.	3
Dry to Handle, hours, max.	6

1045.4.3 Packaging and Labeling. Packaging and labeling shall be in accordance with Sec 1045.2.3.

1045.4.4 Manufacturer and Brand Name Approval. Prior to approval and use of the specified coating system, the manufacturer shall submit to Construction and Materials a one-gallon unit of each coat of the coating system proposed. The manufacturer shall also submit a certified test report from an approved independent testing laboratory showing specific test results obtained on the specified coating system for Relative Humidity Resistance ASTM D 1735 or D 2247, 3000 hours, Salt Fog Resistance ASTM B 117, 3000 hours and Accelerated Weathering ASTM G 153 Cycle 1 (Carbon Arc), 4000 hours. ASTM G 155, Cycle 2, Xenon Arc or G 154, Cycle 2 QUV (Fluorescent UV-Condensation Type using Type A lamps) may be used as an alternate to Carbon Arc.

1045.4.4.1 All coats of the system to be tested shall be applied to steel test panels that have been prepared according to AASHTO M 300. Each coat of the system shall be from the same manufacturer. Test panels for salt fog exposure shall be scribed as specified in ASTM D 1654 and, when rated according to ASTM D 1654, each panel shall receive a rating of 7 or greater. Test panels shall not exhibit more than slight rusting, undercutting, discoloration, fading, blistering, chalking, loss of gloss or change in color. Accelerated weathering resistance testing shall be performed on test panels that have received finish coats in the specified colors for which approval is being requested. After 4,000 hours of testing for accelerated weathering resistance, each color of the finish coat shall show a difference in color of no greater than
3 ΔE, when compared to the control panel. Color change measurements shall be made in accordance with Section 6.2 CIE 1976 L*a*b* of ASTM D 2244. All resistance testing shall be performed on duplicate sets of test panels, and upon completion of the prescribed exposure testing, the manufacturer shall submit one set of the exposed panels to Construction and Materials.

1045.4.4.2 The manufacturer shall provide documentation that the specified coating system has performed satisfactorily for three years. The document shall include the name, address and telephone number of the proprietary agency and location of the structures. Upon approval of the coating by the engineer, further submittals for preliminary approval will not be required of that manufacturer for that brand name of coating, except as hereinafter noted. A new sample, new testing data and new test panels shall be submitted any time the manufacturing process or the batching proportions are changed. The engineer may withdraw manufacturer and brand name approval when sampling and testing of material offered for use indicates nonconformance to any of the requirements herein specified. All data submitted for preliminary approval will be considered confidential to MoDOT.

1045.4.5 Alternate Approval. If approved by Construction and Materials, compliance with all specified requirements for the system under NTPEP or NEPCOAT, in addition to the physical property requirements of this specification, may be substituted for the manufacturer and brand name approval requirements of Sec 1045.4.4. If approval is requested under NTPEP or NEPCOAT, the accelerated weathering requirements stated in Sec 1045.4.4 will apply. The manufacturer shall provide documentation identifying specific products evaluated, along with the manufacturer's code numbers and/or report code numbers.

1045.5 Polyurethane System G Finish Coating.

1045.5.1 Description. The coating shall be a multiple-component, aliphatic acrylic polyurethane suitable for use over High Solids Epoxy Intermediate Coating. The coating shall cure to a semi-gloss to high gloss, abrasion resistant surface and shall provide an easily cleanable finish.

1045.5.2 Mixed Coating. The mixed coating properties shall be as follows:

Polyurethane System G Finish Coating		
Physical Property	**Requirement**	
Color, Federal Standard 595b	Gray 26373	Brown 30045
Viscosity, Krebs-Stormer, 77 F, KU	65-96	
VOC Content, lb/gal , max.	3.50	
Fineness of Grind, Hegeman Gage, min.	6	
Sag Resistance, Leneta Anti-Sag Meter, mils wet, min.	8	
Dry to Touch, hours, max.	4	
Dry to Handle, hours, max.	8	

1045.5.3 Packaging and Labeling. Packaging and labeling shall be in accordance with Sec 1045.2.3.

1045.5.4 Manufacturer and Brand Name Approval. Manufacturer and brand name approval shall be in accordance with Sec 1045.4.4 or Sec 1045.4.5. If approval is requested under Sec 1045.4.5, the accelerated weathering requirements stated in Sec 1045.4.4 will apply. The manufacturer shall provide documentation identifying specific products evaluated, along with the manufacturer's code numbers and/or report code numbers.

1045.6 Waterborne Acrylic System H Intermediate and Finish Coating.

1045.6.1 Description. The intermediate coating shall be a single component waterborne acrylic compatible as a coating over high solids inorganic zinc primers. The finish coating shall be a single component waterborne acrylic suitable for use over a waterborne acrylic intermediate coating. The finish coating shall cure to a tough, abrasion resistant surface that performs well in weathering exposures. The gray finish coat shall cure to a semi-gloss finish and the brown finish coat shall cure to a low-gloss finish.

1045.6.2 Mixed Coating. The color of the intermediate coat shall be gray (Federal Standard 595b No. 26373) or brown (Federal Standard 595b No. 30045) unless otherwise specified. The color of the intermediate coat will normally be required to match the color of the finish coat. The mixed coating properties shall be as follows:

Waterborne Acrylic System H Intermediate and Finish Coating		
Physical Property	**Requirement**	
Color, Finish Coat, Federal Standard 595b	Gray 26373	Brown 30045
Viscosity, Krebs-Stormer, 77 F, KU	80-100	
VOC Content, lb/gal, max.	3.50	
Fineness of Grind, Hegeman Gage, min.	7	
Sag Resistance, Leneta Anti-Sag Meter, mils wet, min.	8	
Dry to Handle, hours, max.	2	

1045.6.3 Packaging and Labeling. Packaging and labeling shall be in accordance with Sec 1045.2.3.

1045.6.4 Manufacturer and Brand Name Approval. Prior to approval and use of waterborne acrylic intermediate and finish coats, the manufacturer shall obtain manufacturer and brand name approval in accordance with Sec 1045.4.4 or Sec 1045.4.5, except that, after the 4000 hour testing for accelerated weathering resistance, the Federal Standard 595b 30045 (brown) color of the finish coat shall show a difference in color of no greater than 4 ΔE when compared to the control panel. If approval is requested under Sec 1045.4.5, the accelerated weathering requirements stated in Sec 1045.4.4 will apply. The manufacturer shall provide documentation identifying specific products evaluated, along with the manufacturer's code numbers and/or report code numbers.

1045.7 Polysiloxane System I Finish Coating.

1045.7.1 Description. The coating shall be a multiple-component, Polysiloxane suitable for use over High Solids Inorganic Zinc, or High Solids Epoxy Intermediate Coating. The coating shall cure to a semi-gloss to high gloss, abrasion resistant surface and shall provide an easily cleanable finish.

1045.7.2 Mixed Coating. The mixed coating properties shall be as follows:

Polysiloxane System I Finish Coating		
Physical Property	**Requirement**	
Color, Federal Standard 595b	Gray 26373	Brown 30045
Viscosity, Krebs-Stormer, 77 F, KU	Within Manufactures submitted range	
VOC Content, lb/gal, max	2.0	
Fineness of Grind, Hegeman Gage, min.	6	
Sag Resistance, Leneta Anti-Sag Meter, mils wet, min.	8+	
Dry to Touch, hours, max.	3	
Dry to Handle, hours, max.	8	

1045.7.3 Packaging and Labeling. Packaging and labeling shall be in accordance with Sec 1045.2.3.

1045.7.4 Manufacturer and Brand Name Approval. Manufacturer and brand name approval shall be in accordance with Sec 1045.4.4 or Sec 1045.4.5. If approval is requested under Sec 1045.4.5, the accelerated weathering requirements stated in Sec 1045.4.4 will apply. The manufacturer shall provide documentation identifying specific products evaluated, along with the manufacturer's code number and/or report code numbers.

1045.8 Aluminum Epoxy-Mastic Primer.

1045.8.1 Description. The coating shall be a one-coat system aluminum epoxy-mastic primer designed for adhesion to rusty steel, aged galvanized steel and other uses. Aluminum epoxy-mastic primer will not be permitted for use on any surface that is to be in contact with fresh concrete. The epoxy-mastic shall be a two-component, modified epoxy-primer containing metallic-aluminum flake.

1045.8.2 Pigment. The primary pigment shall be metallic-aluminum.

1045.8.3 Vehicle. The vehicle shall be an epoxy-type. The curing agent shall have suitable insensitivity to moisture to allow trouble-free application.

1045.8.4 Mixed Coating.

1045.8.4.1 The coating shall be well-ground, not caked, skinned or badly settled in the container. The mixed coating, when applied in one coat, shall be capable of achieving 5 mils dry film thickness without runs or sags.

1045.8.4.2 The mixed coating properties shall be as follows:

Aluminum Epoxy-Mastic Primer	
Physical Property	**Requirement**
Dry to touch, hours, max.	24
Dry hard, days, max.	5[a]
VOC Content, lb/gal, max.	3.50

[a]When air-cured at a temperature of 75 F or above to a hard, tough film by evaporation of solvent and chemical reaction.

1045.8.5 Resistance Tests. Test panels of steel in accordance with ASTM D 609, and having dimensions of 2 x 5 x 1/8 inch shall be prepared by sandblasting all surfaces to a white metal condition in accordance with Structural Steel Painting Council SP5 (SSPC-SP5-82). The cleaned panels shall then be exposed to outdoor weather for 30 days or until uniform rusting occurs. The panel shall then be hand cleaned with a wire brush in accordance with SSPC-SP2-82. A 6-mil dry coating of the epoxy-mastic shall then be applied in one coat in accordance with the manufacturer's current recommendations. The coating shall be cured as recommended by

the manufacturer. Fresh Water, Salt Water, and Weathering and Salt Fog resistance tests, as detailed herein, shall be performed on one or more test panels. The material will not be approved if any individual test panel fails any of the resistance tests specified herein.

1045.8.5.1 Fresh Water Resistance. Panels shall be scribed down to base metal with an "X" of at least 2-inch legs, and shall be immersed in fresh tap water at 75 ± 5 F. The panels shall show no rusting, blistering or softening beyond 1/16 inch from the scribe mark, when examined after 30 days. Discoloration of the coating will be permitted.

1045.8.5.2 Salt Water Resistance. Panels shall be scribed down to base metal with an "X" of at least 2-inch legs and immersed in five percent sodium chloride at 75 ± 5 F. The panels shall show no rusting, blistering or softening beyond 1/16 inch from the scribe mark upon examination after 7, 14 and 30 days. Discoloration of the coating will be permitted. The sodium chloride solution shall be replaced with fresh solution after each examination.

1045.8.5.3 Weathering and Salt Fog Resistance. Panels shall be tested in the weatherometer in accordance with ASTM G 154 QUV (Fluorescent UV-Condensation Tape using Type A Lamps) for 300 hours using a test cycle consisting of four hours light followed by four hours condensation. After this period, the panels shall be removed and scribed with an "X" of at least 2-inch legs down to base metal. The test panels shall then be tested in accordance with ASTM B 117. After 1,000 hours of continuous exposure, the coating shall show no loss of bond, nor shall the coating show rusting or blistering beyond 1/16 inch from the center of the scribe mark.

1045.8.6 Packaging and Labeling. Packaging and labeling shall be labeled in accordance with Sec 1045.2.3.

1045.8.7 Approval and Prequalification.

1045.8.7.1 Manufacturer and Brand Name Approval. Prior to approval and use of the epoxy-mastic primer, the manufacturer shall submit to Construction and Materials a one-gallon sample of the coating and a certified test report from an approved independent testing laboratory showing specific test results conforming to all quantitative and resistance test requirements of these specifications. The certified test report shall contain the exact ratio, by weight, of the pigment component to the vehicle component of the epoxy-mastic used for the tests, the lot tested, the manufacturer's name, brand name of the epoxy-mastic, and date of manufacture. In addition, the manufacturer shall submit a complete set of tested panels that have undergone each required resistance test. The set of panels submitted shall include one untested control panel that has been prepared in accordance with Sec 1045.8.5. Upon approval by Construction and Materials of this certified test report, further resistance tests will not be required of that manufacturer for that brand name of epoxy-mastic primer, except as noted. New certified test results shall be submitted any time the manufacturing process or the epoxy-mastic formulation is changed, and may be required by the engineer when sampling and testing of material offered for use indicates nonconformance to any of the requirements specified herein.

1045.8.7.2 Final Acceptance. Final acceptance of the epoxy-mastic primer will be based on a manufacturer's certification submitted by the contractor to the engineer and on results of tests conducted on samples of the material. Each lot of each component will be sampled and tested prior to approval or use of the material.

1045.9 Gray Epoxy-Mastic Primer.

1045.9.1 Description. This specification covers a one-coat gray epoxy-mastic primer system designed for adhesion to rusty steel, aged galvanized steel and other uses, including uses in contact with freshly poured Portland cement concrete. The epoxy-mastic shall be a multiple-component modified epoxy containing gray pigmentation, and shall be in accordance with the requirements specified herein.

1045.9.2 Pigment. The pigmentation shall be any pigment or combination of pigments formulated to offer the intended protective properties to the cured coating, and shall be totally non-reactive to the constituents contained in both cured and uncured Portland cement concrete.

1045.9.3 Vehicle. The vehicle shall be an epoxy type. The curing agent shall have suitable insensitivity to moisture to allow trouble-free application.

1045.9.4 Mixed Coating.

1045.9.4.1 The provisions of Sec 1045.8.4.1 will apply.

1045.9.4.2 The mixed coating properties shall be as follows:

Gray Epoxy-Mastic Primer	
Physical Property	**Requirement**
Color, Federal Standard 595b	Gray 26373
Viscosity, (Krebs-Stormer, 25 C) KU	90 - 120
Volatile Organic Content, lb/gal, max.	3.50
Dry to touch, hours, max.	24
Dry hard, days, max.	7[a]

[a]When air-cured at a temperature of 75 F or above to a hard, tough film by evaporation of solvent and chemical reaction.

1045.9.5 Resistance Tests. Test requirements and approval criteria shall be in accordance with Sec 1045.8.5.

1045.9.6 Packaging and Labeling. Packaging and labeling shall be in accordance with Sec 1045.2.3.

1045.9.7 Approval and Prequalification.

1045.9.7.1 Manufacturer and Brand Name Approval. Manufacturer and brand name approval shall be in accordance with Sec 1045.8.7.1.

1045.9.7.2 Final Acceptance. Final acceptance will be in accordance with Sec 1045.8.7.2.

1045.10 Calcium Sulfonate System.

1045.10.1 Description. This specification covers calcium sulfonate sealer, calcium sulfonate primer and various colors of calcium sulfonate topcoat paints for steel. The color of topcoat will be specified in the contract and shall be in accordance with all requirements specified herein.

1045.10.1.1 The primary resin used to manufacture each coat of the calcium sulfonate system shall be a modified overbased crystalline calcium sulfonate that creates a highly polar complex capable of protecting the underlying steel from corrosion. In addition to the calcium sulfonate complex, the paint shall contain film forming oleoresinous compounds that act to reduce tack in the dry film.

1045.10.1.2 The coating material shall be uniform, stable in storage, and free from grit and coarse particles.

1045.10.2 Calcium Sulfonate Rust Penetrating Sealer.

1045.10.2.1 General. The sealer, after allowing a minimum drying time, may be recoated with an approved primer or topcoat. The sealer will be suitable for any steel structure that has developed pack rusting in overlapping steel plates, joints or at bolted areas. This coating shall be used on in-place structures as part of a long-term maintenance program, and as such shall be applied in accordance with SSPC-PA1, Shop, Field and Maintenance Painting.

1045.10.2.2 Properties. The mixed coating properties shall be as follows:

Calcium Sulfonate Rust Penetrating Sealer	
Physical Property	**Requirement**
Color	**Red iron oxide**
Modified Crystalline Overbased Calcium Sulfonate, percent by weight, min.	15
Coarse Particles and Skins as retained on No. 325 (45µm) mesh sieve, percent, max.	1.0
Viscosity, #4 Ford Cup, Seconds	50 - 70
VOC Content, lbs/gal., max.	3.5

Drying Time, hours to recoat	2 - 6
Flash Point, F, max	104
Salt Fog Resistance, 500 hours (Coating applied at 1-2 mils dry film over SSPC-SP5 cold rolled steel)	No more than 1% rust undercutting, blistering or peeling.

1045.10.3 Calcium Sulfonate/Alkyd Primer.

1045.10.3.1 General. This primer shall be used in non-abrasion exposures to provide a firm, corrosion resistant, highly adherent film. This primer may be used for in-place structures but shall not be used as a shop-applied primer.

1045.10.3.2 Properties. The mixed coating properties shall be as follows:

Calcium Sulfonate/Alkyd Primer	
Physical Property	**Requirement**
Color	**Red iron oxide**
Modified Crystalline Overbased Calcium Sulfonate, percent by weight, min.	15
Coarse Particles and Skins as retained on No. 325 mesh sieve, percent, max.	1.0
Viscosity, 77 F, KU	90 – 120
VOC Content, lbs/gal, max.	3.50
Fineness of Grind, Hegman Units, min.	5
Drying Time, Hours (3 to 4 Mil Dry Film): Dust Dry Track Free Dry Firm	 1 - 4 5 - 12 24 - 48
Sag Resistance, Mils	12+
Salt Spray Resistance, 1500 hours (4 mil dry film over SSP-SP-5 blasted cold rolled steel – 1 to 2 mil profile)	No more than 1 % under-cutting, blistering or peeling.

1045.10.4 Calcium Sulfonate/Alkyd Topcoat.

1045.10.4.1 General. Calcium sulfonate/alkyd topcoat shall be a medium to light gray, brown, green or tan low-gloss coating as specified in the contract for use over calcium sulfonate/alkyd penetrating sealer or calcium sulfonate/alkyd primer. This paint shall be used as a topcoat for a calcium sulfonate/alkyd corrosion inhibitive primer, and shall be applied in accordance with SSPC-PA 1, Shop, Field, and Maintenance Painting. The topcoat may be used for in-place structures and shall not be used as a shop-applied finish.

1045.10.4.2 Properties. The mixed coating properties shall be as follows:

Calcium Sulfonate/Alkyd Topcoat				
Physical Property	**Requirement**			
	Brown	**Gray**	**Tan**	**Green**
Color, Federal Standard 595b	30045	26373	23522	24260
Modified Crystalline Overbased Calcium Sulfonate, per cent by weight, min.	15			
Coarse Particles and Skins as retained on No. 325 mesh sieve, percent, max.	1.0			
Viscosity, 77 F, KU	90-130			
Fineness of Grind, Hegman Units, min.	5			
Drying Time, 2-3 mils , hours Dust Dry Track Free Dry Firm	 1 - 4 5 - 12 24 – 48			
VOC Content, lbs/gal, max.	3.5			

Sag Resistance, Mils	12+
QUV Weathering Resistance, 1000 hrs. (4 mil dry film over SSP-SP-5 blasted cold rolled steel - 1-2 mil profile)	No excessive chalking, blistering, or change in color.
Salt Spray Resistance, 1000 hrs (4 mil dry film over SSP-SP-5 blasted cold rolled steel – 1-2 mil profile)	No more than 1 % rust under-cutting, blistering or peeling.

1045.10.5 Test Methods. The test methods used to verify compliance with the properties specified in Secs 1045.10.2, 1045.10.3 and 1045.10.4 shall be as follows:

American Standards for Testing and Materials (ASTM)	
G154	Practice for Operating Light- and Water-Exposure Apparatus
B117	Salt Spray (Fog) Testing
D562	Consistency of Paints Using the Stormer Viscometer
D1200	Viscosity of Paints, Varnishes and Lacquers by Ford Viscosity Cup
D1210	Fineness of Dispersion of Pigment-Vehicle Systems
D1475	Density of Paint, Varnish, Lacquer and Related Products
D3278	Flash Point of Liquids by Seta Flash Closed Tester
D3960	VOC Content of Paints
Federal Test Method Standard No. 141	
Method 4061	Drying Time
Method 4494	Sag Test (multi-notch blade)

1045.10.6 Pigment Settlement. The paint shall have perfect suspension (10 rating) when tested as specified in ASTM D 869, when stored for six months.

1045.10.7 Working Properties. The paint shall be uniform and easily spray-applied when tested in accordance with Federal Standard No.141, Method 4331. The primer and topcoat shall show no streaking, running or sagging after drying.

1045.10.8 Storage. The paint shall show no thickening, curdling, gelling or hard caking when tested as specified in Federal Standard No.141, Method 3011 after storage for six months from date of delivery in tightly covered containers at a temperature of at least 50 F and no more than 110 F.

1045.10.9 Packaging and Labeling. Packaging and labeling shall be in accordance with Sec 1045.2.3.

1045.10.10 Approval and Prequalification.

1045.10.10.1 Manufacturer and Brand Name Approval. Prior to approval and use of the calcium sulfonate coating system, the manufacturer shall submit to Construction and Materials a one-gallon sample of each coat of the proposed coating system. The manufacturer shall also submit a certified test report from an approved independent laboratory showing specific test results as follows:

(a) Calcium Sulfonate Penetrating Sealer. Salt spray resistance of steel panels prepared and tested in accordance with Sec 1045.10.2.2.

(b) Calcium Sulfonate Primer. Salt spray resistance of steel panels prepared and tested in accordance with Sec 1045.10.3.2.

(c) Calcium Sulfonate Topcoat. Salt spray resistance and QUV weathering resistance in accordance with Sec 1045.10.4.2.

1045.10.10.2 Final Acceptance. Final acceptance of calcium sulfonate penetrating sealer, calcium sulfonate primer and calcium sulfonate topcoat will be based on the manufacturer's certification submitted by the contractor to the engineer, and on results of tests conducted on samples of the material. Each lot will be sampled and tested prior to approval and use.

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SECTION 1046
PIPE LINER

1046.1 Scope. This specification covers material requirements for pipe liner.

1046.2 Material. Pipe liner shall be in accordance with one of the following.

(a) HDPE pipe in accordance with ASTM F 714, maximum DR 32.5.

(b) HDPE pipe in accordance with ASTM D 3350 cell classification 345464C. This pipe liner shall have approved dimensions on file with Construction and Materials.

(c) HDPE pipe in accordance with ASTM F 894 open profile, Class RSC 100 or RSC 160.

(d) PVC pipe in accordance with ASTM F 949, except that the PVC pipe and fittings shall be made of a PVC compound having a minimum call classification of 12454B, in accordance with ASTM D 1784. The joining method for PVC pipe shall be by elastomeric material in accordance with ASTM F 949.

1046.3 Pipe Marking. Each length of pipe liner furnished shall be permanently marked by the manufacturer with the manufacturer's name and applicable ASTM designation.

1046.4 Certification and Acceptance. The contractor shall furnish a manufacturer's certification to the engineer that the pipe liner was manufactured, tested, and is in accordance with this specification. Acceptance of the material will be based on the manufacturer's certification and statement, pipe liner identification markings and upon the results of such tests as may be performed by the engineer.

1046.5 Inspection.

1046.5.1 The engineer may inspect the fabricated pipe liner at the manufacturing plant, intermediate distribution point or destination. The manufacturer shall furnish to the engineer an itemized statement of the sizes and lengths of pipe liner in each shipment. The engineer shall have access to the manufacturing plant or intermediate distribution point for inspection. Each facility shall provide the means to safely inspect all aspects of production or storage. Any previously rejected pipe liner included in a later lot will be cause for rejection of the entire lot. A lot will be defined as all the material presented for inspection at one time.

1046.5.2 Inspection will include an examination of the pipe liner for markings, variance from specified diameter, net length of fabricated pipe liner, and any evidence of poor workmanship. The inspection may include taking samples.

1046.6 Rejection.

1046.6.1 Any individual section of pipe liner failing to meet the marking, diameter, length or workmanship requirements of these specifications will be rejected.

1046.6.2 If a pipe liner fails to meet the requirements, the pipe liner sampled will be rejected and the lot will be resampled. A resample will be of the same size as the original sample. The resample shall comply in all respects or the entire shipment will be rejected.

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SECTION 1047
POLYETHYLENE CULVERT PIPE

1047.1 Scope. This specification covers polyethylene culvert pipe used for the construction of culverts and other uses specified in the contract documents.

1047.2 Basis of Acceptance. Acceptance of polyethylene culvert pipe will be based on the pipe being provided by a qualified manufacturer, certification, manufacturer quality control documentation, identification markings and tests on samples of the material as required by the engineer.

1047.3 Material. Polyethylene culvert pipe, couplings and fittings shall be in accordance with AASHTO M 294 for corrugated or AASHTO MP 20 for steel reinforced. In case of conflict with AASHTO M 294 or AASHTO MP 20, these specifications shall govern.

1047.3.1 Section properties shall be within the following limits:

	Corrugated						
	Minimum						Maximum
Nominal Size S (in.)	Effective Pipe Wall Area A_{eff} (in.^{2}/in.)	Pipe Wall Centroid to Inside Face y_c (in.)	Pipe Wall Moment of Inertia I (in.^{4}/in.)	Area Ratio[a] A_{eff}/A_g	Extreme Fiber Ratio[b] y_c/c	Inside Diameter D_i (in.)	Outside Diameter D_o (in.)
12	0.163	0.382	0.0313	0.699	0.494	12.02	14.60
15	0.202	0.413	0.0465	0.768	0.447	14.83	17.82
18	0.209	0.569	0.0653	0.749	0.554	17.83	21.42
24	0.233	0.669	0.1317	0.667	0.552	23.71	27.98
30	0.2330	0.757	0.2415	0.816	0.448	29.46	34.98
36	0.294	1.058	0.3153	0.683	0.588	35.44	41.92
42	0.331	1.140	0.5395	0.693	0.564	40.98	48.18
48	0.323	1.095	0.4682	0.681	0.543	47.12	54.34
60	0.438	1.477	0.8150	0.751	0.766	58.90	66.97

[a] A_g equals gross area of pipe wall per unit length of pipe (in^2/in.).

[b] c equals the distance from the pipe wall centroid to the outermost fiber (in.).

	Steel Reinforced			
	Minimum			Maximum
Nominal Size S (in.)	Wall Steel Area A (in.^{2}/ft)	Wall Steel Moment of Inertia I (in.^{4}/in.)	Rib Radius of Gyration r (in.)	Rib Width/ Thickness Ratio b/t
24	0.348	0.00063	0.144	8.97
30	0.344	0.00086	0.170	10.03
36	0.404	0.00122	0.187	10.36
42	0.461	0.00152	0.195	9.91
48	0.379	0.00218	0.257	11.90
60	0482	0.00352	0.290	11.88

1047.3.2 The pipe shall be Type S and not be perforated unless specified otherwise.

1047.3.3 Field joints shall provide circumferential and longitudinal strength to maintain the pipe alignment, prevent separation of pipe and prevent infiltration of fill material. Coupling bands, if used, shall be of the same base material as the pipe. Corrugations in the bands shall have the same configuration as the corrugations in the pipe ends being connected. Prior to use, the design of coupling bands and fastening devices shall be submitted to and approved by Construction and Materials. Final acceptance of coupling bands and fastening devices will be based on field performance.

1047.3.4 The manufacturer shall provide to the engineer an itemized statement of the sizes, section properties and lengths of pipe in each shipment.

1047.3.5 Pipe may be fabricated using English units of measurement. Pipe fabricated using English

measurements shall meet the diameter dimensions shown on the plans. Pipe tolerances will be in accordance with AASHTO M 294 or AASHTO MP 20 .

1047.4 Sampling, Testing and Acceptance Procedures. All manufacturers furnishing pipe meeting the requirements of AASHTO M 294,for MoDOT projects shall be qualified as described herein. All manufacturers furnishing pipe meeting the requirements of AASHTO MP 20 for MoDOT projects shall meet the quality control and assurance requirements of the appendix section in MP 20 and these specifications. All pipes will be subject to inspection by the engineer at the source of manufacture, at an intermediate shipping terminal or at destination. The engineer shall be allowed unlimited access to all facilities and records as required to conduct inspection and sampling in accordance with Sec 106.

1047.4.1 Application for Placement on Qualified List. To become qualified to furnish pipe meeting AASHTO M 294, a written request shall be sent by the manufacturer to Construction and Materials, and shall include the following information:

(a) A copy of the manufacturer's current National Product Evaluation Program(NTPEP) certification.

(b) The pipe manufacturer's certified analysis certificate setting forth the name or brand of pipe to be furnished, the specified type, category, grade and class of polyethylene compounds. The certificate shall be sworn for the manufacturer by a person having legal authority to bind the company. The certificate shall have attached a certified test report from an approved independent testing laboratory showing specific results of tests performed on each diameter pipe to be furnished, conforming to all requirements of these specifications. Pipes shall be randomly selected for test by the independent testing laboratory and shall be representative of that manufacturer's pipe.

(c) A guarantee that all pipe furnished shall be in accordance with the specification requirements, shall bear a suitable identification brand or mark and shall be replaced without cost to the Commission when not in accordance with the specified requirements. The guarantee shall be worded such that the guarantee will remain in effect as long as the manufacturer continues to furnish material. The manufacturer shall conduct tests and measurements as necessary to ensure the material produced complies with all specification requirements. These tests and measurements shall be identified by the identification symbols or code used on the pipe in a manner that will permit the manufacturer to produce specific reports showing test results representative of specific lots of polyethylene pipe. Copies of reports of these tests shall be kept on file and shall be submitted to the engineer upon request. The brand shall be removed or obliterated by the manufacturer on all material where control tests, as outlined herein, are not in accordance with this specification.

(d) Units of measurement, English or metric, used to fabricate the pipe.

1047.4.2 Maintaining Qualification. To maintain qualification to furnish pipe meeting AASHTO M 294 , the manufacturer shall perform and maintain a quality control program in accordance with the NTPEP Certification Program. The manufacturer's NTPEP certification shall be maintained. The manufacturer shall maintain for three years a record of all test results, inspections and the bill of lading for each shipment of material used in the production of pipe and for each shipment of pipe. The manufacturer shall notify Construction and Materials at least 24 hours prior to each shipment of pipe to a MoDOT project. Additional pipe may be considered part of the original shipment when the ordered quantity was underestimated or material was lost or damaged. A bill of lading in accordance with Sec 1047.6 shall be provided for each shipment of pipe.

1047.4.3 Disqualification of a Manufacturer. A manufacturer may be disqualified to provide pipe for use on MoDOT projects based on the discretion of Construction and Materials, for reasons including, but not limited to, not maintaining NTPEP certification, failure of material to consistently meet specifications, falsification of documentation, misbranding of pipe, unsatisfactory performance in the field or for other reasons indicating lack of consistent material quality.

1047.4.3.1 In the case where a manufacturer loses NTPEP certification and was not disqualified for any other reason, reinstatement will be considered when the manufacturer is recertified by NTPEP.

1047.4.3.2 A manufacturer will not be considered for reinstatement until after one year from the date of removal for falsification of documents.

1047.4.3.3 Three notices of failure to meet specification requirements within a 12-month period will be cause for disqualification of the manufacturer for one year, effective from the date of the third notice.

1047.4.3.4 A manufacturer disqualified within one year of the end of a disqualification may be subject to permanent removal, with no application for reinstatement accepted for a period of three years.

1047.4.4 Reinstatement of a Manufacturer. Consideration of reinstatement of a manufacturer once disqualified will be no sooner than specified in Sec 1047.4.3, will require a written document from the manufacturer stating the reasons for disqualification and the action taken to correct those deficiencies, written concurrence from Construction and Materials that the problem has been suitably addressed, followed by a new application in accordance with Sec 1047.4.1.

1047.4.5 Sampling of Material. Random sampling of the pipe will be conducted by the engineer to verify pipe and material is in accordance with this specification. Samples of polyethylene pipe will be obtained from fabricated culvert sections in accordance with AASHTO M 294 or AASHTO MP 20 at a frequency determined by the engineer.

1047.4.6 Inspection. Inspection will include an examination of the pipe for markings, deficiency in specified diameter, net length of fabricated pipe and evidence of poor workmanship. The inspection may include taking samples.

1047.4.7 Testing. Specimen testing size and method of tests shall be in accordance with AASHTO M 294 or AASHTO MP 20. The contractor or manufacturer shall provide the equipment and personnel to cut a sample from a section of pipe. The sample shall include the markings or a record of the markings for that section of pipe.

1047.4.8 Unacceptable Material.

1047.4.8.1 Any individual section of pipe failing to meet the marking, diameter, length or workmanship requirements of these specifications will be unacceptable. If 10 percent of the pipe in any lot fails to meet these requirements, the entire shipment of that pipe diameter may be rejected.

1047.4.8.2 If a test specimen taken in accordance with Sec 1047.4.7 fails to be in accordance with AASHTO M 294 or AASHTO MP 20, the pipe sampled will be rejected, and the lot will be resampled. A resample will be from the same diameter of pipe as the original sample. The resample shall be in accordance to these specifications or the entire shipment will be rejected.

1047.5 MoDOT Identification Number. When the manufacturer contacts the engineer in accordance with Sec 1047.4.2, the engineer will assign a specific MoDOT identification number for each size of pipe in the shipment.

1047.6 Bill of Lading. A bill of lading or delivery receipt for each shipment of pipe shall be furnished to the engineer at the shipping and destination points. The bill of lading shall contain an itemized statement of the sizes and lengths of pipe, with the corresponding designated MoDOT identification number provided to the manufacturer for each size of pipe for that shipment. The bill of lading shall contain a certified statement. The certified statement shall be signed by an authorized representative of the manufacturer and shall state the following:
"This certifies that the pipe and bands in this shipment are in accordance with MoDOT specifications, were fabricated at an approved plant and were fabricated from the following brand names:"

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SECTION 1048
PAVEMENT MARKING MATERIAL

1048.1 Scope. This specification covers all temporary pavement markings, permanent pavement markings and drop-on glass beads.

1048.1.1 Certification and Acceptance. All material contained in Sec 1048 shall be in accordance with the following requirements.

1048.1.1.1 To obtain approval of the material, the manufacturer shall submit material and application specifications, samples of the material, and a history of satisfactory use to Construction and Materials for testing and evaluation. The sample quantity submitted shall be at the discretion of Construction and Materials. The approval process shall not be initiated prior to obtaining the concurrence of Construction and Materials. Following testing and evaluation, satisfactory material will be placed on a qualified list.

1048.1.1.2 For acceptance on a project, the contractor shall furnish to the engineer a manufacturer's certification stating the manufacturer and trade name, lot or batch number and that all material furnished is similar to the material originally qualified. Acceptance of the material will be based on the manufacturer's certification, the results of such tests that may be performed by the engineer and satisfactory performance in the field.

1048.1.1.3 The material may be inspected and sampled at the point of manufacture, at an intermediate shipping terminal or at destination. The engineer shall be allowed access to all facilities and records as required to conduct inspection and sampling. The contractor shall adequately mix the contents of all shipping containers prior to obtaining samples or transferring partial containers of material to tanks on the striping equipment.

SECTION 1048.10 TEMPORARY PAVEMENT MARKING MATERIALS.

1048.10.1 Temporary Paint Materials. This specification covers all temporary paint materials. All materials contained in Sec 1048.20.1 may also be used as Temporary Paint Materials.

1048.10.1.1 Cold Weather Pavement Marking Paint.

1048.10.1.1.1 Acrylic Copolymer Fast Dry Pavement Marking Paint.

1048.10.1.1.1.1 Description. Acrylic copolymer fast dry pavement marking paint shall be capable of receiving and holding glass beads for producing retroreflective pavement marking.

1048.10.1.1.1.2 Material. The paint shall contain no more than 3,200 ppm lead or more than 800 ppm chromium based on dry weight, and shall have limited VOC content as noted herein.

1048.10.1.1.1.2.1 General. The finished paint shall be formulated and manufactured from first-grade material and shall be a fast drying, solvent-based, acrylic copolymer resin type paint capable of withstanding air and roadway temperatures without bleeding, staining, discoloring or deforming. The dried paint film shall be capable of maintaining original dimensions and placement without chipping, spalling or cracking. The dry paint film shall not deteriorate because of contact with normal roadway chemicals or materials.

1048.10.1.1.1.2.2 Durability Testing. Determination of conformance to this specification will include, but will not be limited to, the evaluation of test data from NTPEP or other MoDOT approved facilities. The maintained retroreflectivity and durability shall be in accordance with the following requirements after being installed on at least one NTPEP test deck in a northern, wet climate region for a minimum of six months, including December, January and February.

1048.10.1.1.1.2.3 Maintained Retroreflectivity. Photometric quantity to be measured will be the coefficient of retroreflective luminance (RL) in accordance with the requirements of ASTM E 1743 for 15-meter geometry or ASTM E 1710 for 30-meter geometry. The average RL for concrete and bituminous surfaces shall be expressed in millicandelas per footcandle per square foot and shall be at least 100 for 15-meter geometry or 75 for 30-meter geometry, when measured in the wheel path area.

1048.10.1.1.1.2.4 Durability. Paint shall have a durability rating of at least 4 for both concrete and bituminous surfaces when tested in the wheel path area of the NTPEP test deck.

1048.10.1.1.1.3 Mixed Paint.

1048.10.1.1.1.3.1 The mixed paint shall be strained before filling, using a screen or a sieving device no coarser than 40 mesh.

1048.10.1.1.1.3.2 The VOC content of the finished paint shall be less than 1.25 pounds of volatile organic matter per gallon of total non-volatile paint material when tested in accordance with ASTM D 3960.

1048.10.1.1.1.3.3 The paint shall have the following physical properties.

Property	Requirement
Viscosity, KU	80 - 95
Laboratory Dry Time, ASTM D 711, minutes, max.	10

1048.10.1.1.1.4 Color. For white, the color shall closely match Color Chip 37925 of Federal Standard 595b. For yellow, the color shall closely match Color Chip 33538 of Federal Standard 595b. Color determination will be made for markings and the diffuse daytime color of the markings shall be in accordance with the below CIE Chromaticity coordinate limits. Color determination for liquid marking materials will be made over the black portion of a 2A or 5C Leneta Chart or equal, at least 24 hours after application of a 15-mil wet film. Color readings will be determined in accordance with the requirements of ASTM E 1349 using CIE 1931 2-degree standard observer and CIE standard illuminant D65.

CIE Chromaticity Coordinate Limits (Initial)								
Color	1		2		3		4	
	x	y	x	y	x	y	x	y
White	0.334	0.357	0.334	0.317	0.297	0.357	0.297	0.317
Yellow	0.531	0.483	0.531	0.429	0.471	0.483	0.471	0.429

1048.10.1.1.1.4.1 Contrast Ratio. The contrast ratio shall be a minimum of 0.98 when drawn down as a 15-mil wet film on a 2A or 5C Leneta Chart or equal, and air-dried for 24 hours. The contrast ratio shall be calculated as follows: Contrast ratio = Black/White.

1048.10.1.1.1.4.2 Reflectance. The daylight directional reflectance of a 15-mil wet film applied to a 2A or 5C Leneta Chart or equal and dried for a minimum of 24 hours shall be 84% minimum for the white paint and 50% minimum for the yellow paint.

1048.10.1.1.1.5 Acceptance.

1048.10.1.1.1.5.1 Except as noted, each batch or lot of paint shall be sampled and approved by the engineer prior to use.

1048.10.1.1.1.5.2 No paint shall be used that is more than 15 months old.

1048.10.1.1.1.5.3 In addition to the requirements of Sec 1048.1.1, the certification supplied by the manufacturer shall include reference to the specific NTPEP test deck to which the paint formulation was applied, including NTPEP identification numbers and report numbers.

1048.10.1.1.2 Cold Weather Waterborne Pavement Marking Paint.

1048.10.1.1.2.1 Description. These specifications cover waterborne traffic paint for application on bituminous or Portland cement concrete pavements by department-owned spray equipment at application temperatures of 35 to 150ºF (2 to 66ºC). The paint shall be capable of receiving and holding glass beads for producing reflectorized traffic markings.

1048.10.1.1.2.2 Materials. The paint shall not contain more than 500 ppm lead and/or more than 780 ppm chromium based on dry weight and shall have limited Volatile Organic Content (VOC), as noted herein.

1048.10.1.1.2.2.1 Acrylic Emulsion Polymer. The acrylic emulsion polymer used in the manufacture of the paint shall be Dow Fastrack XSR or preapproved equivalent. Later generation acrylic emulsions may be substituted

only after concurrence of the Chemical Laboratory Director.

1048.10.1.1.2.2.2 General. The finished paint shall be formulated and manufactured from first-grade materials and shall be a fast drying, water based, acrylic resin type paint capable of withstanding air and roadway temperatures without bleeding, staining, discoloring, or deforming. The dried paint film shall be capable of maintaining its original dimensions and placement without chipping, spalling, or cracking. In addition, it shall not deteriorate because of contact with sodium chloride, calcium chloride, mild alkalies and acids, or other ice control materials, or oil, gasoline or diesel fuel drippings from vehicles.

1048.10.1.1.2.2.3 Maintained retroreflectivity. Photometric quantity to be measured is coefficient of retroreflective luminance (RL) in accordance with the requirements of ASTM E1710 for 30-meter geometry. The average RL for concrete and asphalt surfaces shall be expressed in millicandelas per square meter per lux (milicandelas/m2/lux) and shall be at least 75 for 30 meter geometry, when measured in the wheel path area.

1048.10.1.1.2.2.4 Mixed Paint. The mixed paint shall conform to the following requirements.

1048.10.1.1.2.2.4.1 The paint shall be strained before filling, using a screen or strainer not coarser than 40 mesh or equivalent.

1048.10.1.1.2.2.4.2 The volatile content of the finished paint shall contain less than 150 grams of volatile organic matter per liter in accordance with ASTM D3960.

1048.10.1.1.2.2.4.3 The paint shall have the following properties:

1048.10.1.1.2.2.4.3.1 Physical Properties.

Property	Requirement
Weight per Gallon @77 F, lbs	Report
Viscosity, KU	75-92
Grind (Hegman Gage), min.	3
Laboratory Dry Time, ASTM D 711, minutes, max.	10
Dry Through Time, minutes, max	150

1048.10.1.1.2.2.4.3.2 Color. For white the color shall closely match Color Chip 37925 of Federal Standard 595b. For yellow, the color shall closely match Color Chip 33538 of Federal Standard 595b. Color determination will be made for markings and the diffuse daytime color of the markings shall conform to the below CIE Chromaticity coordinate limits. Color determination for liquid marking materials will be made over the black portion of a 2A or 5C Leneta Chart (or equal) at least twenty-four (24) hours after application of a 15-mil wet film. Color readings will be determined in accordance with the requirements of ASTM E1349 using CIE 1931 2º standard observer and CIE standard illuminant D65.

CIE Chromaticity Coordinate Limits (Initial)								
Color	1		2		3		4	
	x	y	x	y	x	y	x	y
White	0.334	0.357	0.334	0.317	0.297	0.357	0.297	0.317
Yellow	0.531	0.483	0.531	0.429	0.471	0.483	0.471	0.429

1048.10.1.1.2.2.4.3.3 Flexibility. The paint shall show no cracking or flaking when tested in accordance with Federal Specification TT-P-1952B.

1048.10.1.1.2.2.4.3.4 Water Resistance. The paint shall show no cracking or flaking when tested in accordance with Federal Specification TT-P-1952B.

1048.10.1.1.2.2.4.3.5 Freeze-Thaw Stability. The paint shall show no coagulation or change in consistency greater than 10 Kreb Units, when tested in accordance with Federal Specification TT-P-1952B.

1048.10.1.1.2.2.4.3.6 Heat Stability. The paint shall show no coagulation, discoloration or change in consistency greater than 10 Kreb Units, when tested in accordance with Federal Specification TT-P-1952B.

1048.10.1.1.2.2.4.3.7 Dilution Test. The paint shall be capable of dilution with water at all levels without

curdling or precipitation such that the wet paint can be readily cleaned up with water only.

1048.10.1.1.2.2.4.3.8 Storage Stability. After 30 days storage in three-quarters filled, closed container, the paint shall show no caking that cannot be readily remixed to a smooth, homogeneous state, no skinning, livering, curdling, or hard settling. The viscosity shall not change more than 5(10) Kreb Units from the viscosity of the original sample.

1048.10.1.1.2.2.4.3.9 Contrast Ratio. The minimum contrast ratio (hiding power) shall be 0.99 for White and 0.98 for Yellow when drawn down with a 0.015 film applicator on a 2A or 5CLeneta Chart (or equal) and air-dried for 24 hours. Contrast Ratio = Black/White.

1048.10.1.1.2.2.4.3.10 Reflectance. The daylight directional reflectance of the white paint shall not be less than 87 percent and not less than 50 percent for yellow paint of a 15 mil wet film applied to a 2A or 5C Leneta Chart (or equal). After drying for a minimum of 24 hours measure the reflectance of the paint over the black portion of the chart using colorimeter, ASTM E 1347.

1048.10.1.1.2.2.4.3.11 Bleeding. The paint shall have a minimum-bleeding ratio of 0.97 when tested in accordance with Federal Specification TT-P-1952B. The asphalt saturated felt shall conform to ASTM D 226 for Type I.

1048.10.1.1.2.2.4.3.12 Dry Through Time. The paint shall be applied to a non-absorbent substrate at a wet film thickness of 15 ± 1 mils and placed in a humidity chamber controlled at 90 ± 5 percent R.H. and 72.5 ± 2.5ºF. The dry through time shall be determined according to ASTM D 1640.

1048.10.1.1.2.5 Acceptance. The Missouri Department of Transportation reserves the right to make field tests of material after receipt of bids, but prior to award to determine the paint's suitability for application in its equipment and for purposes of determining compliance with drying time requirements of this specification.

1048.10.1.1.2.5.1 Stability in Storage. After storage for periods up to twelve (12) months from the date of manufacture, the paint shall comply with the following requirements: a) The pigment shall not settle badly or cake in the container, nor shall the paint skin or thicken in storage sufficiently to cause an undesirable change in consistency, nor show spoilage. b) The paint shall comply with all other provisions of these specifications and be capable of being re-dispersed with a paddle or mixer to a smooth uniform condition of usable consistency.

1048.10.2 Temporary Removable Pavement Marking Tape.

1048.10.2.1 General. Temporary removable pavement marking tape shall be capable of being removed and shall leave no objectionable or misleading image or damage to the pavement after removal.

1048.10.2.2 The tape shall have a minimum specific luminance as shown for White and Yellow per ASTM D 4592, expressed as millicandelas/m2/lux. The tape shall be applied to an 8 x 36-inch panel per instrument recommendation for pavement marking tape and measured in accordance with MoDOT Test Method TM 8 at prescribed CEN geometry.

1048.10.2.3 Adhesive. Tape shall have a pre-coated pressure sensitive adhesive requiring no activation procedures. The adhesive shall be resistant to normal roadway chemicals or materials.

1048.10.2.4 Durability. The tape shall be weather-resistant and show no appreciable fading, lifting or shrinkage during the tape's useful life. Samples of the tape applied to standard specimen plates and tested in accordance with Federal Test Method No. 141, Method 6192, for 1,000 cycles, using a CS-17 wheel and 1,000-gram load shall not expose the backing material over more than five percent of the abraded area.

1048.10.3 Temporary Non-Removable Pavement Marking Tape.

1048.10.3.1 Reflectance. The tape shall have minimum specific luminance as shown for White and Yellow per ASTM D 4592, expressed as millicandelas/m2/lux). The tape shall be applied to an 8 in. x 36 in. panel per instrument recommendation for pavement marking tape and measured in accordance with MoDOT Test Method TM 8 at prescribed CEM geometry.

1048.10.3.2 Adhesive. Tape shall have pre-coated pressure sensitive adhesive requiring no activation

procedures. The adhesive shall be resistant to normal roadway chemicals or materials.

1048.10.3.3 Durability. The tape shall be weather-resistant and show no appreciable fading, lifting or shrinkage during the tape's useful life. Samples of the tape applied to standard specimen plates and tested in accordance with Federal Test Method No. 141, Method 6192, for 1000 cycles, using a CS-17 wheel and 1000-gram load shall not expose the backing material over more than five percent of the abraded area.

1048.10.4 Temporary Raised Pavement Markers.

1048.10.4.1 General. The brand name and manufacturer shall be stamped or indelibly printed on each container.

1048.10.4.2 Temporary Raised Pavement Markers. Markers shall consist of an L-shaped or T-shaped flexible polymer body with a minimum of 6.0 squre inches of ASTM Type V reflective sheeting on both faces of the vertical section. The marker base shall have affixed a pressure-sensitive adhesive, protected by a release paper, for application to the pavement surface. When required per Sec 620.10.5.3.2, a protective sleeve that prevents contamination of the reflective faces during pavement surface treatment operations shall be affixed to each marker in a minimum of two locations. The protective sleeve shall be easily removable after the surface treatment operation is complete

1048.20 PERMANENT PAVEMENT MARKING MATERIALS.

1048.20.1 Pavement Marking Paint Materials.

1048.20.1.1 Standard Acrylic Waterborne Pavement Marking Paint.

1048.20.1.1.1 Description. Standard acrylic waterborne pavement marking paint shall be capable of receiving and holding glass beads for producing retroreflective pavement marking.

1048.20.1.1.2 Material. The paint shall contain no more than 3200 ppm lead or more than 800 ppm chromium, based on dry weight.

1048.20.1.1.2.1 General. The finished paint shall be formulated and manufactured from quality material and shall be a fast-drying, water-based, acrylic resin-type paint capable of withstanding air and roadway temperatures without bleeding, staining, discoloring or deforming. The dried paint film shall be capable of maintaining original dimensions and placement without chipping, spalling or cracking. The dry paint film shall not deteriorate from contact with normal roadway chemicals or materials.

1048.20.1.1.2.2 Acrylic Emulsion Polymer. The acrylic emulsion polymer used in the manufacture of the paint shall be Rohm & Haas E-2706, Dow DT211 or equal. Later generation acrylic emulsions may be substituted as approved by the engineer.

1048.20.1.1.2.3 Durability Testing. The provisions of Sec 1048.20.1.2.2.3 will apply.

1048.20.1.1.2.3.1 Maintained Retroreflectivity. Photometric quantity to be measured will be the coefficient of retroreflective luminance (RL) in accordance with the requirements of ASTM E 1743 for 15-meter geometry or ASTM E 1710 for 30-meter geometry. The average RL for concrete and bituminous surfaces shall be expressed in millicandelas/lux/m2 and shall be at least 100 for 15-meter geometry or 75 for 30-meter geometry, when measured in the wheel path area.

1048.20.1.1.2.3.2 Durability. Paint shall have a durability rating of at least 4 on both concrete and bituminous surfaces when tested in the wheel path area of the NTPEP test deck..

1048.20.1.1.3 Mixed Paint. The provisions of Sec 1048.20.1.2.3 shall apply.

1048.20.1.1.4 Acceptance.

1048.20.1.1.4.1 Except as noted, each batch or lot of paint shall be sampled and approved by the engineer prior to use.

1048.20.1.1.4.2 No paint shall be used that is more than 15 months old.

1048.20.1.1.4.3 In the addition to the requirements of Sec 1048.1.1, the certification supplied by the manufacture shall include reference to specific NTPEP test deck to which the paint formulation was applied, including NTPEP identification numbers and report numbers.

1048.20.1.2 High Build Acrylic Waterborne Pavement Marking Paint.

1048.20.1.2.1 Description. Acrylic waterborne pavement marking paint shall be capable of receiving and holding glass beads for producing retroreflective pavement marking.

1048.20.1.2.2 Material. The paint shall contain no more than 3,200 ppm lead or more than 800 ppm chromium, based on dry weight.

1048.20.1.2.2.1 General. The finished paint shall be formulated and manufactured from quality material and shall be a fast-drying, water-based, acrylic resin-type paint capable of withstanding air and roadway temperatures without bleeding, staining, discoloring or deforming. The dried paint film shall be capable of maintaining original dimensions and placement without chipping, spalling or cracking. The dry paint film shall not deteriorate from contact with normal roadway chemicals or materials.

1048.20.1.2.2.2 Acrylic Emulsion Polymer. The acrylic emulsion polymer used in the manufacture of the paint shall be Rohm & Haas HD-21, Dow DT400 or equal.

1048.20.1.2.2.3 Durability Testing. Determination of conformance to this specification will include, but will not be limited to, the evaluation of test data from NTPEP or other MoDOT approved facilities. The maintained retroreflectivity and durability shall be in accordance with the following requirements after being installed on at least one NTPEP test deck in a northern climate region for at minimum of six months, including December, January and February.

1048.20.1.2.2.3.1 Maintained Retroreflectivity. Photometric quantity to be measured will be the coefficient of retroreflective luminance (RL) in accordance with the requirements of ASTM E 1743 for 15-meter geometry or ASTM E 1710 for 30-meter geometry. The average RL for concrete and bituminous surfaces shall be expressed in millicandelas per footcandle per square foot and shall be at least 100 for 15-meter geometry or 75 for 30-meter geometry, when measured in the wheel path area.

1048.20.1.2.2.3.2 Durability. Paint shall have a durability rating of at least 4 for both concrete and bituminous surfaces when tested in the wheel path area of the NTPEP test deck.

1048.20.1.2.3 Mixed Paint.

1048.20.1.2.3.1 The paint shall be strained before filling using a screen or a sieving device no coarser than 40 mesh or equivalent.

1048.20.1.2.3.2 The volatile content of the finished paint shall contain less than 150 grams of volatile organic matter per liter in accordance with ASTM D 3960.

1048.20.1.2.3.3 The paint shall have the following physical properties:

Acrylic Waterborne Pavement Marking Paint Physical Properties	
Property	**Requirement**
Viscosity, 77 F, KU	83-98
Grind (Hegman Gage), minimum	3
Laboratory Dry Time, ASTM D 711, @ 15 mil, minutes, max.	10
Laboratory Dry Time, ASTM D 711, @ 25 mil, minutes, max.	25
Dry Through Time, minutes, max.	150

1048.20.1.2.3.3.1 Color. For white, the color shall closely match Color Chip 37925 of Federal Standard 595b. For yellow, the color shall closely match Color Chip 33538 of Federal Standard 595b. Color determination will be made for markings and the diffuse daytime color of the markings shall be in accordance with the below CIE Chromaticity coordinate limits. Color determination for liquid marking material will be made over the black

portion of a 2A or 5C Leneta Chart or equal, at least 24 hours after application of a 15-mil wet film. Color readings will be determined in accordance with the requirements of ASTM E 1349 using CIE 1931 2-degree standard observer and CIE standard illuminant D65.

CIE Chromaticity Coordinate Limits (Initial)								
Color	1		2		3		4	
	x	y	x	y	x	y	x	y
White	0.334	0.357	0.334	0.317	0.297	0.357	0.297	0.317
Yellow	0.531	0.483	0.531	0.429	0.471	0.483	0.471	0.429

1048.20.1.2.3.3.2 Flexibility. The paint shall show no cracking or flaking when tested in accordance with Federal Specification TT-P-1952B.

1048.20.1.2.3.3.3 Water Resistance. The paint shall conform to Federal Specification TT-P-1952B. There shall be no blistering or appreciable loss of adhesion, softening or other deterioration after examination.

1048.20.1.2.3.3.4 Freeze-Thaw Stability. The paint shall show no coagulation or change in consistency greater than 10 Kreb Units when tested in accordance with Federal Specification TT-P-1952B.

1048.20.1.2.3.3.5 Heat Stability. The paint shall show no coagulation, discoloration or change in consistency greater than 10 Kreb Units when tested in accordance with Federal Specification TT-P-1952B.

1048.20.1.2.3.3.6 Dilution Test. The paint shall be capable of dilution with water at all levels without curdling or precipitation such that the wet paint can be readily cleaned up with water only.

1048.20.1.2.3.3.7 Storage Stability. After 30 days of storage in a 3/4 filled, closed container, the paint shall show no caking that cannot be readily remixed to a smooth, homogeneous state, and shall show no skinning, livering, curdling or hard settling. The viscosity shall change no more than 5 Kreb Units from the viscosity of the original sample.

1048.20.1.2.3.3.8 Contrast Ratio. The minimum contrast ratio (hiding power) shall be 0.96 when drawn down with a 0.005 bird film applicator on a 2A or 5C Leneta Chart or equal and air-dried for 24 hours. The contrast ratio shall be calculated as follows:
Contrast Ratio = Black/White.

1048.20.1.2.3.3.9 Reflectance. The daylight directional reflectance of a 15-mil wet film, applied to a 2A or 5C Leneta Chart or equal and dried for a minimum of 24 hours, shall be no less than 84 percent for the white paint and no less than 50 percent for the yellow paint.

1048.20.1.2.3.3.10 Bleeding. The paint shall have a minimum bleeding ratio of 0.97 when tested in accordance with Federal Specification TT-P-1952B. The asphalt saturated felt shall be in accordance with ASTM D 226 for Type I.

1048.20.1.2.3.3.11 Dry Through Time. The paint shall be applied to a non-absorbent substrate at a wet film thickness of 15 ± 1 mil and placed in a humidity chamber controlled at 90 ± 5 percent relative humidity and 72.5 ± 2.5 F. The dry through time shall be determined in accordance with ASTM D 1640, except that the pressure exerted shall be the minimum needed to maintain contact with the thumb and film.

1048.20.1.2.4 Acceptance.

1048.20.1.2.4.1 Except as noted, each batch or lot of paint shall be sampled and approved by the engineer prior to use.

1048.20.1.2.4.2 No paint shall be used that is more than 15 months old.

1048.20.1.2.4.3 In addition to the requirements of Sec 1048.1.1, the certification supplied by the manufacturer shall include reference to the specific NTPEP test deck to which the paint formulation was applied, including NTPEP identification numbers and report numbers.

1048.20.2 Durable Pavement Marking Materials.

1048.20.2.1 Plural Component Pavement Marking Materials.

1048.20.2.1.1 Epoxy Pavement Marking Materials.

1048.20.2.1.1.1 Fast Cure Epoxy Pavement Marking Materials.

1048.20.2.1.1.1.1 General. Epoxy pavement marking material shall not contain toxic heavy metals. The material shall be two-component, 100 percent solids and formulated and tested to perform as a pavement marking material with glass beads applied to the surface. The two components shall be epoxy resin and an amine curing agent.

1048.20.2.1.1.1.2 Toxicity. Upon heating to application temperature, the material shall not release fumes that are toxic to persons or property. Upon curing, the material shall be completely inert, with all components fully reacted and environmentally benign.

1048.20.2.1.1.1.3 No Track Time. The material shall have a no-track time of 10 minutes or less, when mixed in the proper proportions and applied at a 25-mil wet film thickness at 75 ± 2 F with the proper application of glass beads and when tested in accordance with ASTM D 711. The material shall fully cure under a constant surface temperature of 32 F or above.

1048.20.2.1.1.1.4 Adhesion to Concrete. The pavement marking material shall have a high degree of adhesion to the concrete surface such that there is a 100 percent concrete failure when tested in accordance with ACI 503, Appendix A.1. The prepared specimens shall have a film thickness of 15 ± 1 mil and shall be applied to concrete with a minimum compressive strength of 4,000 psi. The concrete surface shall be 90 ± 2 F when the material is applied. The applied material shall be cured for 72 hours at 75 ± 2 before performing the test.

1048.20.2.1.1.1.5 Hardness. The material shall have a minimum Shore D Hardness of 75 when tested in accordance with ASTM D 2240.

1048.20.2.1.1.1.6 Tensile Strength. The material shall have a minimum tensile strength of 5,000 psi after 72 hours of cure at 75 ± 2 F when tested in accordance with ASTM D 638.

1048.20.2.1.1.1.7 Compressive Strength. The material shall have a minimum compressive strength of 10,000 psi after 72 hours of cure at 75 ± 2 F when tested in accordance with ASTM D 695.

1048.20.2.1.1.1.8 Abrasion Resistance. The material shall have a maximum abrasion resistance of 150 mg at 15 ± 1 mil thickness after 72 hours of cure and with a CS-17 wheel under a load of 1,000 grams for 1,000 cycles, when tested in accordance with ASTM C 501.

1048.20.2.1.1.1.9 Yellowness Index. The material shall have a maximum yellowness index of 6 before the QUV test and a maximum of yellowness index of 23 after the 72-hour QUV test, when tested in accordance with ASTM D 1925.

1048.20.2.1.1.1.10 Color. The finished white color shall be free from tint, furnishing good opacity and visibility under both daylight and artificial light. The finished yellow color shall closely match Federal Test Standard 595 - Color Chip Number 13538.

1048.20.2.1.1.1.11 Drop-on Glass Beads. Glass beads shall be in accordance with Sec 1048.30.

1048.20.2.1.1.1.12 Qualification. In addition to the requirements of Sec 1048.1.1, the material shall have been field tested at NTPEP test decks in a northern, wet climate region for a minimum of six months. The maintained retroflectivity and durability shall be in accordance with the following requirements after being installed on at least one NTPEP test deck for a minimum of six months, including December, January and February.

1048.20.2.1.1.1.12.1 Maintained Retroreflectivity. Photometric quantity to be measured will be the coefficient of retroreflective luminance (RL) in accordance with ASTM E 1743 for 15-meter geometry or ASTM E 1710 for 30-meter geometry. The average RL for concrete and asphalt surfaces shall be expressed in millicandelas per footcandle per square foot and shall be at least 125 for 15-meter geometry or 100 for 30-meter geometry, when measured in the wheel path area.

1048.20.2.1.1.1.12.2 Durability. Paint shall have a durability rating of at least 5 for both concrete and asphalt surfaces when tested in the wheel path area of the NTPEP test deck.

1048.20.2.1.1.1.13 Packaging. The manufacturer's name and address, product name, color, manufacturing date, date of expiration and if the material is Part A or B shall be visible on the containers. In addition to the requirements of Sec 1048.1.1, the certification supplied by the manufacturer shall include reference to the specific NTPEP test deck to which the paint formulation was applied, including NTPEP identification numbers and report numbers.

1048.20.2.1.2 Polyurea Pavement Marking Material.

1048.20.2.1.2.1 Polyurea Pavement Marking Material. Polyurea pavement marking material shall not contain toxic heavy metals. It shall be two components, 100 percent solids, and formulated and tested to perform as a pavement marking material with glass beads applied to the surface.

1048.20.2.1.2.2 Toxicity. Upon heating to application temperature, the material shall not release fumes that are toxic to persons or property. Upon curing, the material should be completely inert, with all components fully reacted and environmentally benign.

1048.20.2.1.2.3 No Track Time. The material shall have a no-track time of 10 minutes or less when mixed in the proper proportions and applied at 20 mils wet film thickness at 75 ± 2 F with the proper application of glass beads and when tested in accordance with ASTM D 711. The material shall fully cure under a constant surface temperature of 32 F or above.

1048.20.2.1.2.4 Adhesion to Concrete. The pavement marking material shall have a high degree of adhesion to the concrete surface such that there is a 100 percent concrete failure when tested in accordance with ACI 503, Appendix A.1. The prepared specimens shall have a film thickness of 15 ± 1 mils and be applied to concrete with a minimum compressive strength of 4,000 psi. The concrete surface shall be 90 ± 2 F when the material is applied. The applied material shall be cured for 72 hours at 75 ± 2 F before performing the test.

1048.20.2.1.2.5 Hardness. The material shall have a minimum Shore D Hardness of between 70 and 100 when tested in accordance with ASTM D 2240.

1048.20.2.1.2.6 Abrasion Resistance. The material shall have a maximum abrasion resistance of 150 mg at 15 ± 1 mils thickness after 72 hour curing time and with a CS-17 wheel under a load of 1,000 grams for 1,000 cycles, when tested in accordance with ASTM C 501.

1048.20.2.1.2.7 Yellowness Index. The material shall have a maximum yellowness index of 6 before the QUV test and a maximum of 23 after the 72 hour QUV test, when tested in accordance with ASTM D 1925.

1048.20.2.1.2.8 Color. The finished white color shall be free from tint, furnishing good opacity and visibility under both daylight and artificial light. The finished yellow color shall be defined by Federal Test Standard 595 - Color Chip Number 13538, using Federal Tests Standard 141 (Method 4252).

1048.20.2.1.2.9 Accelerated Weathering. The material shall have been field tested at NTPEP test decks for a minimum of six months. The material shall have satisfactory results from the NTPEP test deck.

1048.20.2.1.2.10 Drop-on Glass Beads. Glass beads shall be in accordance with Sec 1048.30.

1048.20.2.1.2.11 Qualification. In addition to the requirements of Sec 1048.1.1, the material shall have been field tested at NTPEP test decks in a northern, wet climate region for a minimum of six months. The maintained retroflectivity and durability shall be in accordance with the following requirements after being installed on at least one NTPEP test deck for a minimum of six months, including December, January and February.

1048.20.2.1.2.11.1 Maintained Retroreflectivity. Photometric quantity to be measured will be the coefficient of retroreflective luminance (RL) in accordance with ASTM E 1743 for 15-meter geometry or ASTM E 1710 for 30-meter geometry. The average RL for concrete and asphalt surfaces shall be expressed in millicandelas per footcandle per square foot and shall be at least 125 for 15-meter geometry or 100 for 30-meter geometry, when measured in the wheel path area.

1048.20.2.1.2.11.2 Durability. Paint shall have a durability rating of at least 5 for both concrete and asphalt surfaces when tested in the wheel path area of the NTPEP test deck.

1048.20.2.1.2.12 Packing. The pavement marking material shall be shipped to the job site in strong, substantial containers. The manufacturer shall include the MSDS with each shipment. The manufacturer's name and address, name of the product, lot number and/or batch number, color, tare weight, manufacturing date, date of expiration, mixing proportions and if it is Part A or B shall be contained on a label and/or painted on the containers.

1048.20.2.2 Durable Preformed Pavement Marking Materials.

1048.20.2.2.1 Cold Applied Preformed Pavement Marking Tape Materials.

1048.20.2.2.1.1 Application. After application, the tape shall be immediately ready to receive traffic.

1048.20.2.2.1.2 Composition. Cold applied preformed pavement marking tape shall consist of a mixture of polymeric material and pigments with beads distributed throughout the cross-sectional area and with a reflective layer of glass beads embedded in the surface. The marking shall be capable of adhering to bituminous or concrete surfaces by a flexible conforming backing. A primer may be required to precondition the pavement surface.

1048.20.2.2.1.3 Dimensions. The marking tape as supplied shall be free of cracks, and have edges true, straight, and unbroken. The actual width of the rolls of preformed tape shall be no less than the nominal (stated) width and no more than 1/8 in. greater than the nominal width. The length shall be no less than the length stated.

1048.20.2.2.1.4 Adhesion. The tape shall be supplied with a precoated factory-applied pressure sensitive adhesive. The marking tape shall have minimum adhesion values as shown in table 2 of ASTM D1000.

1048.20.2.2.1.5 Color. The white and yellow marking tape shall conform to the requirements of ASTM D6628.

1048.20.2.2.1.6 Reflectance. The tape shall have a minimum specific luminance as shown for White and Yellow per ASTM D 4505, expressed as millicandelas /m2/lux. The tape shall be applied to an 8 x 36-inch panel per instrument recommendation for pavement marking tape and measured in accordance with MoDOT Test Method TM 8 at prescribed CEN geometry.

1048.20.2.2.1.7 Index of Refraction. The glass beads mixed into the pliant polymer shall have a minimum index of refraction of 1.50 when tested by the oil immersion method. If ceramic elements are used in the pavement marking, the ceramic elements shall have a minimum index of refraction of 1.70 when tested using the liquid oil immersion method. Ceramic beads with an index of refraction greater than 1.80 shall not be used.

1048.20.2.3 Durable Intersecton Marking Materials.

1048.20.2.3.1 Preformed Thermoplastic Material.

1048.20.2.3.1.1 General. Pavement marking material shall not contain toxic heavy metals. The material shall be solid, formulated and tested to perform as a pavement marking material with glass beads uniformly throughout the marking.

1048.20.2.3.1.2 Toxicity. Upon heating to application temperature, the material shall not release fumes that are toxic to persons or property. Upon curing, the material shall be completely inert, with all components fully reacted and environmentally benign.

1048.20.2.3.1.3 Adhesion to Pavement. The pavement marking material shall have a high degree of adhesion to the pavement surface. The product shall be applied per manufactures specification on a clean dry surface.

1048.20.2.3.1.4 Abrasion Resistance. The material shall have a maximum abrasion resistance of 150 mg with a CS-17 wheel under a load of 1,000 grams for 1,000 cycles, when tested in accordance with ASTM C 501.

1048.20.2.3.1.5 Yellowness Index. The material shall have a maximum yellowness index of 6 before the QUV

test and a maximum of yellowness index of 23 after the 72-hour QUV test, when tested in accordance with ASTM D 1925.

1048.20.2.3.1.6 Color. The finished white color shall be free from tint, furnishing good opacity and visibility under both daylight and artificial light. The finished yellow color shall closely match Federal Test Standard 595 - Color Chip Number 33538.

1048.20.2.3.1.7 Qualification. In addition to the requirements of Sec 1048.1.1, the material shall have been field tested at NTPEP test decks in a northern, wet climate region for a minimum of six months. The maintained retroflectivity and durability shall be in accordance with the following requirements after being installed on at least one NTPEP test deck for a minimum of six months, including December, January and February.

1048.20.2.3.1.8 Maintained Retroreflectivity. Photometric quantity to be measured will be the coefficient of retroreflective luminance (RL) in accordance with ASTM E 1743 for 15-meter geometry or ASTM E 1710 for 30-meter geometry. The average RL for concrete and asphalt surfaces shall be expressed in millicandelas per footcandle per square foot and shall be at least 125 for 15-meter geometry or 100 for 30-meter geometry, when measured in the wheel path area.

1048.20.2.3.1.9 Durability. Paint shall have a durability rating of at least 5 for both concrete and asphalt surfaces when tested in the wheel path area of the NTPEP test deck.

1048.20.2.3.1.10 Packaging. The manufacturer's name and address, product name, color, manufacturing date, date of expiration of the material. In addition to the requirements of Sec 1048.1.1, the certification supplied by the manufacturer shall include reference to the specific NTPEP test deck to which the product was applied, including NTPEP identification numbers and report numbers.

1048.20.2.3.2 Plural Component Intersection Marking Materials.

1048.20.2.3.2.1 Epoxy Materials.

1048.20.2.3.2.1.1 General. Epoxy Materials used for intersection markings shall be in accordance with Sec 1048.20.2.1.1.

1048.20.2.3.2.2 Polyurea Materials.

1048.20.2.3.2.2.1 General. Polyurea Materials used for intersection markings shall be in accordance with Sec 1048.20.2.1.2.

1048.20.2.3.3 Cold Applied Tape Intersection Marking Material.

1048.20.2.3.3.1 General. Cold Applied Tape Materials used for intersection markings shall be in accordance with Sec 1048.20.2.2.1.

SECTION 1048.30 DROP-ON GLASS BEADS.

1048.30.1 General. When tested in accordance with MoDOT Test Method TM 70 for water resistance, the beads shall show no readily discernible dulling and the amount of 0.1 normal hydrochloric acid needed to titrate the filtrate shall not exceed 4.5 mL. When tested in accordance with MoDOT Test Method TM 70 for calcium chloride and sodium sulfide resistance, the beads shall show no readily discernible darkening or dulling.

1048.30.2 Type P Drop-On Glass Beads. Type P beads shall be manufactured from glass of a composition that is highly resistant to traffic wear and to the effects of weathering. If coating is required to meet the performance requirements for the specific marking material used, the beads shall be coated to ensure satisfactory embedment and adhesion.

1048.30.2.1 Refractive Index. Type P beads shall have a minimum refractive index of 1.51 when tested in accordance with AASHTO M 247.

1048.30.2.2 Roundness. All Type P beads passing the No. 30 sieve shall have a minimum of 75 percent true spheres when tested in accordance with ASTM D 1155 or AASHTO PP-74. All Type P beads retained on the

No. 20 and No. 30 sieves shall have a minimum of 80 percent true spheres as determined by ASTM D 1155 or AASHTO PP-74.

1048.30.2.3 Gradation. Type P beads shall meet the following gradation requirements when tested in accordance with ASTM D 1214.

U. S. Standard Sieve No.	Percent Retained
20	3-10
30	15-35
50	45-75
70	0-10
Pan	0-5

1048.30.3 Type L Drop-On Glass Beads. Type L beads shall be embedment coated and manufactured from glass of a composition that is highly resistant to traffic wear and to the effects of weathering. The beads shall be in accordance with AASHTO M 247, Type 1, except as follows.

1048.30.3.1 Coating. The beads shall be coated to ensure satisfactory embedment and adhesion when applied to uncured traffic marking material. The coating shall be tested in accordance with MoDOT Test Method TM 70.

1048.30.3.2 Roundness. Type L beads shall have a minimum of 80 percent rounds per screen for the two highest sieve quantities, and no more than 3 percent angular particles per screen, as determined by ASTM D 1155 or AASHTO PP-74. The remaining sieve fractions shall be determined by ASTM D 1155 or AASHTO PP-74to be no less than 75 percent rounds.

1048.30.3.3 Gradation. Type L beads shall meet the following gradation requirements when tested in accordance with ASTM D 1214:

Type L Bead Gradation Requirements	
Sieve Size	**Percent Passing**
No. 12	100
No. 14	95 - 100
No. 16	80 - 95
No. 18	10 - 40
No. 20	0 - 5
No. 25	0 - 2

1048.30.4 Type 1 Drop-On Glass Beads. Type 1 beads shall be moisture-resistant and manufactured from glass of a composition that is highly resistant to traffic wear and to the effects of weathering. Glass beads shall be in accordance with AASHTO M 247, Type 1.

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SECTION 1049
PRECAST CONCRETE BOX CULVERTS

1049.1 Scope. This specification covers precast concrete box culverts.

1049.2 Acceptance. The basis of acceptance will be with producer's QMP in accordance with Sec 1001.14.

1049.2.1 Lot Size Definition. A lot is defined as one day's production.

1049.2.2 Quality Control. The producer QMP shall define quality control testing and inspection frequencies and shall include the following minimum requirements.

1049.2.2.1 Compressive strength of cylinders or cores shall be taken at a minimum of once per lot in accordance with ASTM C1577. Compressive strength testing shall also be performed to control handling and curing operations. Cylinders shall be cured in accordance with AASHTO T23 field curing procedures.

1049.2.2.2 Air and slump of fresh concrete shall be taken a minimum of once per lot.

1049.2.2.3 Aggregate gradation, absorption and deleterious shall be checked a minimum of once per month per aggregate source in accordance with Sec 1005.

1049.2.2.4 Steel placement shall be checked and documented for each unit.

1049.2.2.5 Finished dimensions shall be checked and documented for each unit.

1049.2.2.6 All equipment used for testing shall be maintained and calibrated in accordance with AASHTO R18 or equivalent program.

1049.2.2.7 Concrete plant(s) shall be calibrated and monitored in accordance with the producer's QMP.

1049.2.3 Quality Assurance. The QMP shall reference an industry organization or define independent QA testing frequencies including the following:

Tested Property[a]	Test Method	Independent QA
Air	T152	Twice a year
Slump	T119	Twice a year
Coarse Aggregate Deleterious	TM71	Twice a year
Coarse Aggregate Absorption	T85	Twice a year
Compressive Strength	T22	Twice a year
Absorption (per mix)	T280	Once a year

[a] All samples shall be taken at the precast plant

1049.2.4 MoDOT Hold Points.

1049.2.4.1 MoDOT shall verify steel placement prior to concrete pour.

1049.2.4.2 Prior to shipping, producers shall notify MoDOT and obtain a MoDOT identification number(s).

1049.2.4.3 Repair methods and completion of repairs for non-conforming work shall be approved by the engineer.

1049.2.5 MoDOT Quality Assurance and Auditing. The engineer may perform QA testing and audit the producer's QMP, documentation and production at any time, which may include coring of the precast units at the producer's expense.

1049.2.6 Deficient Work. A procedure addressing deficient work in accordance with Sec 1001.14.

1049.2.6.1 Filling of form tie cavities and repair of other defects shall be in accordance with Sec 703.

1049.2.7 Non-Conforming Work. A procedure addressing non-conforming work in accordance with Sec 1001.14.

1049.3 Material.

1049.3.1 Cement. Cement shall be in accordance with Sec 1019.

1049.3.2 Fly Ash. Fly ash shall be in accordance with Sec 1018.

1049.3.3 Ground Granulated Blast Furnace Slag. Ground granulated blast furnace slag shall be in accordance with the requirements of Sec 1017.

1049.3.4 Aggregate. Fine and coarse aggregate for the concrete mixture shall be in accordance with Sec 1005, except the requirements for gradation and percent passing the No. 200 sieve will not apply.

1049.3.5 Steel Reinforcement. Reinforcement shall be in accordance with Sec 1036.3.

1049.3.6 Concrete Mixture. Concrete shall be a minimum of 5,000 psi in accordance with ASTM C1577 and the mix design shall be approved by the engineer. Admixtures or blends may be used with approval from engineer.

1049.4 Design. Except as otherwise specified herein, precast concrete box sections for the culvert shall be in accordance with ASTM C 1577. Designs shall be submitted to the inspecting District.

1049.4.1 Substituted precast concrete box culvert sections shall be designed for the earth cover shown on the plans for the cast-in-place box culvert, and shall be equal in height and cross sectional area or as approved by the engineer.

1049.4.2 Special Designs. The producer shall request approval of any modified and special designs which differ from the designs in ASTM C 1577. The request for such modified and special designs shall fully describe any deviations from those standards, including a drawing showing wall thickness, concrete design strength, the type, size and placement of reinforcement, and inside or outside dimensions of both of the box sections.

1049.4.3 The minimum barrel length for box or end section shall be 2 feet.

1049.4.4 End sections may be precast or cast-in-place. If precast, the barrel, floor and wing walls shall be cast as an integral unit. In either case, the end sections shall be constructed to the same dimensions, shapes, and with the same reinforcement as shown on the plans for cast-in-place culvert.

1049.4.5 Segmented end sections may be provided, but will be considered a modified design and will require approval as such.

1049.4.6 Toe walls shall be provided on both the upstream and downstream ends as shown on the plans, and may be cast-in-place or precast. Precast toe walls shall be connected to the end section floor.

1049.5 Manufacture.

1049.5.1 Curing. Curing shall be in accordance with Sec 1026 until the concrete has developed the specified compressive strength.

1049.5.2 The producer shall ensure that the placing, finishing and consolidating of concrete is in accordance with their producer quality management plan. Temperatures shall be maintained to prevent detrimental effects to precast production and the following:

> a) Concrete placed in cold weather shall be protected from freezing during the curing period by the use of a heated, weatherproof enclosure. Concrete shall not be placed on or against reinforcing steel or other surfaces with temperatures lower than 35 F. No concrete shall be placed when the enclosure ambient temperature is below 35 F.

The temperature of the mixed concrete when placed shall be no higher than 90 F. The forms and reinforcing

steel shall be cooled by acceptable methods to an ambient temperature of 90 F or lower.

1049.5.3 Permissible Variations. Dimensions, position of reinforcement, area of reinforcement and haunch dimensions shall be in accordance with ASTM C1577.

1049.6 Marking. The following information shall be legibly marked on each box section by indentation, waterproof paint or other approved means. Box section span, rise, maximum and minimum design earth cover and specification designation.

a) Date of manufacture.

b) Name or trademark of the manufacturer.

c) Indicator required by the QC program.

d) Sample Identification Number.

e) Station where the unit will be installed.

f) Each section shall be clearly marked on either the inner or the outer surface during the process of manufacture. In addition, the word "top" shall be lettered with waterproof paint on the inside of the top surface.

1049.7 MoDOT Identification Number. The producer shall contact the engineer, a minimum of one business day, prior to shipping precast products. The engineer shall assign a specific MoDOT identification number for each size and type of product in the shipment.

1049.7.1 Prior to delivery to the jobsite, the source, intermediate agent, shipper or contractor's representative shall notify the inspecting District by fax or electronically a minimum of one business day or earlier, prior to the impending shipment of precast material. This notification shall include a shipping form (Precast Shipping Form) and will include, at minimum, the following:

a) Contract Number and Project Number.

b) Receiving Purchaser/Contractor.

c) Type and quantity of material.

d) Date of expected delivery to the jobsite.

e) Manufacturer's name.

f) Stationing or structure number on precast unit, if applicable.

1049.7.2 The precast unit shall be clearly and permanently marked by the precaster with the ID number in accordance with Sec 1049.7 prior to shipment. Requests for alternate precast labeling shall be submitted to the inspecting District for approval. Material without proper identification number shall not be permitted for use on a project.

1049.8 Delivery. A bill of lading or delivery receipt for each shipment shall be furnished to the engineer at the destination point. The bill of lading shall contain an itemized statement of the sizes and lengths of precast units with the corresponding designated MoDOT identification number provided to the manufacturer for each size and type of precast unit for that shipment. The bill of lading shall contain a certified statement. The certified statement shall be signed by an authorized representative of the manufacturer and shall state the following:

"This certifies that the precast products in this shipment are in accordance with MoDOT specifications."

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SECTION 1050
LUMBER, TIMBER, PILING, POSTS AND POLES

1050.1 Scope. This specification covers wood products as defined in the AWPA Standards.

1050.2 Posts.

1050.2.1 Posts and Blocks for Guardrail. Posts and blocks for guardrail shall be rectangular, standard rough sawn and of the size and length shown on the plans. Posts and blocks shall be pressure treated in accordance with Sec 1050.6. All framing and boring shall be completed before treatment. Douglas Fir shall be "Dense No. 1 Structural Grade" in accordance with Paragraph 131-bb of the current Standard Grading Rules for West Coast Lumber. Southern Pine shall be "No. 1 Dense Grade" in accordance with Paragraph 406 of the current Standard Grading Rules for Southern Pine Lumber.

1050.2.2 Posts for Fence. Posts for fence shall be round and of the sizes and lengths shown on the plans. Posts shall be pressure-treated in accordance with Sec 1050.6. Allowable tolerances for size and length will be as follows:

Fence Post Tolerances	
Dimension	**Tolerance**
≤4-inch diameter	+1/2, No minus tolerance
> 4-inch diameter	+1 inch, No minus tolerance
All Lengths (any diameter)	No limit on over length, Minus 1 inch

1050.2.2.1 Grade. Wood for posts shall be sound, free of decay, excessive knots and of end splits and seasoning checks that might affect serviceability. Posts shall be free of multiple crooks, except crooks in one plane only in accordance with Sec 1050.2.2.2 will be permitted.

1050.2.2.2 Straightness. A straight line drawn from the center of one end of the post to the center of the opposite end shall not deviate from the longitudinal axis of the post at any point more than one percent of the length of the post.

1050.2.2.3 Manufacture. Posts shall be clean peeled to remove all bark, except that strips of inner bark no more than 1/2 inch wide or more than 3 inches long will be permitted to remain on the peeled post. All protruding knots shall be trimmed flush, and all spurs and splinters shall be removed. The natural taper of round posts shall be followed in machine peeling operations. The ends of all posts shall be cut square, except posts to be driven shall be machine-pointed on the small end prior to treatment.

1050.2.3 Posts for One-Strand Access Restraint Cable. Posts for one-strand access restraint cable may be round or rectangular, as shown on the plans. Round posts shall be in accordance with Sec 1050.2.2. Rectangular posts shall be standard rough sawn and of the grade specified in Sec 1050.2.2.1. All posts shall be in accordance with Sec 1050.6.

1050.2.4 Posts for Signs. Posts for signs shall be rectangular, rough sawn or surfaced four sides (S4S), with square cut ends, and shall be of the grade, size and length shown on the plans. Posts shall be pressure-treated in accordance with Sec 1050.6. Other preservatives and wood species shall be in accordance with applicable AWPA Standards. If framing and boring is completed after pressure treatment, field treatment shall be in accordance with Sec 1050.7.

1050.2.4.1 Permanent. Project sign posts shall be treated to Use Category (UC) 4B.

1050.2.4.2 Temporary. Post for temporary use shall be treated to UC 4A.

1050.3 Lumber and Timber.

1050.3.1 Species and Grade Requirements. Unless otherwise specified, lumber and timber to be used as a permanent part of a structure shall be one of the species shown in Table I or other treatable species as specified in the AWPA Standards, and of the grade specified on the plans. Lumber and timber for temporary structures

shall be of the species and grades shown on the plans.

1050.3.2 Dressing Requirements. Lumber and timber shall be standard rough sawn or shall be surfaced as specified in the contract. Lumber and timber shall be cut to exact lengths or to permissible variations in lengths shown in the contract documents.

1050.3.3 Treatment. If treatment is specified, lumber and timber shall be pressure-treated in accordance with Sec 1050.6.

1050.4 Electric Substation, Service and Span Wire Assembly Poles.

1050.4.1 Electric Substation and Services Poles. Electric substation and service poles shall be of the length and class specified in the contract documents, and shall be in accordance with ANSI O5.1. Poles shall be pressure treated in accordance with Sec 1050.6. Poles may be gained and drilled in the field after treatment. Areas exposed shall be treated in accordance with Sec 1050.7 before cross-arms or equipment are mounted.

1050.4.2 Span Wire Assembly Poles. Span wire assembly poles shall be of the length specified in the contract and shall be in accordance with ANSI 05.1, Class IV, unless otherwise specified. The poles shall be pressure treated in accordance with Sec 1050.6. All poles shall have a minimum diameter of 6 3/4 inches, measured at the top of the pole.

1050.4.3 Pole Crossarms. The species, grade and treatment of crossarms to be erected on substation and service poles will be shown on the plans.

1050.5 Round Timber Piles.

1050.5.1 Material. All round timber piles shall be in accordance with ASTM D 25, except for size, which shall be in accordance with Table I for the class specified in the contract.

1050.5.2 Chemical Treatment. Piles shall be pressure treated in accordance with Sec 1050.6. Framing and boring will not be required before treatment. Exposed untreated areas resulting from framing of treated piling shall be field treated in accordance with Sec 1050.7. Untreated piles for use in unexposed locations or in temporary bridges shall be of the species approved by the engineer.

1050.6 Timber Preservatives. Pressure preservative treatment shall be in accordance with current AASHTO Standard M-133.

1050.6.1 Responsibility for Quality. The contractor shall use preservatives that meet these specifications or the treated material will be subject to rejection, or to approved retreatment with an approved preservative.

1050.7 Care After Treatment. Care shall be taken in handling pressure-treated material to avoid damage. Cant hooks, peavies, pickaroons and end cant hooks shall not be used on the side surfaces of treated material. All handling of treated round stock with pointed tools shall be confined to the ends. If damaged material is permitted for use by the engineer, or framing at site is required, remediation following current AWPA Standard M4 shall be followed.

1050.8 Inspection Requirements.

1050.8.1 Inspection. All material shall be inspected for compliance with these specifications in accordance with AWPA Standard M2.

1050.8.1.1 Timber products treated within the State of Missouri or within 100 air miles of the border may be inspected by MoDOT personnel.

1050.8.1.2 The inspection of lumber, timber, piling, posts and poles shall be performed by the supplier or an approved inspection agency, and the cost for inspection shall be at the contractor's expense.

1050.8.2 Inspection Agency. An approved inspection agency will be a laboratory, accredited by the American Lumber Standards Committee, P.O. Box 210, Germantown, MD, or an experienced testing laboratory approved by the engineer. Inspection agencies not accredited by the American Lumber Standards Committee shall submit

for approval a resume to Construction and Materials. The resume of the agency shall include the agency's history of inspection of timber and treated products, a listing of state highway agencies which have approved the inspection agency and a listing of state agencies for which the inspection agency has performed inspection.

1050.9 Certification. The contractor shall furnish to the engineer certification from the supplier or inspection agency that the material furnished is in accordance with these specifications. Certification shall include or shall have attached a listing of the material being supplied. Except as noted, the certification shall have attached a certified test report, as detailed in Section 7.2 of AWPA Standard M2, from the supplier or inspection agency attesting to complete compliance with AWPA and these specifications. Electric substation, service and span wire assembly poles will not require certified test reports.

1050.10 Acceptance. Acceptance of material will be based on satisfactory supplier's certification or inspection agency certifications, and upon results of any tests deemed necessary by the engineer at destination to ascertain compliance with these specifications.

TABLE I

Circumferences and Diameters of Timber Piles, (in.)

Length ft	Class A 3 ft From Butt				Tip		Class B 3 ft From Butt				Tip		Class C 3 ft From Butt				Tip	
	Min		Max		Min		Min		Max		Min		Min		Max		Min	
	Cir	Dia	Cir	Dia	Cir	Dia	Cir	Dia	Cir	Dia	Cir	Dia	Cir	Dia	Cir	Dia	Cir	Dia
Up to 50	47	15	57	18	28	9	38	12	63	20	25	8	38	12	63	20	25	8
Over 50	47	15	57	18	25	8	41	13	63	20	22	7	38	12	63	20	22	7

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SECTION 1051
SLOTTED DRAIN

1051.1 Scope. This specification covers slotted drain.

1051.2 Pipe. The pipe portion of the slotted drain shall be 16 gage. The material and fabrication of the pipe shall be in accordance with Sec 1020. The diameter of the pipe shall be as shown on the plans.

1051.3 Slotted Drain Grate Assembly. The grate assembly of Type A, B or C slotted drain shall be fabricated as shown on the plans. The grate assembly shall be 6 inches high unless otherwise specified on the plans.

1051.3.1 Type B and Type C slotted drain grate assemblies shall be fabricated from 3/16-inch thick ASTM A 36 structural steel. The entire grate assembly shall be hot dip galvanized, prior to attachment to the pipe, in accordance with AASHTO M 111.

1051.3.2 Type A slotted drain guide assemblies shall be fabricated from 14 gage galvanized steel meeting the same material requirements as the pipe. The drain guide slot shall be assembled with mechanical interlocks requiring no welding.

1051.4 All coupling devices and other necessary fittings shall be in accordance with Sec 1020.

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SECTION 1052
MECHANICALLY STABILIZED EARTH WALL SYSTEM COMPONENTS

1052.1 This specification covers material requirements for metallic soil reinforcement, non-metallic soil reinforcement, concrete facing panels for large block wall systems, and concrete blocks for small block wall systems that are supplied as part of mechanically stabilized earth wall systems. All precast items shall be in accordance with Sec 1001.

SECTION 1052.10 METALLIC SOIL REINFORCEMENT.

1052.10.1 Scope. This specification covers metallic soil reinforcement and the accompanying attachments utilized in mechanically stabilized earth wall systems.

1052.10.2 Reinforcement Strips. Metallic soil reinforcement strips shall be in accordance with the specifications of the manufacturer of the wall system and the contract documents. The minimum grade of steel for strips and connection devices shall be AASHTO M 270, Grade 36.

1052.10.3 Reinforcement Mesh. Metallic soil reinforcement mesh shall be in accordance with the specifications of the manufacturer of the wall system and the contract documents. The minimum grade of steel for strips and connection devices shall be either AASHTO M 270 Grade 36, ASTM A 1011 Grade 50 or ASTM A 463 Grade 50. Welding shall be in accordance with AASHTO M 55.

1052.10.4 Fasteners. Fasteners shall consist of either AASHTO M 164 hexagon head bolts or AASHTO M 164 hexagonal cap screws with nuts and washers.

1052.10.5 Galvanizing and Aluminizing. All soil reinforcement material shall be either galvanized or aluminized. Galvanized soil reinforcement shall be in accordance with AASHTO M 111. Aluminized soil reinforcement shall be in accordance with ASTM A 463 Aluminized Type 2-100, SS, Grade 50, Class 2. Fasteners, including bolts, nuts and washers, shall be galvanized in accordance with AASHTO M 232. All connection devices shall be galvanized in accordance with either AASHTO M 111 or M 232.

1052.10.6 Certification. The manufacturer of the wall system shall certify in writing that the soil reinforcement, connections and fasteners meet the minimum requirements directed by the design and this specification. The contractor shall provide this certification and any other supporting documentation to the engineer prior to the material being delivered to the construction site.

SECTION 1052.20 NON-METALLIC SOIL REINFORCEMENT.

1052.20.1 Scope. This specification covers non-metallic or geosynthetic soil reinforcement utilized in mechanically stabilized earth wall systems.

1052.20.2 Geogrids. Non-Metallic or geosynthetic soil reinforcement shall be of a polymeric nature and shall consist of a geogrid determined by the wall manufacturer or supplier.

1052.20.2.1 The geogrid shall be dimensionally stable and shall be able to maintain geometry during transport, handling and installation.

1052.20.2.2 The geogrid manufacturer shall maintain a quality control program to ensure that the manufactured material meets the requirements of the index tests shown below. Sampling and conformance testing for the index tests shown in the table shall be done in accordance with ASTM D 4354.

Geogrids	
Property	**Test Procedure**
Specific Gravity (HDPE only)	ASTM D 1505
Wide Width Tensile	ASTM D 4595, GRI GG1
Melt Flow (HDPE and PP only)	ASTM D 1238
Inherent Viscosity (PET only)	ASTM D 4603, GRI GG8
Hydrolysis Resistance (PET only)	GRI GG7
UV Oxidation Resistance	ASTM D 4355
Survivability	ASTM D 5261

1052.20.3 Certification. The manufacturer of geogrid shall certify in writing that the geogrid is in accordance with this specification. The certification shall include the roll numbers and identification, the sampling procedures, the results of the quality control tests along with the tests used, and the Minimum Average Roll Value (MARV) for each roll. This certification and any other supporting documentation shall be provided to the engineer prior to the material being delivered to the construction site.

SECTION 1052.30 MSE PANEL AND SOUND WALLS.

1052.30.1 Scope. This specification covers the concrete facing panels used as part of mechanically stabilized earth wall systems and sound wall systems.

1052.30.2 Acceptance.

1052.30.2.1 Lot Definition. A production lot will be defined as a group of panels and precast posts that will be represented by a single compressive strength sample, and shall consist of either 40 panels and or precast posts or single day's production, whichever is less.

1052.30.2.2 Quality Control. The QMP shall define QC testing and inspection frequencies including the following.

1052.30.2.3 Compressive strength of cylinders or cores shall be taken at least once a lot in accordance with AASHTO M199. Compressive strength testing may also be performed to control handling and curing operations. Cylinders shall be cured in accordance with AASHTO T23 field curing procedures. For field cure compressive strength samples sufficient cylinders shall be cured in the same manner as the panels and precast posts and tested in accordance with AASHTO T22, shall represent the initial strength of the concrete. In addition, a set of cylinders shall be cured in accordance with AASHTO T23 and tested at 28 days. The average compressive strength of these cylinders, when tested in accordance with AASHTO T22, shall represent the compressive strength of the production lot.

1052.30.2.4 Air content testing shall be performed in accordance with AASHTO T152 or AASHTO T196. Air content samples shall be taken at the beginning of each day's production and at the same time as compressive samples are taken to ensure compliance with this specification.

1052.30.2.5 Slump testing shall be performed in accordance with AASHTO T119. The slump shall be determined at the beginning of each day's production and at the same time as the compressive strength samples are taken.

1052.30.2.6 Aggregate gradation and quality shall be checked at least once a month per aggregate source to ensure compliance with the specifications.

1052.30.2.7 Steel placement shall be checked for each unit.

1052.30.2.8 All equipment used for testing shall be maintained and calibrated in accordance with AASHTO R18 or equivalent program.

1052.30.2.9 QC shall ensure the concrete plant is calibrated, monitored, and maintained in a manner sufficient to provide uniform compliant concrete.

1052.30.2.10 Quality Assurance. The QMP shall reference an industry organization or define independent QA testing frequencies including the following:

Tested Property[a]	Test Method	Independent QA
Air	T152	Twice a year
Slump	T119	Twice a year
Coarse Aggregate Deleterious	TM71	Twice a year
Coarse Aggregate Absorption	T85	Twice a year
Compressive Strength	T22	Twice a year
Absorption (per mix)	T280	Once a year

[a] All samples shall be taken at the precast plant.

1052.30.2.11 MoDOT QA and Auditing. The engineer may perform MoDOT QA testing or audit the producer's QMP, documentation and production at any time, which may include coring of the precast units at the producer's expense.

1052.30.2.12 Other Criteria. Concrete facing panels, coping and precast posts will not be accepted if any of the following defects in physical characteristics are found: imperfect molding, honeycombing or open texture concrete, cracked or severely chipped panels and precast posts, soil reinforcement attachment devices improperly installed/damaged, lifting inserts not useable, exposed reinforcing steel, and color variation on the front face of the panel due to excess form oil or other reasons.

1052.30.3 Material.

1052.30.3.1 Concrete. Concrete material, proportioning, air entraining, mixing, slump and transporting of concrete shall be in accordance with Sec 501, except as noted in this section.

1052.30.3.2 Aggregate. Fine and coarse aggregate for the concrete mixture shall be in accordance with Sec 1005, except that the requirements for gradation and percent passing the No. 200 sieve will not apply.

1052.30.3.3 Steel Reinforcement. Reinforcement shall be in accordance with Sec 1036.

1052.30.4 Design. Shop drawings shall be approved by the Bridge Division when the MSE wall is constructed in conjunction with a bridge abutment.

1052.30.4.1 The concrete shall be an approved MoDOT mix that is air-entrained, with a minimum compressive strength of 4,000 psi at 28 days. No additional admixtures will be permitted unless approved by the engineer.

1052.30.4 Casting. The panels shall be cast in such a manner that the acceptance criteria of this specification are met. Soil reinforcement connection devices shall not be in contact with or attached to the reinforcing steel in the concrete facing panels.

1052.30.5 Manufacturing.

1052.30.5.1 Casting. The panels and precast posts shall be cast in such a manner that the acceptance criteria of this specification are met. Soil reinforcement connection devices shall not be in contact with or attached to the reinforcing steel in the concrete facing panels.

1052.30.5.2 Curing. One of the following methods shall be used. Curing as recommended by the wall designer. Curing membrane, in accordance with Sec 1055, may be applied and if used shall be left intact until the strength requirements are met. Steam and moisture curing methods shall be in accordance with Sec 1029.

1052.30.5.3 Tolerances.

1052.30.5.3.1 Panel and Post Systems. Shall be in accordance with approved shop drawings. Any variations from the approved shop drawings such as dimensions, materials, or finish must be approved by the wall manufacturer. Post dimensions for sound walls shall be within 1/4 inch in width and depth and within one inch along the length dimension.

1052.30.5.3.2 Panel Dimensions. Panel connection devices shall be within one inch of the specified dimension. The panel face and thickness dimensions shall be within 1/8 inch of the specified dimension. All other dimensions or items shall be within 1/4 inch of the specified dimensions.

1052.30.5.3.3 Panel Squareness. Squareness, as determined by the difference between the two diagonals, shall not exceed 1/2 inch.

1052.30.5.3.4 Panel Surface Finish. Surface defects on smooth formed surfaces measured over a length of 5 feet shall not exceed 1/8 inch. Surface defects on the textured finish surfaces, measured over a length of 5 feet, shall not exceed 3/8 inch.

1052.30.5.4 Other Criteria. Concrete facing panels, coping and precast posts will not be accepted if any of the following defects in physical characteristics are found: imperfect molding, honeycombing or open texture concrete, cracked or severely chipped panels and precast posts, soil reinforcement attachment devices improperly installed/damaged, lifting inserts not usable, exposed reinforcing steel, and color variation on the front face of the panel due to excess form oil or other reasons.

1052.30.6 Marking. The date of manufacture, production lot number and piece mark shall be clearly scribed on an unexposed face of each panel.

1052.30.7 MoDOT Identification Number. When the manufacturer contacts the engineer one business day, or earlier, in advance of shipping precast products the engineer will assign a specific MoDOT identification number for each size and type of product in the shipment.

1052.30.7.1 Prior to delivery to the jobsite, the source, intermediate agent, shipper or contractor's representative shall notify the inspecting District by fax or electronically a minimum of one business day, or earlier, prior to the impending shipment of precast material. This notification shall include a shipping form (Precast Shipping Form) and will include, at minimum, the following:

a) The specific contract number.

b) Receiving Purchaser/Contractor.

c) Line number for which the material will be used.

d) Type and quantity of material.

e) Date of expected delivery to the jobsite.

f) Manufacturer's name.

g) Stationing or structure number on precast unit, if applicable.

h) Panel type, quantity and wall number for MSE panels.

1052.30.7.2 Upon approval, the precaster will receive an identification number. The precast unit shall be clearly and permanently marked by the precaster with the ID number as required by appropriate 1000 specification prior to shipment. Requests for alternate precast labeling shall be submitted to the inspecting District for approval. Material without proper identification number(s) will not be permitted for use on a project.

1052.30.8 Handling, Storage and Shipping. All panels shall be free of chips, discoloration, cracks, fractures, and any other defects determined to be detrimental to the cosmetic value or to the performance characteristics of the panels. The panels shall not be subjected to excessive bending stresses and the panel connection devices and exposed exterior finish shall be protected from damage.

1052.30.9 Documentation. Copies of test results for all required tests, and any other supporting documentation shall be in accordance with Sec 1001.14.

1052.30.10 Delivery. A bill of lading or delivery receipt shall be furnished to the engineer at the destination point. The bill of lading shall contain an itemized statement of the sizes and lengths of precast units with the corresponding MoDOT identification number provided to the manufacturer for each size and type of precast unit for that shipment. The bill of lading shall contain a certified statement. The certified statement shall be signed by an authorized representative of the manufacturer and shall state the following:

"This certifies that the precast products in this shipment are in accordance with MoDOT specifications."

SECTION 1052.40 SMALL BLOCK WALL SYSTEMS - CONCRETE BLOCKS.

1052.40.1 Scope. This specification covers the concrete blocks used as part of small block mechanically stabilized earth wall systems. Wet cast blocks shall be produced in accordance with Sec 1052.30. Dry cast

blocks shall be produced at stated below.

1052.40.2 Acceptance. Acceptance will be based upon manufacture test results compliant with the following requirements.

1052.40.2.1 Freeze Thaw Testing. The concrete blocks shall be tested for freeze-thaw durability in accordance with ASTM C1262. Freeze-thaw durability shall be based on tests from five specimens made with the same material, concrete mix design, manufacturing process and curing method conducted not more than 18 months prior to delivery. Test results will be required for each project.

1052.40.2.2 Units that are not exposed to deicing salts shall be in accordance with the following testing requirements. When tested in water, the weight loss of each of five test specimens at the conclusion of 100 cycles shall not exceed 1.0 percent of its initial weight; or the weight loss of each of four of the five test specimens at the conclusion of 150 cycles shall not exceed 1.5 percent of its initial weight.

1052.40.2.3 Test results for units that are exposed to deicing salts shall be tested in a 3 percent saline solution and shall be in accordance with the following:

a) When tested in 3 percent saline solution the weight loss of each of five test specimens at the conclusion of 40 cycles shall not exceed 1.0 percent of the initial weight; or the weight loss of each of four of the five test specimens at the conclusion of 50 cycles shall not exceed 1.5 percent of its initial weight.

1052.40.2.4 Compressive Strength. Acceptance of the compressive strength of the concrete blocks will be based on production lots in compliance with ASTM C140. Acceptance of the compressive strength of a production lot will occur if the compressive strength test results is equal to or greater than the design strength at 28 days. The engineer of record shall evaluate and approve acceptance of deviations below design strength.

1052.40.2.5 Absorption. The manufacturer shall sample and test units based on production lots for absorption in accordance with ASTM C140.

1052.40.2.6 Dimensional Tolerances. Concrete blocks shall be manufactured within the following tolerances:

a) The length and width of each concrete block shall be within 1/8 inch of the specified dimension.

b) The height of each concrete block shall be within 1/16 inch of the specified dimension.

c) When a broken face finish is used, the dimension of the front face shall be within one inch of the theoretical dimension of the concrete block.

1052.40.2.7 Other Criteria. All concrete blocks shall be sound and free of cracks or other defects that would interfere with the proper placement of the blocks or significantly impair the strength or permanence of the construction. At the time of the delivery to the work site the concrete blocks shall:

a) A maximum water absorption of 5 percent.

b) Minor cracks incidental to the usual method of manufacture or minor chipping resulting from shipment and delivery will not be grounds for rejection. Minor cracks will be defined as cracks that are no wider than 1/64 inch and no longer than 25 percent of the block height.

c) Any exposed face of a concrete block shall be free of chips, cracks or other imperfections when viewed from a distance of 30 feet under diffused lighting. Up to 5 percent of a shipment may contain slight cracks or small chips no larger than one inch.

1052.40.2.8 Concrete blocks shall not be accepted if any of the requirements specified above or the following defects in physical characteristics are found:

a) Defects indicating imperfect molding.

b) Defects indicating honeycomb or open texture concrete.

c) Cracked or severely chipped blocks.

d) Color variation on front face of blocks.

1052.40.3 Material.

1052.40.3.1 Concrete. Concrete material, proportioning, air entraining, mixing, slump and transporting of concrete shall be in accordance with Sec 501, except as noted in this section. Coloring pigments, integral water repellants, finely ground silica and other constituents shall be previously directed as suitable for use and shall be in accordance with applicable ASTM standards, or evidence shall be provided to prove the product is not detrimental to the durability of the concrete blocks or any material customarily used in masonry construction.

1052.40.3.2 Aggregate. Fine and coarse aggregate for the concrete mixture shall be in accordance with Sec 1005, except that the requirements for gradation and percent passing the No. 200 sieve will not apply.

1052.40.4 Design. The concrete mixture shall have a minimum compressive strength of 4,000 psi at 28 days. The design including all contents of the mixture and curing method shall be submitted to the engineer for approval prior to use.

1052.40.5 Manufacturing.

1052.40.5.1 Finish Color. Color and finish shall be as shown on the plans. If no color or finish is specified on the plans, the contractor shall provide a color and finish to the engineer for approval.

1052.40.6 Certification. The manufacturer of the concrete blocks shall certify that the concrete blocks are in accordance with this specification. This certification, copies of test results for all required tests, and any other supporting documentation shall be provided to the engineer prior to the material being shipped to the construction site.

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SECTION 1053
CONCRETE SEALER AND CONCRETE CRACK FILLER

SECTION 1053.10 PENETRATING CONCRETE SEALER

1053.10.1 Scope. This specification covers concrete sealers for the protection of concrete against damage from de-icing chemicals.

1053.10.2 Acceptance. All material under this specification shall be obtained from a source identified on the PAL designated for this specification. All material under this specification will be inspected and accepted in accordance with Sec 106. ASTM and AASHTO specifications, when referenced, control only the physical and chemical properties of the material.

1053.10.3 The sealer shall be a alkyltrialkoxysilane, with low oligomer and polymer compound content. The chemical composition shall meet the following requirements:

Property	Specification
Purity	95% minimum monomer by weight
Solvent	Less than 5% by weight
Residue	Less than 2% by weight
Density	Per the manufacturer's recommendation
Flash Point	ASTM D93: greater than 125 degrees F
Dry Time	ASTM D1640 Sec 7.5.1: One hour or less

1053.10.3.1 The ASTM D1640 test shall be performed on a concrete surface. This concrete shall be a mix design called for in Sec 1053.10.3.2. The application rate shall be the same rate specified in Sec 703.

1053.10.3.2 The sealer shall meet the following performance criteria based on a single application at the application rate specified in Sec 703. MoDOT reserves the right to verify any qualification tests at their expense on any field application. Test specimens shall be produced using either the MoDOT Class B-2 concrete in accordance with Sec 501 or the concrete mix specified by the test being performed.

Test	Test Method	Duration	Max Absorption / Cl^-
Water Immersion	ASTM C642	48 hours	0.5 percent by weight (mass)
Water Immersion	ASTM C642	50 days	1.5 percent by weight (mass)
Salt Water Ponding (based on non-abraded specimen)	AASHTO T259	90 days	80% min reduction in Cl^- absorption & 0.50 lbs/cu yd Cl^- at a depth of 1/2" - 1" max

1053.10.3.3 The sealer shall not permanently stain, discolor or darken the concrete. Application of the sealer shall not alter the surface texture or form a coating on the concrete surfaces.

1053.10.3.4 The sealer shall not leave residue on glass, painted metal or automobiles.

1053.10.3.5 The sealer shall not reduce the bond of pavement markings or reduce the skid resistance of the surface being sealed. Any sealer determined to have these adverse effects will be removed from the pre-qualified list.

1053.10.3.6 The sealer shall be delivered to the project in unopened containers with the manufacturer's label identifying the product and with the seal(s) intact. Each container shall be clearly marked by the manufacturer with the following information:

(a) Manufacturer's name and address.

(b) Product name.

(c) Date of manufacture and expiration date.

(d) Lot identification.

(e) Storage requirements.

1053.10.4 Manufacturer and Brand Name Approval. Prior to approval and use of concrete sealers, the manufacturer shall submit to Construction and Materials a certified test report from an approved testing laboratory showing specific test results conforming to the requirements of these specifications. The certified test report shall also contain the manufacturer's name, product brand name, lot number and date of manufacture. Upon approval of the certified test report by the engineer the manufacturer and brand name will be added to the PAL designated for this specification. New certified test results shall be submitted any time the manufacturing process or the sealer formulation is changed, and may be required by the engineer when sampling and testing of material offered for use indicates nonconformance to any of the requirements herein specified.

SECTION 1053.20 CONCRETE CRACK FILLER

1053.20.1 Scope. This specification covers concrete crack fillers for the protection of concrete against damage from de-icing chemicals.

1053.20.2 Acceptance. All material shall be obtained from a source identified on the PAL designated for this specification, except as otherwise listed below. All materials under this specification will be inspected and accepted in accordance with Sec 106.

1053.20.3 The concrete crack filler shall be a low viscosity polymer. The chemical composition shall meet the following requirements:

Property	Test Method	Specification
Viscosity	AASHTO D-2393	Less than or equal to 25 cps
Gel Time	AASHTO T-237	Less than or equal to 20 minutes @ 70 deg F
Tensile Strength	ASTM D638	Greater than or equal to 1500 psi
Elongation	ASTM D638	Greater than or equal to 5%
Solids Content		Greater than or equal to 95%
Flash Point	ASTM D1310	Greater than or equal to 50 deg F
Cure Rate	AASHTO T-237	Less than or equal to 3 hrs@ 70 deg F

1053.20.4 The concrete crack filler shall meet the procedures and the application rates as specified in Sec 704. MoDOT reserves the right to verify any qualification tests at their expense on any field application.

1053.20.5 Manufacturer and Brand Name Approval. Prior to approval and use of concrete crack fillers, the manufacturer shall submit to Construction and Materials a certified test report from an approved testing laboratory showing specific test results conforming to the requirements of these specifications. The certified test report shall also contain the manufacturer's name, product brand name, lot number and date of manufacture. Upon approval of the certified test report by the engineer the manufacturer and brand name will be added to the PAL designated for this specification. New certified test results shall be submitted any time the manufacturing process or the crack filler formulation is changed, and may be required by the engineer when sampling and testing of material offered for use indicates nonconformance to any of the requirements herein specified.

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SECTION 1054
CONCRETE ADMIXTURES

1054.1 Scope. This specification covers air-entraining admixtures, water-reducing admixtures, retarding admixtures, accelerating admixtures and latex emulsion admixtures for concrete.

1054.2 Acceptance. All material under this specification shall be obtained from a source identified on the PAL designated for this specification. All material under this specification will be inspected and accepted in accordance with Sec 106.

1054.3 Air-Entraining Admixtures. Air-entraining admixtures shall be in accordance with AASHTO M 154, except as modified herein.

1054.3.1 Certification. The manufacturer shall submit a certification to Construction and Materials prior to approval. The certification shall provide the following:

(a) The brand name and designation.

(b) The composition or description of the admixture.

(c) The manufacturing ranges for percent total solids and pH by AASHTO T 200.

(d) The infrared spectrum.

(e) The manner in which the material will be identified on containers.

(f) The material is in accordance with these specifications.

1054.3.1.1 Certifications shall include or have attached specific test results as required in Sec 1054.3.1.2 or Sec 1054.3.1.3.

1054.3.1.2 For an air-entraining admixture other than that specified in Sec 1054.3.1.3, the certification shall include results of tests conforming to the requirements of AASHTO M 154. Tests for bleeding, bond strength and volume change will not be required.

1054.3.1.3 For an air-entraining admixture that is an aqueous solution of vinsol resin manufactured by neutralizing the resin with sodium hydroxide, the certification shall include results of tests showing the ratio of sodium hydroxide to vinsol resin. The certification or test report shall also state that no other additive or chemical agent is present in the solution.

1054.3.2 Packaging and Marking. The containers in which air-entraining admixtures are delivered shall be plainly marked with the manufacturer's name, the brand name and designation of the material, lot number and net quantity. A delivery ticket showing this information shall accompany bulk shipments. If the manufacturer supplies air-entraining admixtures in more than one concentration, the concentration shall be designated on the container, or for bulk shipments, in a prominent manner on the delivery ticket.

1054.4 Water-Reducing Admixtures. Water-reducing admixtures shall be in accordance with AASHTO M 194, Type A, except as modified herein. High range water-reducing admixtures, when permitted for use, shall be in accordance with AASHTO M 194, Type F or Type G.

1054.4.1 Certification. The manufacturer shall submit certification to Construction and Materials prior to approval.

1054.4.1.1 The certification shall provide the following:

(a) The brand name and designation.

(b) The composition or description of the admixture.

(c) The manufacturing ranges for specific gravity at 77 F and percent total solids.

(d) The infrared spectrum.

(e) The manner in which the material will be identified on containers.

(f) The material is in accordance with these specifications.

1054.4.1.2 The certification shall include or have attached specific test results in accordance with AASHTO M 194, Type A, F or G, as applicable, and the recommendation for use, including amounts to be added.

1054.4.2 Packaging and Marking. The containers in which water-reducing admixtures are delivered shall be plainly marked with the manufacturer's name, the brand name and designation of the material, lot number and net quantity. A delivery ticket showing this information shall accompany bulk shipments.

1054.5 Retarding Admixtures. Retarding admixtures shall be in accordance with AASHTO M 194, Type B or D, except as modified herein.

1054.5.1 Certification. The manufacturer shall submit certification to Construction and Materials prior to approval.

1054.5.1.1 The certification shall provide the following:

(a) The brand name and designation.

(b) The composition or description of the admixture.

(c) The manufacturing ranges for specific gravity at 77 F and percent total solids.

(d) The infrared spectrum.

(e) The manner in which the material will be identified on containers.

(f) The material is in accordance with these specifications.

1054.5.1.2 The certification shall include or have attached specific test results in accordance with AASHTO M 194, Type B or D, and the recommendation for use, including amounts to be added.

1054.5.2 Packaging and Marking. The containers in which retarding admixtures are delivered shall be plainly marked with the manufacturer's name, the brand name and designation of the material, lot number and net quantity. A delivery ticket showing this information shall accompany bulk shipments.

1054.6 Accelerating Admixtures. Accelerating admixtures shall be in accordance with AASHTO M 194, Type C or E, except as modified herein.

1054.6.1 Certification. The manufacturer shall submit certification to Construction and Materials prior to approval.

1054.6.1.1 The certification shall provide the following:

(a) The brand name and designation.

(b) The composition or description of the admixture.

(c) The manufacturing ranges for specific gravity at 77 F and percent total solids.

(d) The infrared spectrum.

(e) The manner in which the material will be identified on containers.

(f) The material is in accordance with these specifications.

1054.6.1.2 The certification shall include or have attached specific test results in accordance with AASHTO M 194, Type C or E, and the recommendation for use, including amounts to be added.

1054.6.2 Packaging and Marking. The containers in which accelerating admixtures are delivered shall be plainly marked with the manufacturer's name, the brand name and designation of the material, lot number and net quantity. A delivery ticket showing this information shall accompany bulk shipments.

1054.7 Latex Emulsion Admixtures. Latex emulsion admixtures shall be non-toxic, film-forming, polymeric emulsion in water to which all stabilizers have been added at the point of manufacture. The admixture shall be a styrene-butadiene latex emulsion in which at least
90 percent of the non-volatiles are styrene-butadiene polymers.

1054.7.1. Properties. The admixture shall be homogeneous, uniform in composition and shall be in accordance with the following requirements when tested with the procedures shown in Report No. FHWA RD 78 35, April 1978, Styrene-Butadiene Latex Modifiers for Bridge Deck Overlay Concrete:

Property	Requirement
Color	White
Polymer Type	Styrene-Butadiene
Percent Solids	46 - 53
pH	5.0 - 12.0, the pH may not vary more than ± 1 from the pH of matl. submitted for prequalification.
Particle Size	1400 to 2500 Angstroms, the mean particle size shall not vary more than ± 300 Angstroms from the mean diameter of material submitted for prequalification.
Viscosity	± 20 centipoises of the viscosity of material submitted for prequalification.
Percent Coagulum	0.10 percent by weight, max.
Freeze-Thaw Stability	0.10 percent by weight max. coagulum after 2 freeze-thaw cycles.
Surface Tension	50.0 dynes/cm, max.
Percent Butadiene	30 to 40 by weight

1054.7.2 Certification. The manufacturer shall submit certification to Construction and Materials prior to approval.

1054.7.2.1 The certification shall provide the following:

(a) The brand name and designation.

(b) The composition or description of the admixture.

(c) The manufacturing ranges for specific gravity at 77 F by AASHTO T 157, percent total solids by ASTM D 1644, Method A and pH by AASHTO T 200.

(d) The infrared spectrum.

(e) The manner in which the material will be identified on containers.

(f) The material is in accordance with these specifications.

1054.7.2.2 The certification shall include or have attached specific test results in accordance with this specification.

1054.7.3 Packaging and Marking. The containers in which latex emulsion admixtures are delivered shall be plainly marked with the manufacturer's name, the brand name and designation of the material, lot number and net quantity. A delivery ticket showing this information shall accompany bulk shipments.

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SECTION 1055
CONCRETE CURING MATERIAL

1055.1 Scope. This specification covers material to be used for the purpose of curing concrete.

1055.2 Liquid Membrane-Forming Curing Compounds.

1055.2.1 Acceptance. All material under this specification shall be obtained from a source identified on the PAL designated for this specification. If the manufacturer is different from the source supplying the material, the manufacturer shall also be listed. All material under this specification will be inspected and accepted in accordance with Sec 106.

1055.2.2 Material.

1055.2.2.1 General. Water retention properties for all curing compounds shall be determined by ASTM Test Method C 156. The vehicle class of all curing compounds shall be Class A.

1055.2.2.2 Type 1-D Curing Compounds. Type 1-D liquid membrane-forming curing compounds shall be in accordance with ASTM C 309 for Type 1-D, clear or translucent with fugitive dye.

1055.2.2.3 Type 2 Curing Compounds. Type 2, liquid membrane-forming curing compounds shall be in accordance with ASTM C 309 for Type 2, white pigmented.

1055.2.2.4 Bridge Curing Compounds. Bridge curing compounds shall be liquid membrane-curing compounds in accordance with ASTM C 309 for Type 1-D or Type 2 and shall be designated to be dissipating. All bridge curing compounds shall be manufactured such that the curing compounds may be removed prior to dissipation.

1055.2.3 Documentation.

1055.2.3.1 Certification For Qualification. Prior to use and in addition to the required PAL documentation, the manufacturer shall submit certification to Construction and Materials, setting forth the brand name and designation, the composition or description of the curing material, the manner in which the material will be identified on the containers, and shall list typical values of current tests for consistency, drying time, reflectance and moisture retention.

1055.2.3.2 Additional Certification. Certification for bridge curing compounds shall include a statement that the product is manufactured to dissipate. The certification shall specify the method by which removal of the compound prior to dissipation or removal of residual material from the surface can be accomplished.

1055.2.3.3 Shipment Documentation. For each shipment of material, the source shall maintain the manufacturer's certification and test results showing that the product is in accordance with this specification. The manufacturer's certification and test results shall be made available upon request.

1055.3 Other Concrete Curing Material.

1055.3.1 Acceptance. All material under this specification shall be obtained from a source identified on the PAL designated for this specification. All material under this specification will be inspected and accepted in accordance with Sec 106.

1055.3.2 Material.

1055.3.2.1 Waterproof Paper. Waterproof paper shall be in accordance with ASTM C 171.

1055.3.2.2 Polyethylene Sheeting. Polyethylene sheeting shall be in accordance with Sec 1058 for curing Portland cement concrete.

1055.3.2.3 White Burlap-Polyethylene Sheeting. White burlap-polyethylene sheeting shall be in accordance with ASTM C 171.

1055.3.2.4 Burlap and Mats of Jute or Cotton. Burlap shall be fabric made from jute or other suitable fibers. Jute mats shall consist of two plies of burlap stitched together to maintain the shape and stability of the unit. Cotton mats shall consist of filler or cotton batts covered with unsized cloth or burlap, and tufted or stitched to maintain the shape and stability of the unit. Burlap, mats or other synthetic material equivalents shall, in the judgment of the engineer, be of such construction and in such a condition as required to adequately maintain free moisture on the surface of the concrete with the type of system being used to provide the water. Material shall be free from deleterious matter harmful to concrete.

1055.3.3 Documentation. The distributor shall maintain certification that the material supplied is in accordance with these specifications. The certification shall be made available upon request.

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SECTION 1056
CONCRETE TINTING AND STAINING MATERIAL

SECTION 1056.10 CONCRETE TINTING MATERIAL

1056.10.1 Description. This work item shall consist of providing a concrete tinting material to aesthetically color concrete as shown on the plans.

1056.10.2 Material Requirements. This material shall consist of a homogeneous mixture mineral oxide pigment of an approved tint with such other additives as deemed necessary by the manufacturer. The tinting material shall conform to the specification outlined on ASTM C979. The material shall be free from oil, grease, dirt and nonferrous particles. The tinting material shall not contain any material that might promote oxidation of the iron particles if exposed to air and moisture, or that might have any detrimental effect on concrete. The contractor shall supply the engineer with a maufacturer's certification indicating that the material supplied is in accordance with this specification.

1056.10.3 Construction Requirements. The contractor shall incorporate the tinting material into the concrete through mixing with the aggregate, cementitious material and water in accordance with the manufacturer's recommendation. The dry shake method; whereby the tinting material powder, combined with dry cement and sand, is sprinkled onto the concrete and worked into the surface through finishing; shall not be allowed.

SECTION 1056.20 CONCRETE STAINING MATERIAL

1056.20.1 Description. This work item shall consist of providing a field concrete stain to aesthetically color concrete exteriors as shown on the plans.

1056.20.2 Material Requirements. The material shall be two-coat, pigmented acrylic resin system which penetrates into the concrete surface to provide water repellency, semi-opaque aesthetic color and salt resistance and shall form a breathable film allowing trapped moisture vapor to safely migrate through the coating without blistering or peeling. The contractor shall supply the engineer with a manufacturer's certification indicating that the material supplied is in accordance with this specification.

1056.20.3 Construction Requirements. The concrete surface shall be fully cured a minimum of 28 days prior to application of the aesthetic concrete stain. The absence of moisture in the concrete surface shall be verified with standard test ASTM D4263. Pressure washing with a minimum of 3,000 psi shall be used to remove all foreign matter, form oils, waxes, curing compounds, laitance, efflorescence and dirt. Sand blasting will not be permitted for cleaning. The cleaned surface shall be free of blemishes, discolorations, surface voids and conspicuous form marks to the satisfaction of the engineer. The concrete stain shall be adequately mixed within its container until homogenous in color. Application of the stain shall be in accordance with the manufacturer's recommendations including allowable ambient conditions. Application of the stain will not be allowed during rain. All manufacturers’ safety precautions shall be submitted to the engineer prior to work and followed during staining.

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SECTION 1057
MATERIAL FOR JOINTS

1057.1 Scope. This specification covers joint material to be used as specified or as shown on the plans.

1057.2 Acceptance. All material under this specification shall be obtained from a source identified on the PAL designated for this specification.

1057.3 Dowel Bars. Dowels for transverse joints shall be in accordance with the requirements for plain rounds of AASHTO M 31. The dowels shall be epoxy coated in accordance with Sec 1036, except the coating thickness shall be a 5-mil minimum, the flexibility of coating requirement will not apply and the cut ends will not be required to be coated. The dowels shall be free of cutting burrs and other projections. Dowel supporting units shall be in accordance with one of the types shown on the plans.

1057.3.1 Alternative Dowel bars manufactured with steel in accordance with ASTM A 1035 may be used in lieu of AASHTO M 31. Alloy Types CM and CS shall be used. The dowel bars manufactured with this type steel will not be required to be epoxy coated. Grades 100 and 120 may be used.

1057.3.2 Graphite Grease. The free end of the dowel bar shall be coated with an approved graphite grease for a length of 11 inches. Graphite grease shall contain a minimum of 25 percent graphite, and the graphite content shall be certified by the manufacturer or shown on the container label. Graphite grease shall be applied with a thin, uniform coating that will result in a thorough covering of the free end of the bar.

1057.3.3 Pre-Dipped Bondbreaker. In lieu of the graphite grease application, the dowel bar basket supplier may supply completed basket units pre-dipped in an approved bondbreaker solution. The bondbreaker solution shall not be applied in a spray or field application. The resulting dry dowel bar coating shall be visually evident. The coating shall be uniformly applied without excessive drips or thickness. Dirty or excessively scraped dowel bar units will be rejected. Rejected units may be used if the units are fully cleaned of all dirt and bondbreaker coating and graphite grease is applied according to these specifications. The dowel basket supplier shall provide a certification for the coating with each shipment, certifying the bondbreaker product name, manufacturer and date of coating application.

1057.4 Tie Bars. Tie bars for longitudinal joints and construction joints shall be round, deformed and in accordance with AASHTO M 31, except for tie bars that are to be bent and straightened shall be in accordance with AASHTO M 31, Grade 40. Tie bars shall not be bent and straightened more than one time. Tie bars shall be epoxy coated in accordance with Sec 1036, except the coating thickness shall be a 5-mil minimum, the flexibility of coating requirement will not apply and the cut ends will not be required to be coated.

1057.4.1 Alternative. Tie bars manufactured with steel in accordance with ASTM A 1035 may be used in lieu of AASHTO M 31. Alloy Types CM and CS shall be used. The tie bars manufactured with this type of steel will not be required to be epoxy coated. Grades 100 and 120 may be used for straight bars. For tie bars that are to be bent and straightened, ASTM A 1035 steel shall not be used.

1057.5 Concrete and Asphalt Joint Sealer, Hot-Poured Elastic Type. The sealer material shall be in accordance with ASTM D 6690, Type II. The joint sealer material shall be packed and shipped in suitable commercial containers clearly marked with the name of the material, the name of the manufacturer, brand name, weight, batch number, pouring temperature recommended by the manufacturer and maximum safe heating temperature.

1057.6 Pavement Joint Forming Material.

1057.6.1 Preformed Fiber Expansion Joint Filler. Preformed fiber expansion joint filler material shall be in accordance with AASHTO M 213. Percent asphalt content shall be tested in accordance with AASHTO T 42 or 164 with the following modifications: Oven dry test strips at 104 ± 3 C for one hour. Cool and weigh approximately 50 g into an extraction bowl. Cover test portion in the bowl with a chlorinated solvent, such as trichloroethylene, and allow sufficient time for solvent to soak the test portion. Follow test procedure outlined in AASHTO T 164 section 12.3 and 12.4, except discard extract and washings. Carefully transfer extracted test strips and scrap residue from the filter ring into a tared weighing pan. Oven dry at 104 ± 3 C for one (1) hour and cool in a desiccators. Calculate the percent asphalt content by weight on an oven dry basis per ASTM D 545 subsection 7.5.4. In cases of dispute, AASHTO T 42 test results will control.

1057.6.2 Semi-rigid, Closed-cell Polypropylene Foam, Preformed Expansion Joint Filler. This material shall be semi-rigid, closed-cell polypropylene foam, preformed expansion joint filler in accordance with ASTM D8139.

1057.7 Joints for Concrete Structures.

1057.7.1 Plastic Waterstop. The plastic waterstop shall consist of a basic resin of polyvinyl chloride (PVC) with additional resins, plasticizers and stabilizers as necessary to produce a durable material with a high fatigue point, resistant to acid and alkali solutions, showing little deterioration under accelerated aging tests and shall meet the approval of the engineer. The plastic waterstop shall have a tensile strength of no less than 1,800 psi and an ultimate elongation of no less than 200 percent. The waterstop shall be a continuous strip, ribbed on both sides, and with a hollow bulb center, a "U" shaped reinforced center-pleat section, or other approved type of center section.

1057.7.2 Rubber Waterstop. The rubber water stop shall consist of a durable, elastic, cured rubber compound capable of effectively sealing joints in concrete against the infiltration of moisture.

1057.7.2.1 Physical Properties. The rubber waterstop shall be in accordance with the following requirements:

(a) Hardness - The Shore A durometer hardness shall be 60 - 70.

(b) Elongation - The elongation shall be no less than 450 percent.

(c) Tensile Strength - The tensile strength shall be no less than 3,000 psi.

(d) Water Absorption - The water absorption shall be a maximum of five percent by weight (mass) after immersion in water for two days at 158 F.

(e) Tensile Strength After Aging - The tensile strength of the test specimen, after accelerated aging test of seven days at 158 F, shall be no less than 80 percent of the tensile strength prior to the aging test. The tensile strength of the test specimen, after accelerated aging test of 48 hours in oxygen at 158 F and 300 psi, shall be no less than 80 percent of the tensile strength prior to the test.

(f) Compression Set - The compression set after 22 hours at 158 F shall be no more than 30 percent.

1057.7.2.2 Visual Inspection. The waterstop shall be manufactured in such a manner that the finished product will have an integral cross section that will be dense, homogeneous, and free from porosity and other imperfections. Minor surface defects, such as surface peel covering less than one square inch, and surface cavities or bumps less than 1/4 inch in the longest lateral dimension and less than 1/16 inch deep, will be permitted.

1057.7.3 Copper Sheeting for Flashing. Copper sheeting shall be of soft grade containing no less than 99.7 percent copper and shall be capable of being bent cold through an angle of 180 degrees flat upon itself without evidence of cracking. Test specimens shall have an elongation in 2 inches of at least 20 percent. The weight per square foot of the sheeting to be used will be shown on the plans. Tolerances in thickness shall be in accordance with ASTM B 248.

1057.7.4 Preformed Sponge Rubber Expansion and Partition Joint Filler. This material shall be in accordance with AASHTO M 153, Type I, Sponge Rubber.

1057.8 Plastic Joint Compound for Vitrified Clay and Concrete Pipe. Plastic joint compound shall be a homogeneous blend of bituminous or butyl rubber material, inert filler and suitable solvents or plasticizing compounds thoroughly mixed at the factory to a uniform consistency suitable for sealing joints of vitrified clay and concrete pipe. The physical requirements of the compound shall be in accordance with ASTM C 990. Trowel grade material shall conform to the following requirement:

Bitumen, soluble in soluble chlorinated solvent, such as Trichloroethylene, percent by weight, min	45
Ash, percent by weight	15-50

Penetration, standard cone, 150 g, 5 sec, 25 C - uses 12 ounce can, d mm	110-275

Primer, as recommended by the manufacturer, shall be used with extruded rope or flat tape types, if required to maintain the material in position while pipe sections are being joined.

1057.9 Tubular Joint Seal. Tubular joint seal shall be manufactured from extruded closed-cellular rubber, the base polymer being a blend of nitrile and vinyl meeting the physical requirements of ASTM D 1056, Type 2, Class C, Grade 1, and the chemical resistance requirements of ASTM C990. The seal shall be a single continuous part conforming to the joint shape. The outer surface shall be completely covered with a natural skin. The cross-sectional diameter and installation shall be in accordance with the manufacturer's recommendations for the size of pipe being placed.

1057.10 Silicone Expansion Joint Sealant. The sealant for expansion joints shall be in accordance with Sec 717.30. The silicone joint sealant shall be a rapid cure, self-leveling, cold applied, single or two-component silicone sealant. The sealant shall demonstrate resilience, flexibility and resistance to moisture and puncture upon curing. The sealant shall demonstrate excellent adhesion to Portland cement concrete, polymer concrete and steel over a range of temperatures from –30 to 130 F, while maintaining a watertight seal. The sealant shall not contain any solvents or diluents that cause shrinkage or expansion during curing. Acid-cure sealants shall not be used. The date of manufacture or "use by" date shall be provided with each lot of sealant or primer. Material 12 months old or older from the date of manufacture or past the "use by" date shall not be used. The engineer reserves the right to test representative samples from material proposed for use. If a backer rod is required, it shall be closed-cell material, as recommended by the sealant manufacturer. The manufacturer shall certify that the sealant meets or exceeds the following test requirements before installation begins:

Physical Properties:	Requirement
Each component as supplied:	
Specific Gravity (ASTM D 1475)	1.2 - 1.4
Extrusion Rate (ASTM C 1183)	200 - 550 g/minute
Durometer Hardness, Shore (ASTM D 2240) "00" (0 C and 25 C ± 1 C [77 ± 3 F])	30 - 60
Ozone and U.V. Resistance (ASTM C 793)	No chalking, cracking or bond loss after 5000 hrs.
After Mixing:	
Flow	Self-Leveling
Tack-Free Time (ASTM C 679)	60 minutes maximum
Upon Complete Cure: (ASTM D 5329[a])	
Joint Elongation (Adhesion to concrete/ steel/polymer concrete)	600% minimum
Joint Modulus (at 100% elongation)	3-12 psi

[a]Modified; Sample cured two days at 77 ± 2 F and 50 ± 5 percent relative humidity.

1057.11 Silicone Joint Sealant for Saw Cut and Formed Joints. The sealant for sawed and formed joint shall be in accordance with Sec 717.40. The silicone joint sealant shall be a cold applied, single component, chemically curing gray sealant with 100 percent elongation and 50 percent compressive joint movement capability. If a backer rod is required, it shall be closed-cell material, as recommended by the sealant manufacturer. The sealant shall be type NS (Non-Sag) and the physical properties shall be in accordance with ASTM D 5893 and the following:

Physical Properties	Requirement
Color	Gray
Tack free time	35 – 75 minutes
Cure time	7 days @ 75 F – 90 F and 45 – 55 % relative humidity

1057.12 Documentation. All material specified in this section shall include certification showing representative test results of the material and certify that the material supplied is in accordance with these specifications.

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SECTION 1058
POLYETHYLENE SHEETING

1058.1 Scope. This specification covers polyethylene sheeting for use in highway construction.

1058.2 Polyethylene Sheeting for Curing. Polyethylene sheeting for curing Portland cement concrete shall be white and shall be in accordance with ASTM C 171.

1058.3 Polyethylene Sheeting as a Bond Breaker. Polyethylene sheeting for use as a bond breaker between a bridge approach slab and a granular base shall be in accordance with ASTM E 1745 Performance Class A.

1058.4 Certification and Acceptance. The contractor shall furnish a manufacturer's certification that the material supplied is in accordance with these requirements.

SECTION 1059
PROTECTIVE COATING MATERIAL

SECTION 1059.10 PROTECTIVE COATING–CONCRETE BENTS AND PIERS (URETHANE).

1059.10.1 Scope. This specification covers modified urethane or polyurethane elastomeric coating to be used as shown on the plans. This material will typically be applied under expansion devices for protection from deleterious agents in areas where aesthetics is not a high priority.

1059.10.2 General Requirements. The material shall be suitable for outdoor exposure and shall be resistant to deterioration by ultraviolet light. Additives for ultraviolet stabilization shall not be added after the original manufacturing process. The material shall be suitable for application to concrete surfaces. Surface preparation shall be in accordance with the manufacturer's recommendations. The material shall be suitable for application to obtain a thickness of 40 mils, dry film without runs or sags when applied to a vertical concrete surface. The material shall have a minimum shelf life, in unopened containers, of at least six months from the date of delivery.

1059.10.3 Cured Material. The cured material shall be in accordance with the following:

Protective Coating – Concrete Bents and Piers (Urethane)	
Property	**Requirement**
Shore A Hardness, ASTM D 2240 (Material shall be cured in 40 mil thick film for 7 days at 75 ± 2 F at 50% relative humidity. Test specimen shall be composed of plied pieces, to a minimum 1/4-inch thickness).	15, minimum
Tensile Strength, ASTM D 412 (Method and time of cure may be modified as recommended by the manufacturer).	45 psi, minimum
Elongation, ASTM D 412 (Method and time of cure may be modified as recommended by the manufacturer).	200 percent, minimum
Water Vapor Permeability, ASTM D 1653 or ASTM E 96, Method BW 40 mil film thickness.	0.8 perms, maximum

1059.10.4 Packaging. All two-component materials shall be prepackaged to exact mixing quantities.

1059.10.5 Manufacturer and Brand Name Qualification. Prior to approval and use, the manufacturer shall submit a representative one-gallon sample to Construction and Materials. Upon approval of the material, the brand name and manufacturer will be placed on a list of qualified Urethane Protective Coating Agents for Concrete Bents and Piers. The sample shall be identified by brand name, manufacturer's name and address, and shall be accompanied by the following:

(a) Manufacturer's complete material data showing typical test results for the properties specified, generic name of the major components of the material, mixing instructions, surface preparation and application instructions and intended use.

(b) Test results after 1000 hours of exposure in an accelerated weathering device, in accordance with ASTM D 822, Procedure B. The film thickness of test specimens shall be 40 mils and shall show no cracking, flaking or blistering after exposure. Slight discoloration will be permitted.

(c) In lieu of the accelerated weathering test results required in Sec 1059.10.5(b), the manufacturer may submit a use history showing satisfactory performance for three years in at least two exposed applications. Name, address and telephone number of the users shall be included in the use history.

1059.10.6 Acceptance. The contractor shall furnish a manufacturer's certification stating that the material supplied is in accordance with all requirements specified and that the material furnished is of the same composition as originally qualified. The engineer reserves the right to sample the material at destination if deemed necessary.

SECTION 1059.20 PROTECTIVE COATING – CONCRETE BENTS AND PIERS (EPOXY).

1059.20.1 Scope. This specification covers two-component modified polyamide converted epoxy to be used as shown on the plans. This material will typically be applied under expansion devices where aesthetics is a high

priority.

1059.20.2 Material. The material shall be suitable for application to obtain a minimum coating thickness of 6 mils, dry film without runs or sags when applied to a vertical concrete surface. Pot life and method and time of cure shall be in accordance with the manufacturer's recommendation. The material shall be suitable for outdoor exposure and shall be resistant to deterioration by ultraviolet light. Additives for ultraviolet stabilization shall not be added after the original manufacturing process. The material shall have a minimum shelf life, in unopened containers, of at least six months from the date of delivery.

1059.20.2.1 Color. The color shall be clear or concrete gray.

1059.20.2.2 Finish. The finish shall be high gloss.

1059.20.3 Packaging. Two-component material shall be prepackaged to exact mixing quantities.

1059.20.4 Manufacturer and Brand Name Qualification. Prior to approval and use, the manufacturer shall submit a representative one-gallon sample to Construction and Materials. Upon approval of the material, the brand name and manufacturer will be placed on a list of qualified Epoxy Protective Coating Agents for Concrete Bents and Piers. The sample shall be identified by brand name, manufacturer's name and address, and accompanied by the following information:

(a) Manufacturer's complete material data showing typical test results for the properties specified, generic name of the major components of the material, mixing instructions, surface preparation and application instructions and intended use.

(b) Test results after 1000 hours of exposure in an accelerated weathering device shall be provided. The tests shall be conducted in accordance with ASTM D 822 or ASTM G 154 using test cycle No. 2 defined in ASTM D 822, except that during the six hour period of darkness, the relative humidity of the air shall be 95 ± 4%. If ASTM G 154 QUV exposure testing is used, Type A lamps shall be used.

1059.20.4.1 For either test, specific operating conditions shall be summarized and provided with the test results. The film thickness on test specimens shall be 6 mils and shall show no cracking, flaking or blistering after exposure. Only slight discoloration will be permitted.

1059.20.4.2 In lieu of the accelerated weathering test results required in Sec 1059.20.4 (b), the manufacturer may submit a use history showing satisfactory performance for three years in at least two exposed applications. Name, address and telephone number of the users shall be included in the use history.

1059.20.5 Acceptance. The contractor shall furnish a manufacturer's certification stating that the material supplied is in accordance with all requirements specified and that the material furnished is of the same composition as originally qualified. The engineer reserves the right to sample the material at destination if deemed necessary.

SECTION 1059.30 CONCRETE AND MASONRY PROTECTION SYSTEM.

1059.30.1 Scope. This specification covers clear penetrating siloxane or silane based sealer for use as shown on the plans.

1059.30.2 Physical Properties. The sealer shall be breathable and non-yellowing and shall be in accordance with the following requirements:

Concrete and Masonry Protection System		
Specification Item[a]	**Sealer Type**	
	Vertical Application	**Horizontal Application**
Solids Content, percent by weight, min.	6.7	20
Reduction in Water Absorption, percent, min.	80	85
Reduction in Chloride Intrusion, percent, min.	82	85
Water Vapor Transmission, percent, min.	110	

[a]Tested in accordance with NCHRP 244 Series tests.

1059.30.3 Manufacturer and Brand Name Qualification. Prior to approval and use, the manufacturer shall submit a representative one-quart sample to Construction and Materials. The sample shall be identified as to brand name, designation as to horizontal or vertical application, manufacturer's name and address, and shall be accompanied by the manufacturer's data and application sheets, and test results in accordance with Sec 1059.30.2. The manufacturer shall submit certification that the material complies with all requirements of this specification. Upon approval of the material, the brand name and manufacturer will be placed on a list of qualified Concrete and Masonry Protection Systems.

1059.30.4 Field Approval. Prior to application of the sealer, including bulk purchase and delivery of products, the contractor shall prepare a minimum 12 x 12 inch application sample on each of the specified concrete or masonry products for the purpose of demonstrating the final effect, visual and physical/chemical, of the planned installation. The contractor shall proceed with work only after the engineer's acceptance of the test application for color and compatibility with the substrate.

1059.30.5 Acceptance. The contractor shall furnish a manufacturer's certification stating that the material supplied is in accordance with all requirements specified and that the material furnished is of the same composition as originally approved. The engineer reserves the right to sample the material at destination if deemed necessary.

SECTION 1059.40 SACRIFICIAL GRAFFITI PROTECTION SYSTEM.

1059.40.1 Scope. This specification covers a sacrificial graffiti protection system for application to all surfaces as shown on the plans.

1059.40.2 Physical Properties. The sacrificial graffiti protection system shall be in accordance with the following physical properties and shall be chemically compatible with any other coatings to be used. The material shall be suitable for application to obtain a wet-film thickness of 4 to 6 mils without runs or sags when applied to a vertical surface.

Sacrificial Graffiti Protection System	
Item	**Requirement**
Melting Point, F, ASTM F 766	165 ±5
Solids Content, min., percent by weight, ASTM D 2834	26
Volatile Organic Content (VOC), lb/gal, max, ASTM D 3960	0.58

1059.40.3 Manufacturer and Brand Name Qualification. Prior to approval and use, the manufacturer shall submit a representative one-gallon sample to Construction and Materials. The manufacturer shall submit documentation to Construction and Materials stating brand name, manufacturer's name and address and accompanied by the manufacturer's data and application sheets. The manufacturer shall submit certification, including specific test results, that the material complies with all requirements of this specification. Upon approval of the material, the brand name and manufacturer will be placed on a list of qualified Sacrificial Graffiti Protection Systems.

1059.40.4 Field Approval. Prior to application of the sacrificial graffiti protection system, including bulk purchase and delivery of products, the contractor shall prepare a minimum 12 x 12 inch application sample on each of the specified concrete or masonry products for the purpose of demonstrating the compatibility of the planned installation. If the sacrificial graffiti protection system is to be applied over previous coatings, the test specimen shall have already received these previous coatings. The contractor shall proceed with work only after the engineer's acceptance of the test application for appearance and compatibility.

1059.40.5 Acceptance. The contractor shall furnish a manufacturer's certification stating that the material supplied is in accordance with all requirements specified and that the material furnished is of the same composition as originally approved. The engineer reserves the right to sample the material at destination if deemed necessary.

SECTION 1059.50 TEMPORARY COATING – CONCRETE BENTS AND PIERS (WEATHERING STEEL).

1059.50.1 Scope. This specification covers a system for protection against absorptive staining from unpainted, corrosion-resistant steel during initial weathering as shown on plans.

1059.50.2 Physical Properties. The temporary coating shall be in accordance with the following physical properties and shall be compatible with any other coatings to be used. The material shall be suitable for application to obtain a wet-film thickness of 4 to 6 mils without runs or sags when applied to a vertical surface.

Temporary Coating – Concrete Bents and Piers (Weathering Steel)	
Item	**Requirement**
Melting Point, F , ASTM F 766	165 ±5
Solids Content, min., percent by weight, ASTM D 2834	26
Volatile Organic Content (VOC), lb/gal, max, ASTM D 3960	0.58

1059.50.3 Manufacturer and Brand Name Qualification. Prior to approval and use, the manufacturer shall submit a representative one-gallon sample to Construction and Materials. The manufacturer shall submit documentation to Construction and Materials stating brand name, manufacturer's name and address, and accompanied by the manufacturer's data and application sheets. The manufacturer shall submit certification, including specific test results, that the material complies with all requirements of this specification. Upon approval of the material, the brand name and manufacturer will be placed on a list of qualified Rust Staining Protection Systems.

1059.50.4 Acceptance. The contractor shall furnish a manufacturer's certification stating that the material supplied is in accordance with all requirements specified and that the material furnished is of the same composition as originally approved. The engineer reserves the right to sample the material at destination if deemed necessary.

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SECTION 1060
ELECTRICAL CONDUIT

1060.1 Scope. This specification covers electrical conduit to be used as specified or as shown on the plans.

1060.2 Acceptance. All material in this section will be accepted based on certification indicating the material is in accordance with this specification and any testing as required by the engineer.

1060.3 Material.

1060.3.1 Rigid Metallic Conduit and Tubing. Except for rigid aluminum conduit, rigid metallic conduit shall be galvanized on both the inside and the outside surfaces. The weight of zinc coating shall be no less than 0.5 ounce per square foot of coated surface, as determined in accordance with AASHTO T 65. The interior or exterior surface, or both, may be given a coating of suitable material to facilitate installation of wires and cables and to permit the conduit to be readily distinguished from pipe used for purposes other than electrical.

1060.3.1.1 Rigid Steel Conduit, Zinc Coated. Rigid steel conduit, zinc coated, (GRC) shall be in accordance with ANSI C80.1, except as noted herein.

1060.3.1.2 Intermediate Metal Conduit. Intermediate metal conduit (IMC) shall be in accordance with ANSI C80.6, except as noted herein.

1060.3.1.3 Rigid Aluminum Conduit. Rigid aluminum conduit (RAC) shall be in accordance with ANSI C80.5.

1060.3.1.4 Electrical Metallic Tubing, Zinc Coated. Electrical metallic tubing (EMT), zinc coated, shall be in accordance with ANSI C80.3 except as noted herein.

1060.3.1.5 Fittings for Rigid Metal Conduit and Electrical Metallic Tubing. Fittings shall be in accordance with ANSI C80.4.

1060.3.1.6 Fittings for Intermediate Metal Conduit. Fittings shall be in accordance with UL 1242, except the coating shall meet the same requirements as the conduit with which the fittings are used.

1060.3.1.7 Inspection. Conduit, tubing and fittings will be inspected for compliance with specifications. Test specimens for determination of weight of coating will be at least 2 inches long, cut no less than 6 inches from the end of the length of conduit or tubing selected for testing. If the prescribed two additional samples for retests are taken, and either sample does not comply, the lot represented will be rejected.

1060.3.2 Rigid Non-Metallic Conduit. Rigid non-metallic conduit shall be either polyvinyl chloride (PVC) or high-density polyethylene (HDPE).

1060.3.2.1 Polyvinyl Chloride Conduit. PVC conduit, bends, couplings and fittings shall be in accordance with UL 651.

1060.3.2.2 High Density Polyethylene Conduit. HDPE conduit shall be in accordance with ASTM D 3035 SDR11.

1060.3.2.3 Fittings for Polyvinyl Conduit. Fittings for PVC conduit shall be in accordance with UL 514. Cement used for the fittings shall be in accordance with the conduit manufacturer’s recommendations.

1060.3.2.4 Fittings for High Density Polyethylene Conduit. Fittings for HDPE conduit shall be in accordance with ASTM D 2683. Epoxy used for the fittings shall be in accordance with the conduit manufacturer’s recommendations.

1060.3.2.5 Inspection and Testing. Material will be inspected for compliance with the specifications, and samples for testing will be taken at either the project location or warehouse, as determined by the engineer.

1060.4 Certification. The contractor shall furnish a manufacturer's certification that the material supplied is in accordance with all requirements. If requested by the engineer, the contractor shall also furnish typical test

results representative of the material.

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SECTION 1061
ELECTRICAL CONDUCTORS

1061.1 General. This specification covers electrical conductors and associated material for use on highway construction projects. Contractor furnished equipment that will become the property of the Commission shall be of new stock unless stated otherwise in the contract documents. Electrical conductors and associated equipment shall be in accordance with applicable requirements of ICEA, IMSA, NEMA, EIA, NEC, NFPA and regulations of the National Board of Fire Underwriters and shall meet the approval of the engineer.

1061.2 Conductors. Except as noted, all conductors shall be soft drawn, Class B or C stranded copper wire in accordance with NEMA WC70/ICEA A-95-658. Solid conductors may be used only for grounding where connected to a ground rod.

1061.3 High Voltage Power Cable. The voltage rating for high voltage power cable supplying primary electrical power shall be 5 KV for primary voltages less than 5,000 volts, and 15 KV for voltages of 5,000 volts and greater. The specific type of cable shall be as recommended and approved by the utility company or municipality supplying power.

1061.4 Low Voltage Power Cable. Low voltage power cable shall be 600-volt, single conductor cable and thermoplastic or thermosetting cross-linked polyethylene insulated. All cable shall be plainly marked on the outside with the manufacturer's name and identification in accordance with industry practice. Insulation type shall be THHN/THWN-2 orXHHW-2. Average thickness of insulation shall be no less than specified in the following table, with a minimum thickness of 90 percent thereof.

Size (AWG or kcmil)	Thickness, Mils THHN/THWN-2)
14-12	15
10	20
8-6	30
4-2	40
1-4/0	50
250-500	60
501-1000	70
Size (AWG or kcmil)	**Thickness, Mils THHN/XHHW-2)**
14-10	30
8-2	45
1-4/0	55
213-500	65
501-1000	80

1061.5 Cable-Conduit. Cable-conduit shall consist of one to four low voltage power cables with an insulated sized electrical neutral and a bare safety ground, factory installed in black polyethylene conduit intended for direct burial. The conduit shall be plainly marked on the outside with manufacturer's name and identification in accordance with industry practice and shall be in accordance with ASTM D 3485. Cable-conduit shall be accompanied by the manufacturer's certification stating the conduit is in accordance with the requirements of this specification.

1061.6 Pole and Bracket Cable. Pole and bracket cable located in the lighting or signal pole that supplies electrical power to highway lighting shall consist of two single conductors. Wire size shall be No. 10 AWG in accordance with the requirements of low voltage power cable. Insulation type shall be THHN/THWN-2 or XHHW-2. Average insulation shall be in accordance with Sec 1061.4.

1061.7 Multi-Conductor Cable. Multi-conductor cable for traffic signals shall be No. 16 AWG, rated at 600 volts. The cable shall be in accordance with IMSA Specification No. 19-1 or No. 20-1.

1061.8 Induction Loop Detector Cable. Induction loop detector cable shall be single-conductor No. 14 AWG wire, with Type XHHW insulation, marked as such, rated at 600 volts. The cable shall be in accordance with IMSA Specification No. 51-7.

1061.9 Loop Detector Lead-In Cable. Lead-in cable used between the loop detector and the controller shall be two-conductor, twisted, shielded No. 14 AWG wire rated at 600 volts. The cable shall be in accordance with IMSA Specification No. 50-2.

1061.10 Certification. All cables and conductors shall be accompanied by certification from the supplier indicating: (1) the supplier is familiar with the requirements of these specifications and, (2) cable furnished was from a lot manufactured by (manufacturer's name) whose test results are in accordance with these specifications.

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SECTION 1062
PULL AND JUNCTION BOXES

1062.1 Scope. This specification covers pull and junction boxes intended for use on highway lighting and traffic signal projects.

1062.2 Pull Boxes. Pull boxes may be cast-in-place concrete, precast concrete, preformed polymer concrete or preformed fiberglass reinforced polymer concrete. Pull box dimensions shall be as shown on the plans. Each pull box shall be equipped with cable hooks as shown on the plans. Cable hooks shall be galvanized steel or brass with a minimum diameter of 3/8 inch and a minimum length of 5 inches.

1062.2.1 Cast-in-place concrete pull boxes shall be constructed of Class B or B-1 concrete, or a commercial mixture in accordance with Sec 501. Material, proportioning, mixing, slump and transporting of concrete shall be in accordance with Sec 501. Placing, finishing and curing shall be in accordance with Sec 703. Pull boxes shall be cast in a neat and workmanlike manner. Forms will be required for the inside surfaces of the pull box walls; and if the excavation is irregular, forms will also be required for the outside surfaces of the walls. An outside form shall be installed across all trenches leading into the pull box excavation. The ends of all conduits through the walls shall fit tightly against the form.

1062.2.2 Precast concrete pull boxes shall be constructed of Class B or B-1 concrete, or a commercial mixture in accordance with of Sec 501. Material, proportioning, mixing, slump and transporting of concrete shall be in accordance with Sec 501. Concrete for precast pull boxes shall be placed, finished and cured in accordance with Sec 703.

1062.2.3 Preformed pull boxes shall withstand a wheel load of 20,000 pounds. Pull box walls may be either flared or vertical. Metal conduit, if used in preformed pull boxes, shall be electrically bonded to one another inside each pull box.

1062.3 Pull Box Covers. Each pull box shall be equipped with a bolt down cover. The threaded hole that receives the cover lock-down bolt shall be open at the bottom to allow the cleanout of sand, dirt and other debris. Lock-down bolts shall be stainless steel or brass with a penta-head. Frames and covers for cast-in-place and precast concrete pull boxes shall be cast iron in accordance with AASHTO M 105, Class 30, and shall be of the dimensions and weights shown on the plans. Preformed pull box covers shall be polymer concrete and shall have a minimum wheel load rating of 20,000 pounds. A lift opening shall be provided on all covers. Covers for pull boxes to be used for highway lighting or sign lighting shall be embossed with "STATE LIGHTING". Covers for pull boxes to be used for traffic signals, or a combination of traffic signals and 120 volt intersection lighting, shall be embossed with "STATE SIGNALS". Covers for pull boxes to be used for fiber optics shall be embossed with “STATE FIBER OPTICS”.

1062.4 Junction Boxes. Junction boxes shall be flanged and designed for flush mounting if encased in concrete, or designed for surface mounting if external mounting is specified. Junction boxes shall be drilled or tapped for all conduit connections. Junction boxes shall be installed such that covers are removable. Junction boxes shall be stainless steel, fiberglass or PVC watertight NEMA 4 enclosures. PVC junction boxes shall have a minimum wall thickness of 1/4 inch. Junction boxes shall be in accordance with the following minimum sizes unless otherwise specified:

Maximum Entering Conduit Size, Inches	Minimum Box Size, Inches
2	12 x 12 x 4
4	16 x 12 x 6

1062.4.1 PVC and metal conduit shall be joined to junction boxes to make a rigid and waterproof connection. If metal conduit is used, an insulated bushing shall be provided at the end of the metal conduit on the inside of the junction box to prevent scuffing of the cable insulation.

1062.4.2 The junction box cover shall be made watertight with a suitable gasket and secured with stainless steel or cadmium plated screws or bolts.

1062.5 Certification and Acceptance. The contractor shall furnish a manufacturer's certification that the material supplied, excepting material made from cast-in-place concrete, is in accordance with these

specifications.

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SECTION 1063
TEMPORARY TRAFFIC CONTROL DEVICES

1063.1 Scope. This specification covers material to be used for temporary traffic control devices.

1063.2 General Requirements. All temporary traffic control devices shall be manufactured as shown on the plans and as specified, in accordance with MUTCD requirements and shall be NCHRP 350 compliant. Nominal dimensions will be permitted for dimensional lumber where applicable. All temporary traffic control devices shall exhibit good workmanship and shall be free of objectionable marks or defects that affect appearance or serviceability. The brand name or model number shall be permanently identified on each traffic control device.

1063.3 Channelizers. All trim-lines and drum-like channelizers shall be manufactured from a non-metallic material, pigmented and molded of a Highway Orange color throughout and stabilized against fading by ultraviolet or other light rays by the incorporation of adequate inhibitors. All reflective sheeting for channelizers shall be in accordance with Sec 1042.2.7.3.

1063.3.1 Temporary Tubular Delineators. Temporary tubular delineators shall be a nominal height of 28 inches and manufactured from a non-metallic material, pigmented and molded of a Highway Orange color throughout and stabilized against fading by ultraviolet or other light rays by incorporation of adequate inhibitors. All reflective sheeting for temporary tubular delineators shall be in accordance with Sec 1042.2.7.5.

1063.4 Signs.

1063.4.1 Rigid Signs.

1063.4.1.1 Sign Substrate. All signs shall be fabricated of substrate designed to provide satisfactory structural rigidity.

1063.4.1.2 Sign Sheeting. All signs shall have a retroreflectorized background. Retroreflective sheeting shall be in accordance with Sec 1042.2.7.2. Sheeting shall be applied to the sign substrate in accordance with the manufacturer's recommendations and the surface shall be free of air bubbles, wrinkles or other blemishes as determined by the engineer.

1063.4.2 Roll-up Signs.

1063.4.2.1 Sign Substrate. Sign and overlay blanks shall consist of either white, yellow, fluorescent orange and/or pink microprismatic retroreflective sheeting sealed to a heavy-duty coated fabric or vinyl material. The sheeting shall have a minimum coefficient of retroreflection, expressed as candelas per footcandle per square foot, as shown below, when measured in accordance with ASTM E 810 and shall meet the minimum color requirements in accordance with MGS-04-01L specification. The color specifications shall be in accordance with ASTM D 4956. Material shall be submitted by the manufacturer to NTPEP for a minimum exposure time of one year. Results shall be published by NTPEP and available for MoDOT review. For all NTPEP test decks, weathered material shall be within the color specification limits. Heat and impact resistance of the sheeting shall be in accordance with the latest version of ASTM D 4956.

1063.4.2.2 Overlays. Overlays, when used, shall be mechanically fastened to the face of the sign in a manner that will ensure the overlay remains securely attached. Fasteners shall not detract from the appearance of the sign when the overlay is not in use. Velcro fasteners will not be permitted.

1063.4.2.3 Bracing. Each sign shall have a horizontal and vertical cross brace and at least one anti-kiting device located near the center of the sign. Cross braces of sufficient cross-section shall be fastened to each other at the midpoints and the ends securely held to the back of the sign by mechanical means. The design shall ensure that the sign remains taut and retains the sign's intended shape when exposed to normal field conditions.

1063.4.3 Legend and Borders. Legends and borders of all signs shall be vinyl or silk-screened. Vinyl shall be cut by die or a computer-driven cutter. Stencil ink used shall be in accordance with the sheeting manufacturer's recommendations. Free-hand legend and borders will not be permitted.

1063.4.4 Sign Layout and Design. Sign layout and design shall be as shown on the plans or as directed by the engineer.

1063.4.5 Flag Assembly. Flag assemblies, when specified, shall consist of a flag bracket and two flags. Flags shall be 18 in x 18 in fluorescent orange, vinyl and be securely attached on one side to a blank suitable for displaying the flag as shown on the plans. The flag shall not be of mesh material. The blank shall be securely attached to the flag bracket, be of sufficient cross-section to display the flag in wind speeds up to 50 mph and be of sufficient length to hold the flags approximately six inches from the sign.

1063.4.6 Advance Warning Rails. Advanced warning rails shall be supplied as a system of three rails as shown on the plans. The rail system may be post mounted or mounted on portable structures. When used on post mounted signs, the advance warning rails shall consists of substrate of high-density polyethylene plastic. The rail wall thickness shall be 1/4 in. with white and orange reflective sheeting in accordance with Sec 1042.2.7.4, and shall be applied as shown on the plans.

1063.5 Warning Lights.

Warning Lights				
Item	**Type A Low Intensity**	**Type B High Intensity**	**Type C Steady Burn**	**Sequential Flashing**
Lens Directional Faces	1 or 2	1	1 or 2	1
Flashing Rate per Minute	55 to 75	55 to 75	Constant	55 to 75
Minimum (1)	10%	8%	Constant	Constant
Hours of Operation	Dusk to Dawn	24 hrs/day	Dusk to Dawn	24 hrs/day

1063.6 Flashing Arrow Panels. All lamps shall have a nominal 5-inch, 360-degree tunnel visor. A lamp on the back side of the flashing arrow panel shall be continuously energized during operation of the flashing arrow panel. Lamps shall be visible at an angle of 15 degrees to the left and right of center and 4 degrees above and below center during "on" time. The flashing arrow panel shall contain a device to align the arrow panel to oncoming traffic. Arrow panels shall be capable of displaying the flashing arrow, flashing double arrow and four corner flashing caution modes. Solar-powered flashing arrow panels shall be capable of operating in the flashing arrow mode for 20 consecutive days and shall be provided with a device to indicate the remaining charge in batteries.

1063.6.1 Trailer-Mounted Flashing Arrow Panels. Trailer-mounted flashing arrow panels shall be MUTCD, Type C. Trailer-mounted flashing arrow panels shall be solar powered.

1063.6.2 Truck-Mounted Flashing Arrow Panels. Truck-mounted flashing arrow panels shall be MUTCD, Type B.

1063.7 Changeable Message Sign. Each Changeable Message Sign (CMS) shall consist of a message board, solar power supply, control systems and mounting and transporting equipment.

1063.7.1 Message Board. The CMS shall be equipped with a power source and battery back-up to provide continuous operation when failure of the primary power source occurs. Either message board shall be capable to provide three lines of eight individual changeable characters per line. Each character shall be yellow in display on a black background and be a minimum of 18-inches. The CMS shall be legible up to a distance of 650 feet for both day and night operation.

1063.7.1.1 The CMS shall have a control system to allow the message to be changed from the CMS location without connection. The control system shall include a display screen upon which messages can be reviewed before being displayed on the sign. For on-sight operation, the CMS shall have a removable waterproof keyboard with display panel.

1063.7.1.2 The supplier shall provide web based software and licenses necessary to change the message from a remote location. This software shall be compatible with MoDOT's operating systems and shall be able to issue - compatible modem commands.

1063.7.2 Communication Interface. If specified the CMS shall have a digital cellular transceiver capable of receiving a message in the location deployed from a remote location and forwarding the message to the CMS controller to change the displayed message.

1063.7.3 Solar Power Supply. The CMS shall be equipped with a power source and battery back-up to provide continuous operation when failure of the primary power source occurs.

1063.8 Portable Traffic Signals. Each portable traffic signal (PTS) system shall consist of two trailer-mounted PTS units, a controller assembly and communication link. Each PTS unit shall consist of signal heads and indications, a solar power supply, vehicle detection and mounting and transporting equipment. All components shall be capable of operating in a temperature range of -20 to 120 F.

1063.8.1 Controller Assembly. The controller assembly shall be a minimum two-phase, solid-state traffic signal controller with a conflict monitor capable of operating the signals in accordance with MUTCD requirements and NEMA Standard TS1. The controller shall operate as a fully-actuated unit and shall have the capability of being manually operated to display simultaneous red on both phases. The controller shall be capable of red rest during non-actuated periods. Upon detection of a conflict, the system shall change to a solid red clearance interval followed by flashing red.

1063.8.2 Communication Link. A continuous communications link between the PTS units shall be provided. If a break in communications between the PTS units occurs, the system shall change to a solid red clearance interval followed by flashing red. Upon restoration of communications, the system shall change to a solid red clearance interval followed by normal operations.

1063.8.3 Signal Heads and Indications. Each unit shall consist of two polycarbonate signal heads, including backplates and visors. One signal head shall be mounted on the mast arm assembly and the other on the vertical upright. The signal head mounted on the mast arm shall provide a minimum lateral clearance of 9.5 feet from the center of the outer signal head to the edge of the trailer and a minimum vertical clearance of 16 feet from the bottom of the backplate to the roadway surface. The signal head mounted on the vertical upright shall provide a minimum clearance of 8 feet from the bottom of the backplate to the roadway surface. All signal indications shall be 12 inches in diameter. Traffic signal heads and indications shall be in accordance with the vehicle traffic control signal head requirements of ITE and NEMA Standard TS1 and TS2.

1063.8.4 Solar Power Supply. The power supply shall use a battery bank with sufficient capacity to operate the PTS for 20 consecutive days with no sun. All terminals and connections shall be clearly labeled.

1063.8.5 Vehicle Detection. Detection shall be provided by one of the non-intrusive vehicular detection methods specified in Sec 902 or temporary loop detectors with the capability of providing coverage for a 6-foot x 30-foot area. Temporary loops shall be preformed at the factory. The temporary loops shall have self-adhesive rubberized asphalt backing, which shall bond to the pavement.

1063.8.6 Support. A factory trained service representative shall be available at the delivery location to provide technical assistance and training, including the installation and operation of software. No additional payment will be made for travel expenses.
1063.9 Portable Signal Flagging Device. Each portable signal flagging device (PSFD) system shall consist of four portable cart-mounted units. Each PSFD unit shall provide a vertical upright with one signal head, vehicle detection, radio controller, and self-contained power supply capable of operating the unit for 16 continuous hours. All components shall be capable of operating in a temperature range of –20 to 120 F.

1063.9.1 Signal Heads and Indications. The signal head shall consist of three (red ball, amber ball, green ball) 12-inch LED signal indications. All signal heads shall be mounted on the vertical uprights with a minimum clearance of 7 feet when the upright is fully extended.

1063.9.2 Vehicle Detection. Detection shall be provided by one of the non-intrusive vehicular detection methods specified in Sec 902 with the capability of providing coverage for a 6-foot x 30-foot area.

1063.9.3 System Operation. The system shall be able to operate in a fixed-time, traffic-actuated, and manual-control mode. The system shall be MUTCD compliant with a controller and conflict monitor and include a wireless radio communication package and wireless remote.

1063.10 Radar Speed Advisory System. Each radar speed advisory system shall consist of a radar unit, speed display, speed limit display, solar power supply and mounting and transporting equipment.

1063.10.1 Radar Unit. The radar unit shall include necessary cables for connection to the digital display and

power supply, shall be capable of instantaneously displaying and locking readings and shall meet the following minimum requirements:

Radar Unit Requirements	
Speed range	15 to 99 mph
Accuracy	±1 mph
Internal test	32 mph check

1063.10.2 Speed Display. The speed display shall be a minimum of 12 inches high and shall be capable of displaying the radar unit output from 0 to 99 mph.

1063.10.3 Speed Limit Display. The speed limit display shall indicate the work zone speed limit by means of a 36 x 48-inch speed limit sign. The speed limit sign may be comprised of a rigid or roll-up sign or a rigid sign with a variable speed display. The variable speed display shall be a minimum of 12 inches high and shall be capable of displaying two digits.

1063.10.4 Solar Power Supply. The power supply shall be capable of operating the radar unit, speed display and speed limit display, if applicable, for a minimum of eight hours per day.

1063.11 Truck or Trailer Mounted Attenuators. Each Truck or Trailer Mounted Attenuator (TMA) shall be in accordance with Test Level 3 criteria as set forth in NCHRP 350 or MASH. Each TMA shall have a standard trailer lighting system, including brake lights, taillights, turn signal lights and Federal Motor Carrier Safety Administration identification bar lights. In the operating position, the rear facing of the TMA shall be marked with alternating 8-inch yellow and 8-inch black retroreflective sheeting forming an inverted “V” at the center and slope downward at an angle of 45 degrees toward each side of the unit or a checkered board pattern consisting of 12-inch square red and 12-inch square white retroreflective sheeting. The TMA may be marked with the same operating pattern or red and white DOT conspicuity tape to simulate the looks of a standard van body trailer when traveling. The TMA shall have the same standard trailer lighting system noted above when the unit is in the transport position.

1063.12 Certification. The contractor shall furnish a manufacturer's certification for all material governed by this specification. The certification shall indicate full compliance with each applicable specification.

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SECTION 1064
TEMPORARY TRAFFIC BARRIER

1064.1 Scope. This specification covers temporary traffic barrier for use in highway construction.

1064.2 Type F Temporary Concrete Barrier.

1064.2.1 Acceptance.

1064.2.1.1 Three-Loop Concrete Barrier. The manufacturer shall provide certification to the contractor that the barrier is in accordance with the contract documents.

1064.2.1.2 Two-Loop Concrete Barrier. District material personnel when notified to re-stamp previously accepted barrier will be responsible for re-stamping the barrier if the previous acceptance stamp is legible and if the barrier is not damaged to the extent that it is felt that the barrier cannot perform properly. Reasons for rejection will be, but not limited to:

(a) Exposed steel reinforcement.

(b) Damage or cracks in the connecting loops.

(c) Missing chunks of concrete.

(d) Excessive marring or scarring.

(e) Extensive scaling of the concrete.

(f) Misalignment of the connecting loops that would hinder insertion of the keeper pin.

1064.2.2 Material.

1064.2.2.1 All material, in the manufacturing of three-loop type F temporary concrete barrier, shall be in accordance with the following specifications:

Item	Specification
Reinforcing Steel for Concrete	AASHTO M 31, Grade 60
Connection Rod	A36 Steel
Anchor Bolts	ASTM A307
Connection Rod Assembly	AASHTO M 183
Retainer Bolt and Nut	SAE Grade 8
Asphalt Pin	A36 Steel
Thrie Beam	Nested 12 Gage or 10 Gage
Thrie Beam Bolts	ASTM A307

1064.2.2.1.1 All reinforcing steel shall be deformed bar. Loop steel shall be 0.75-inch smooth steel bars with a minimum yield of 60 ksi, shall have a tensile strength of no less than 1.25 times the yield strength, but a minimum of 80 ksi, a minimum 14 percent elongation in
8 inches, and passing a 180-degree bend test using a 3.5 times diameter pin bend diameter. The loops shall be installed within 0.125 inch of the plan dimensions.

1064.2.2.1.2 The manufacturer shall retain, at a minimum, all compressive strength test results, entrained air content records, and reinforcing steel certification for at least five years.

1064.2.3 Manufacture.

1064.2.3.1 Welding of loop steel shall be limited to the minimum surface welding necessary to maintain the position required for placement.

1064.2.3.2 Visual cracks in the loop steel will be cause for rejection.

1064.2.3.3 Concrete shall be air-entrained with 28-day compressive strength of 5,000 psi. Concrete shall be continuously cured until 5,000 psi is attained. Fine and coarse aggregate shall be in accordance with Sec 1005, except that gradation requirements and percent passing the No. 200 sieve will not apply. Temporary concrete traffic barrier shall be manufactured in accordance with industry standard practices for pre-cast construction.

1064.2.3.4 All temporary concrete traffic barrier units shall be permanently marked with the name and location of the manufacturer, and the month and year of manufacture in a location visible after installation. Paint or other liquid marking will not be permitted.

1064.2.3.5 The surface of temporary concrete traffic barrier shall be smooth and non-deformed and substantially free of honeycomb, surface spalls and surface defects. Barrier units shall be straight and square on the ends and shall meet the following tolerances:

Dimension	Tolerance
Length	+ 3/4 inch
Width	+ 1/4 inch
Height	+ 1/4 inch

1064.3 Alternative Temporary Traffic Barrier.

1064.3.1 Approval. Prior to approval and use, the manufacturer shall submit to MoDOT, the manufacturer's name, the product brand name or model number, a copy of the MASH or NCHRP 350 test results, a copy of the FHWA acceptance letter, shop drawings and any other information requested by the engineer.

1064.3.2 Acceptance. Acceptance of the material will be based on the manufacturer's certification and upon satisfactory field performance.

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SECTION 1065
DELINEATORS

1065.1 Scope. This specification covers delineators for use in highway construction.

1065.2 Delineator Body. The delineator body shall be flat sheet aluminum in accordance with Sec 1042.2.1 and meet dimensions as shown on the plans.

1065.3 Permanent Tubular Delineators. Permanent tubular delineators shall be a nominal height of 36 inches and manufactured from a non-metallic material, pigmented and molded to match the color of the closest pavement or curb marking, and stabilized against fading by ultraviolet or other light rays by incorporation of adequate inhibitors.

1065.4 Temporary Traffic Barrier Delineators. Temporary tabs shall be manufactured from a thermoplastic material and meet dimensions as shown on the plans.

1065.5 Retroreflective Sheeting. Retroreflective sheeting shall be permanently affixed to the body of the delineator and follow guidelines in accordance with Sec 1042.2.7.5 for application of sheeting. Manufacturer's certification shall be provided for delineator sheeting.

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SECTION 1066
MORTARS AND GROUT

1066.1 Scope. This specification covers mortars and grout for use in pipe joints, rubble and brick masonry.

1066.2 Mortars and Grout. Mortars and grout shall be mixed in small quantities as needed and shall not be retempered or used after setting has begun. Type I Portland cement shall be accordance with Sec 1019. Sand shall be clean and shall be in accordance with Sec 1005, except the minus No. 200 sieve requirement will not apply. Water shall be in accordance with Sec 1070.

1066.2.1 Mortar For Pipe Joints. Mortar shall consist of one part Type I Portland cement and two parts sand, by volume, mixed with sufficient water to form a plastic mortar.

1066.2.2 Mortar for Grout. Mortar used for grout shall consist of one part Type I Portland cement and three parts sand, by volume, mixed with sufficient water to form a grout of proper consistency.

1066.2.3 Mortar For Rubble and Brick Masonry. The mortar shall be composed of one part Portland cement plus 10 percent, by volume, of hydrated lime and of two parts sand by volume. Hydrated lime shall be in accordance with ASTM C 207, Type N. After the dry material has been thoroughly mixed, water shall be added, and the mixture shall be turned and chopped by hand or mechanical methods until a stiff mortar results. Mortar shall be mixed no more than 30 minutes prior to use. Mortar for pointing shall be mixed in the proportions of one part Portland cement to one part sand by volume.

1066.2.4 Expansive Mortar.

1066.2.4.1 Aluminum Powder Expansive Mortar. The mortar shall consist of one part Type I Portland cement and three parts sand, by volume, mixed with sufficient water to form a stiff plastic mortar. Unpolished aluminum powder at the rate of 4 grams per sack of cement shall be thoroughly dry mixed with the cement before incorporation with other ingredients.

1066.2.4.2 Other Expansive Mortars. Upon approval from the engineer, other expansive mortars may be used. The expansive mortars shall contain no more than 0.02 percent chlorides by weight and, when subjected to a pull-out test, shall equal or exceed the results of tests conducted using the material specified in Sec 1066.2.4.1.

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SECTION 1067
TRUNCATED DOMES

1067.1 Scope. This specification covers truncated domes used for sidewalk curb cuts and pedestrian island cut-throughs.

1067.2 Domes. Domes shall have a base diameter of 0.9 to 1.4 inches. The top diameter shall be 50 to 65 percent of the base diameter. The dome height shall be 0.2 inches. Dome center-to-center spacing shall be 1.6 to 2.4 inches with a minimum base-to-base spacing of 0.65 inches. Stamped concrete will not be accepted.

1067.3 Panels. Truncated dome surfaces shall extend a minimum of 24 inches in the direction of sidewalk travel and the full width of the curb ramp (exclusive of flares), the landing, or blended transition. The panels shall be made of a durable material. The panels shall carry a manufacturer warranty covering all defects for a five-year period from the time of installation.

1067.4 Acceptance. All material shall be obtained from a source identified on the Qualified List (QL) designated for this specification.

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SECTION 1068
TRENCH DRAINS

1068.1 Scope. This specification covers trench drains used in median and shoulder drainage systems.

1068.2 Acceptance. All material shall be obtained from a source identified on the Qualified List (QL) designated for this specification.

1068.3 Materials.

1068.3.1 Drain grates shall meet AASHTO M 306 requirements for proof-load testing.

1068.3.2 The drain grate inflow area shall be a minimum of 0.27 ft2/lf. Drain grate retaining devices shall not obstruct hydraulic flow in the channel.

1068.3.3 The drain grate retaining device shall withstand, without maintenance, repetitive cyclic vertical loads of 500 pounds.

1068.3.4 The drain grate retainers shall withstand a pullout resistance of 250 pounds per foot after completing a 1,000-hour ASTM B117 salt spray test.

1068.4 Drain grates shall be bicycle safe.

1068.5 The use and location of the trench drain shall be as shown on the plans.

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SECTION 1070
WATER

1070.1 Scope. This specification covers water for use in mixing and curing concrete, and for use in mortar and grout.

1070.2 Requirements. Water for use in mixing and curing concrete, and in mortar and grout, shall be reasonably clean and shall be free from injurious quantities of deleterious substances such as oil, acid, alkali, salt or organic matter. Potable water may be accepted without being tested. Requirements for testing water for mixing or curing purposes may be waived if in the judgment of the engineer, the water is considered satisfactory for the purpose.

1070.3 Testing. As required by the engineer, and if laboratory testing shows that the pH of the water is less than 4.5 or more than 9.5, or that the water contains deleterious substances, the following requirements shall also be met. Autoclaved bars, made with the water and a cement that shows satisfactory soundness when mixed with distilled water, shall show an expansion not to exceed 0.5 percent. The compressive strength at seven days of a mortar consisting of one part cement and 2.75 parts of natural silica sand and the water being tested shall show a reduction of no more than 10 percent of the compressive strength developed by 1:2.75 mortar containing the same cement and sand and mixed with distilled water.

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SECTION 1071
ASPHALT RELEASE AGENTS, FIBER ADDITIVES AND LIQUID ANTI-STRIP ADDITIVES

1071.1 Scope. This specification covers asphalt release agents for use in coating truck beds and bituminous mixture additives.

1071.2 Acceptance. All material under this specification shall be obtained from a source identified on the Pre-Acceptance List designated for this specification. All material will be inspected and accepted in accordance with Sec 106.

1071.3 Asphalt Release Agent. The asphalt release agent shall not be detrimental to bituminous mixtures and shall not dissolve asphalt binder when applied to the truck bed.

1071.3.1 Physical Properties. The following physical properties shall be determined.

1071.3.1.1 Unit Weight. The weight per gallon shall be determined in accordance with AASHTO T 59, Weight per Gallon of Emulsified Asphalt.

1071.3.1.2 Solids. The percent solids shall be determined in accordance with ASTM D 1644, Method A.

1071.3.1.3 Acidity or Alkalinity Level (pH). The pH of the undiluted agent shall be determined by appropriate methods.

1071.3.1.4 Asphalt Miscibility. When tested in accordance with MoDOT Test Method TM 63, the asphalt release agent shall show no evidence of dissolving the asphalt binder.

1071.3.2 Dilution. Dilution by diesel or other petroleum products will not be permitted.

1071.3.3 Documentation. The manufacturer shall submit a certification and guarantee to Construction and Materials prior to initial approval showing the brand name and designation, the composition or description of the release agent, and the manner in which the material will be identified on the containers. The manufacturer shall certify that the material is in accordance with this specification and shall list typical values of current tests for the properties listed in Sec 1071.3.1. The certified test report shall show the manufacturer's name, brand name of material, lot and date tested. The manufacturer shall also submit a one-quart sample accompanied by an MSDS for the material. In addition, the manufacturer shall furnish information for any dilution requirements, including the minimum dilution rate and special application requirements.

1071.3.4 Packaging and Marking. The containers in which release agents are delivered shall be plainly marked with the manufacturer's name, the brand name and designation of the material, lot number and net quantity. Special applicators and dilution rates shall be designated on the container. Bulk shipments shall be accompanied by a delivery ticket showing this information.

1071.4 Bituminous Mixture Fiber Additives. Fibers for stone matrix asphalt mixture may be either cellulose or mineral fiber, and shall be in accordance with AASHTO MP8, Table 3 for cellulose fibers, or Table 4 for mineral fibers when tested in accordance with MoDOT Test Method TM 60.

1071.4.1 Documentation. The manufacturer shall submit a certification and guarantee to Construction and Materials prior to initial approval, showing the brand name and designation, the composition or description of the fibers, and the manner in which the material will be identified on the containers. The manufacturer shall certify that the material is in accordance with this specification and shall list typical values of current tests for the properties listed in AASHTO MP8. The certified test report shall show the manufacturer's name, brand name of material, lot and date tested. The manufacturer shall submit at least a 5-pound sample accompanied by an MSDS for the material.

1071.4.2 Packaging and Marking. The containers in which fibers are delivered shall be plainly marked with the manufacturer's name, the brand name and designation of the material, lot number and net quantity. Bulk shipments shall be accompanied by a delivery ticket showing this information.

1071.5 Liquid Anti-Strip Additives. Liquid anti-strip additives shall not be detrimental to the bituminous

mixture.

1071.5.1 Physical Properties. Amine-type liquid anti-strip additives that are physically mixed with the asphalt binder will be classified as Type I. Latex-type liquid anti-strip additives that are applied to the aggregate will be classified as Type II. The following physical properties shall be determined for each type.

1071.5.1.1 Type I Liquid Anti-Strip Additives.

Test	Test Method
Specific Gravity @ 77 F	AASHTO T 228
Brookfield Viscosity 77 F using an RVT viscometer. The report shall include the corresponding test temperature, speed, spindle and model of instrument.	ASTM D2196
Pensky-Martens Closed Cup Flash Point or Cleveland Open Cup Flash Point	ASTM D93 AASHTO T 48
Infrared Spectrum (neat material)	Appropriate Method

1071.5.1.2 Type II Liquid Anti-Strip Additives.

Test	Test Method
Weight Per Gallon @ 77 F	ASTM D1475
Brookfield Viscosity 77 F using an RVT viscometer. The report shall include the corresponding test temperature, speed, spindle and model of instrument.	ASTM D2196
pH	Appropriate Method
Percent Solids	ASTM D1644 Method A
Infrared Spectrum (latex portion)	Appropriate Method

1071.5.2 Heat Stability. The additive shall be stable and shall not separate under all manufacturer listed storage and use temperatures. When Type I or Type II additives are blended with the proposed bituminous material to be used at the anticipated application rate, the blended material shall still meet all bituminous material specifications and shall be heat stable. Heat stability shall be established by comparing AASHTO T 283 specimens made by preparing three conditioned specimens using aged, blended material that has been held at 325 F for 96 hours and three conditioned specimens using fresh blended material. The average tensile strength of conditioned specimens using aged material shall be compared with conditioned specimens made with fresh blended material. If the average conditioned strength of the mixture with aged material is less than 90 percent of the mixture with fresh blended material, the anti-strip additive will not be permitted for use. This requirement will also apply if tested on any specific mix design using the approved anti-strip additive.

1071.5.3 Unconditioned Strength. The anti-strip additive shall not significantly lower the unconditioned strength of AASHTO T 283 specimens. This shall be determined by preparing an additional six unconditioned specimens, three with and three without the liquid anti-strip additive. The average tensile strengths of unconditioned specimens shall be compared with specimens with and without the liquid anti-strip additive. If the average unconditioned strength of the mixture with the additive is less than 90 percent of the mixture without the additive, the anti-strip additive will not be permitted for use in that bituminous mixture.

1071.5.4 Documentation. The manufacturer shall submit a certification and guarantee to Construction and Materials prior to initial approval showing the brand name and designation, the composition or description of the anti-strip liquid, and the manner in which the material will be identified on the containers. The manufacturer shall certify that the material is in accordance with this specification and shall list typical values of current tests for the properties listed in Sec 1071.5.1. A copy of the bituminous mix design used to test for heat stability and unconditioned strength shall be included with the test results. The certified test report shall show the manufacturer's name, brand name of material, lot and date tested. The manufacturer shall submit at least a one-gallon sample accompanied by an MSDS for the material.

1071.5.5 Packaging and Marking. The containers in which anti-strip liquids are delivered shall be plainly marked with the manufacturer's name, the brand name and designation of the material, lot number and net quantity. Bulk shipments shall be accompanied by a delivery ticket showing this information.

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SECTION 1073
JOINT MATERIAL FOR STRUCTURES

1073.1 Scope. This specification covers material for performed compression seals and strip seals with lubricant-adhesive for sealing joints, and expanded or extruded polystyrene material for use as bedding material under prestressed panels and in the corrugation areas of stay-in-place forms used on bridge decks.

1073.2 Acceptance. All material under this specification shall be obtained from a source identified on the PAL designated for this specification. All material will be inspected and accepted in accordance with Sec 106.

1073.3 Preformed Compression Seal. Preformed compression seals shall be in accordance with ASTM D 3542 and with the following additional requirements.

1073.3.1 The movement range of the seal as defined in ASTM D 3542 shall be as shown in the contract documents, and the height of seal shall be no less than the nominal width. The seal shall be delivered in containers marked with the manufacturer's name, size of the seal, lot number and date of manufacture.

1073.3.2 The lubricant adhesive applied for installation shall be in accordance with the seal manufacturer and in accordance with Sec 717. The lubricant adhesive shall be delivered in containers marked with the manufacturer's name, lot number, date of manufacture and instructions for storage and use.

1073.4 Strip Seal. Strip seals shall be in accordance with ASTM D 5973 and the following additional requirements.

1073.4.1 The gland lugs of the seal that fasten into the steel extrusion shall be of a type that exerts pressure to the contact surfaces. Glands with snap or arrowhead-type lugs will not be permitted. The seal shall be delivered in containers marked with the manufacturer's name, size of the seal, lot number and date of manufacture.

1073.4.2 The lubricant adhesive applied for bonding the gland to the steel extrusion shall be as recommended by the seal manufacturer and in accordance with Sec 717. The lubricant-adhesive shall be delivered in containers marked with the manufacturer's name, lot number, date of manufacture and instructions for storage and use.

1073.5 Expanded or Extruded Polystyrene Material.

1073.5.1 Bedding Material for Prestressed Panels. The expanded or extruded polystyrene material shall be in accordance with the following:

Property	Test	Requirement
Compression Strength	ASTM D 1621	60 psi, min.
Water Absorption	ASTM D 2842	2% by volume, max.
Oxygen Index	ASTM D 2863	24 minimum

1073.5.2 Material for Corrugation Areas of Stay-In-Place Forms. Expanded polystyrene material shall be in accordance with the following:

Property	Test	Requirement
Compression Strength	ASTM D 1621	10 psi, min.
Water Absorption	ASTM D 2842	2% by volume, max.

1073.5.3 Adhesive for Expanded or Extruded Polystyrene Materials. Adhesive for use with expanded or extruded polystyrene material shall be in accordance with the polystyrene manufacturer's recommendations.

1073.6 Open Cell Foam Joint System. All components of the system shall be supplied by one manufacturer. The joint system shall be comprised of the following components.

(a) Cellular polyurethane foam impregnated with 100% hydrophobic polymer, water based emulsion and factory coated, on the roadway surface, with highway-grade, fuel resistant silicone.

(b) Field-applied epoxy adhesive primer.

(c) Field-applied silicone sealant bands that seal the gap between the edge of the bridge and the silicone topping on the joint. This silicone will also be used for locking field splices in the joint together.

1073.6.1 General Movement Requirements. The seal shall have a working range of 50% in tension and 50% in compression. Changes in plane and direction shall be executed using factory fabricated watertight transition assemblies conforming to the plans and specifications.

1073.6.2 Seal Properties. The seal shall be able to meet the following properties:

Property	Requirement
Temperature Service Range, ASTM C 711	-40° F to 185° F
Bleeding	None at 180° F @ 50% compression for 3 hrs.
UV Resistance, ASTM G 155	No Changes at 2000 hrs.
Polymer impregnation agent	Free of any waxes or asphalts

1073.6.3 Adhesive Properties. The epoxy adhesive shall be a 100% solids, two component moisture sensitive modified epoxy adhesive which meets ASTM C 881.

1073.6.4 Sealant Properties. The silicone sealant shall be a one part, cold applied chemically curing silicone joint sealant which meets ASTM D 5893.

1073.7 Preformed Silicone or EPDM Joints. All components, materials and equipment required for the installation shall be obtained through an approved supplier of the system. All components of each respective joint system shall come from the same manufacturer and cannot be substitutes for others.

1073.7.1 Joint Properties. The joint material shall meet or exceed the following physical requirements:

Property	Specification	Requirement
Durometer (Shore A)	ASTM D 2240	55 ±5 min.
Tensile Strength	ASTM D 412	550 psi min.
Elongation	ASTM D 412	350% min.
Tear Strength (Die B)	ASTM D 624	100 ppi min.
Compression Set At 350° F 22 hrs.	ASTM D 395	30% max.
Operating Temperature Range		-60° F to 350° F
Specific Gravity		1.51 ±0.10

1073.7.1.1 The joint seal shall be pre-qualified by undergoing and passing a cyclic loading test. Any rips, tears or bond failure will be cause for rejection. Manufacturer shall provide documentation to verify testing meeting these minimum requirements.

Cyclic Loading Test	
Property	**Requirement**
Test Sample Length	2 feet min.
Joint Skew	45°
Number of Cycles	200 min.
Joint Opening	2 inches
Movement	min. to max. opening
Temperature	-20° F

1073.7.2 Epoxy Primer. Epoxy primer shall be used to ensure the appropriate bond of the joint sealing system and to protect the surfaces of the joint after installation of the seal. The epoxy primer shall meet the following physical requirements:

Epoxy Primer		
Property	**Specification**	**Requirement**
Viscosity (centipoises)	ASTM D 2196	44
Solids	ASTM D 4209	41
Specific Gravity	ASTM D 1217	0.92
Flashpoint	ASTM D 56	48
VOC	ASTM D 3960	520

1073.7.3 Locking Adhesive. The adhesive material shall cure quickly and shall be as recommended by the manufacturer. The material shall adhere to concrete, elastomeric concrete, polymer concrete and steel and shall meet the following physical requirements:

Locking Adhesive		
Property	**Specification**	**Requirement**
Sag/Flow	ASTM C 639	3/16 inch max.
Hardness	ASTM C 661	20-30
Tack Free Time	ASTM C 679	30 minute max.
Cure Through to ¼ inch Thickness	At 75° F/50% Relative Humidity	24 hours max.
Skin Over Time (Tooling Time)	At 75° F/50% Relative Humidity	5 minute max.
Resistance to U.V.	ASTM C 793	No cracking, Ozone Chalking or Degradation
Flashpoint	ASTM D 412	200 psi min.
VOC	ASTM D 412	450% min.

1073.8 Documentation. Prior to approval and use of this material, the manufacturer shall submit to Construction and Materials a certified test report showing specific test results in accordance with all requirements of these specifications. The certified test report shall contain the manufacturer's name, brand name of material, lot tested and date of manufacture. In addition, the manufacturer shall submit a sample of the seal or polystyrene material and a one-pint sample of the adhesive for laboratory testing, accompanied by a technical data sheet and an MSDS. With approval by the engineer of the certified test report and satisfactory results of tests performed on the sample submitted, the brand name and manufacturer will be placed on the appropriate pre-acceptance list. Pre-acceptance lists are available through Construction and Materials or MoDOT's web site. New certified test results and samples shall be submitted any time the manufacturing process or the material formulation is changed, and may be required when random sampling and testing of material offered for use indicates nonconformity with any of the requirements herein specified.

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SECTION 1075
CENTRIFUGALLY-CAST FIBERGLASS-REINFORCED POLYMER MORTAR PIPE

1075.1 Scope. This specification covers centrifugally-cast fiberglass-reinforced polymer mortar pipe to be used in pipejacking and microtunneling for horizontal boring applications under roadways.

1075.2 Acceptance. Acceptance of the material will be based on the manufacturer's certification and upon the results of any tests required by the engineer.

1075.3 Manufacture.

1075.3.1 Pipe shall be manufactured from polyester resin systems with a proven history of acceptable performance for the particular application. The historical data shall have been acquired from a composite material of similar construction and composition as the proposed product.

1075.3.2 Pipe shall be manufactured from reinforcing glass fibers of commercial grade E-glass filaments with binder and sizing compatible with impregnating resins.

1075.3.3 Pipe shall be manufactured from silica sand, with a minimum of 98 percent silica, and a maximum moisture content of 0.2 percent.

1075.3.4 When used, resin additives, such as curing agents, pigments, dyes fillers, thixotropic agents, etc., shall not detrimentally affect the performance of the product.

1075.4 Documentation. The manufacturer shall provide certification to the contractor that the material provided is in accordance with ASTM D 3262 and that pipe joints meet the performance requirements of ASTM D 4161. The certification shall state the manufacturer's name and shall have attached typical results of tests on the material and pipe joints.

1075.5 Construction Inspection. Pipe will be inspected for defects prior to installation. Damaged pipe will be rejected. Any pipe that appears cracked near the joint will be rejected.

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SECTION 1080
STRUCTURAL STEEL FABRICATION

1080.1 Scope. This specification covers the fabrication and inspection of bridges and structures made of structural steel and miscellaneous metals.

1080.2 Material. Except as amended by Sec 1080.2.4, all material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section/Specification
Shear Connectors	1037
Paint for Structural Steel	1045
Coating of Structural Steel	1081
Structural Carbon Steel	AASHTO M 270, Grade 36 ASTM A 709, Grade 36
Structural Low Alloy Steel	AASHTO M 270, Grade 50 ASTM A 709, Grade 50 AASHTO M 270, Grade 50W ASTM A 709, Grade 50W
Quenched and Tempered Alloy Steel	AASHTO M 270, Grade HPS 50W ASTM A 709, Grade HPS 50W AASHTO M 270, Grade HPS 70W ASTM A 709, Grade HPS 70W ASTM A 709, Grade 100/100W
Low Carbon Steel Bolts and Nuts	ASTM A 307
High Strength Bolts, Nuts and Washers	ASTM A 325 ASTM A 490 ASTM F 436 ASTM A 563 AASHTO M 292
Cold Finished Carbon Steel Shafting	AASHTO M 169
Carbon Steel Forgings	AASHTO M 102 Class F
Alloy Steel Forgings	AASHTO M 102 Class G
Gray Iron Castings	AASHTO M 105 Class 50
Malleable Iron Castings	ASTM A 47
Carbon Steel Castings	AASHTO M 103 Grade 485-275
Galvanized Coatings	AASHTO M 111 AASHTO M 232 Class C ASTM B 695 Class 55
Lead for Bearing Pads	ASTM B 29
Identification of Metals	ASTM A 6

1080.2.1 Galvanized Bolts. Bolts, nuts and washers specified to be galvanized shall be galvanized in accordance with the requirements of AASHTO M 232, Class C or shall be mechanically galvanized in accordance with ASTM B 695, Class 55. Except for anchor bolts, galvanizing thickness shall not exceed 6 mils. Fasteners installed prior to the completion of shop blast cleaning will not require galvanizing. The thickness of the zinc coating for galvanized bolts shall be measured on the wrench flats and top of the bolt head. For mechanically galvanized bolts, the significant surfaces as referenced in ASTM B 695 shall be the entire bolt surface, excluding the underside of the surface of the head and the shank surface between the threaded portion and the underside of the head. The thickness of the zinc coating on the galvanized nuts shall be measured on the wrench flats. For mechanically galvanized nuts, the significant surfaces shall be all surfaces of the nut excluding the threads. The thickness of the zinc coating on galvanized washers shall be measured on both sides. The significant surfaces on mechanically galvanized washers shall be all surfaces of the washer.

1080.2.2 Fit Up Bolts. Fit up and shipping bolts shall be coated to prevent corrosion where a finish coat will not be applied. Shipping bolts for uncoated weathering steel will not require coating.

1080.2.3 Falsework. Falsework material will be subject to the engineer's approval. All falsework material shall be in good condition such that the material performs as designed. Falsework piling shall be capable of withstanding driving to a depth sufficient to develop adequate bearing.

1080.2.4 Certified Mill Test Reports. For structural steel, the contractor shall submit a copy of the certified mill test report giving the chemical analysis and results of physical tests on the material furnished. The mill test

report shall state the location of the mill where the molten metal was produced. Two copies of the mill test report will be required for material used in railroad structures. If steel is produced outside the United States, the contractor shall submit a certified test report from a MoDOT approved U. S. laboratory showing specific results of chemical analysis and physical tests for each heat furnished and stating that the material meets the specification requirements. Mill tests and laboratory reports shall be submitted for approval before any request is made for shop or field inspection. In addition, the engineer may take samples for chemical analysis and physical tests from the fabricated steel delivered to the project site. Any time or cost effects caused by obtaining and analyzing samples from delivered steel shall be anticipated by the contractor as part of the quality assurance process and no compensation or additional time will be allowed for costs or delays associated with this activity. Unless otherwise specified, the supplementary requirements of AASHTO M 270 for Charpy V-notch impact tests in temperature zone 2 shall be mandatory where the contract documents indicate notch toughness is required for fracture critical or non-fracture critical components. Mill test reports shall include the results of Charpy V-notch testing and impact serial numbers for fracture critical components.

1080.2.5 High Strength Fastener Assemblies. In addition to the requirements of Sec 712.2, high strength bolts, nuts and washers shall meet the following requirements. The contractor shall furnish a manufacturer's certification showing results of tests performed. Identification in accordance with the appropriate AASHTO/ASTM specifications shall be maintained by container markings which shall match identifying numbers on the certifications and be traceable to the certified mill test reports. High strength fastener assemblies shall be galvanized unless used with unpainted weathering steel or specifically indicated otherwise by the contract documents. When high strength bolts are used with weathering steel, the fasteners shall be Type 3. ASTM A 490 bolts shall be installed black, tensioned and then cleaned and coated with the coating system as specified on the plans. The cleaning and the zinc coating shall not be applied by any process, which can cause hydrogen embrittlement. All certification testing requirements and mill test reports referenced in the following sections shall be in accordance with Sec 106.

1080.2.5.1 Bolts. All bolts shall be in accordance with ASTM A 325 except when ASTM A 490 bolts are specified on the plans. If the contractor elects to use load indicator bolts, only a hex head will be permitted. The type of head used shall be consistent throughout the entire structure, unless otherwise approved by the engineer.

1080.2.5.1.1 Proof Load Tests. Proof load tests in accordance with ASTM F 606 Method 1 shall be performed. Minimum test frequency shall be in accordance with ASTM A 325.

1080.2.5.1.2 Wedge Tests. Wedge tests on full size bolts, in accordance with ASTM F 606, paragraph 3.5 shall be performed. If bolts are to be galvanized, tests shall be performed after galvanizing. Minimum test frequency shall be in accordance with ASTM A 325.

1080.2.5.2 Nuts. All nuts shall be in accordance with AASHTO M 292 as applicable or ASTM A 563, except as follows.

1080.2.5.2.1 Nut Grades. Ungalvanized nuts shall be grades 2, C, D or C3 with a minimum Rockwell hardness of 89 HRB or Brinell hardness 180 HB or heat treated grades 2H, DH or DH3. Nuts that are to be galvanized shall be heat treated grade 2H, DH or DH3.

1080.2.5.2.2 Overtapping. Nuts to be galvanized shall be tapped oversize the minimum amount required for proper assembly. The amount of overtap in the nut shall be such that the nut will assemble freely on the bolt in the coated condition and shall be in accordance with the mechanical requirements and the rotational-capacity test requirements of ASTM A 563. The overtapping requirements of ASTM A 563 will apply, except these limits shall be considered maximum values instead of the minimum, as currently shown.

1080.2.5.2.3 Nut Lubrication. All galvanized nuts, including ASTM A 194 nuts, shall meet the supplementary requirements of ASTM A 563. Galvanized nuts shall be lubricated with a lubricant containing a dye of any color that contrasts with the color of the galvanizing.

1080.2.5.2.4 Proof Load Tests. Proof load tests in accordance with ASTM F 606 shall be performed. Minimum test frequency shall be in accordance with ASTM A 563 or AASHTO M 292. If nuts are to be galvanized, tests shall be performed after lubricating.

1080.2.5.2.5 Weathering Steel. When Type 3 fasteners are specified for use with weathering steel, nuts shall be in accordance with ASTM A 563 and shall be grades C3 or DH3.

1080.2.5.3 Washers. All washers shall be in accordance with ASTM F 436. Hardness testing shall be performed on galvanized washers. The coating shall be removed prior to taking hardness measurements.

1080.2.5.4 Rotational-Capacity Tests. Rotational-capacity tests shall be performed on all bolt, nut and washer assemblies by the manufacturer or distributor prior to shipping. Washers shall be part of the test, regardless if they are required as part of the installation procedure or not. Tests shall be conducted after galvanizing when galvanizing is required.

1080.2.5.4.1 Test Methods. Except as modified herein, the rotational-capacity test shall be performed in accordance with ASTM A 325.

1080.2.5.4.2 Test Lots. Each combination of bolt production lot, nut lot and washer lot shall be tested as an assembly. Where washers are not required as part of the installation procedures, washers need not be included in the lot identification. A rotational-capacity lot number shall be assigned to each combination of lots tested. The minimum frequency of testing shall be two assemblies per rotational-capacity lot.

1080.2.5.4.3 Testing Device. The bolt, nut and washer assembly shall be assembled in a Skidmore-Wilhelm Calibrator or an acceptable equivalent device.

1080.2.5.4.4 Minimum Rotation. The minimum rotation, from a snug tight condition, 10 percent of the specified proof load, shall be as follows:

Minimum Bolt Rotation	
Bolt Length	**Rotation**
≤ 4 Diameters	240° (2/3 turn)
> 4 Diameters and ≤ 8 Diameters	360° (1 turn)
> 8 Diameters	480° (1 1/3 turn)

1080.2.5.4.5 Required Tension. The tension reached at the above rotation shall be equal to or greater than 1.15 times the required installation tension. The installation tension and the tension for the turn test for ASTM A 325 and ASTM A 490 bolts shall be as follows:

Required Bolt Tensions									
Diameter, in.	**1/2**	**5/8**	**3/4**	**7/8**	**1.00**	**1-1/8**	**1-1/4**	**1-3/8**	**1-1/2**
ASTM A 325									
Req. Installation Tension, kips	12	19	28	39	51	56	71	85	103
Turn Test Tension, kips	14	22	32	45	59	64	82	98	118
ASTM A 490									
Req. Installation Tension, kips	15	24	35	49	64	80	102	121	148
Turn Test Tension, kips	17	28	40	56	74	92	117	139	170

1080.2.5.4.6 Torque. After the required installation tension has been exceeded, one reading of tension and torque shall be taken and recorded. The torque value shall be as follows:

$$\text{Torque} \leq 0.25\ PD$$

Where:

Torque = measured torque, foot-pounds
P = measured bolt tension, pounds
D = bolt diameter, feet

1080.2.5.4.7 Short Bolts. Bolts that are too short to test in a Skidmore-Wilhelm Calibrator may be tested in a steel joint. The maximum torque requirement shall be computed using a value of P equal to the turn test tension shown in Sec 1080.2.5.4.5.

1080.2.5.5 Reporting. The results of all tests, including zinc coating thickness, required herein and in the applicable AASHTO/ASTM specifications and the location and date of the tests performance, shall be recorded on the appropriate document. The tests need not be witnessed by an inspection agency. The manufacturer or distributor performing the tests shall certify the results are accurate.

1080.2.5.6 Documentation for High Strength Fastener Assemblies.

1080.2.5.6.1 Mill Test Reports. A Mill Test Report (MTR) shall be furnished for all mill steel used in the manufacture of the bolts, nuts or washers. The MTR shall indicate the location where the material was melted and manufactured.

1080.2.5.6.2 Manufacturer Certified Test Reports. The manufacturer of the bolts, nuts and washers shall furnish a Manufacturer Certified Test Report (MCTR) for each item furnished including the following information:

(a) The lot number of each of the items tested.

(b) The rotational-capacity lot number as required in Sec 1080.2.5.4.2.

(c) The results of the tests required in Sec 1080.2.5.5.

(d) The pertinent information required in Sec 1080.2.5.4.2.

(e) A statement that MCTR for the items are in conformance to this specification and the applicable AASHTO/ASTM specifications.

The location where the bolt assembly components were manufactured.

Rotational capacity testing if completed by the manufacturer.

1080.2.5.6.3 Distributor Certified Test Reports. The Distributor Certified Test Report (DCTR) shall include MCTR for the various bolt assembly components. The rotational-capacity test may be performed by a distributor in lieu of a manufacturer and shall be reported on the DCTR. The DCTR shall indicate the following if not included in the MCTR:

(a) The results of the tests required in Sec 1080.2.5.5.

(b) The pertinent information required in Sec 1080.2.5.4.2.

(c) The rotational-capacity lot number as required in Sec 1080.2.5.4.3.

(d) A statement that the MCTR are in accordance with this specification and the applicable AASHTO/ASTM specifications.

(e) Certification of galvanizing from the galvanizing supplier shall be in accordance with Sec 1080.2.1.

1080.2.5.7 Shipping of High Strength Fastener Assemblies. Bolts, nuts and washers, where required, from each rotational-capacity lot shall be shipped in the same container in proportionate quantities for use. If there is only one production lot number for each size of nut and washer, the nuts and washers may be shipped in separate containers. Each shipping container shall be permanently marked by the manufacturer or distributor with the rotational-capacity lot number such that identification will be possible at any stage prior to installation. The appropriate MTR, MCTR or DCTR shall be supplied in accordance with the contract documents.

1080.2.6 Machine Bolts. Machine bolted field connections shall be made with machine bolts having American Standard Regular Heads and Nuts of hexagonal shape and shall be in accordance with ANSI B 18.2.1 and B 18.2.2. Threads shall extend slightly beyond the nut to permit burring. One plain washer in accordance with

ANSI B 18.22.1 shall be used at all slotted holes.

1080.2.7 Cast Steel. For cast steel, the foundry shall furnish a certified copy of foundry reports giving the chemical analysis and results of physical tests on the material from each heat. These reports shall be submitted for approval of material being furnished before any required machine work is done on the castings.

1080.2.8 Cast Iron. For gray iron castings, the foundry shall furnish one finished tension test specimen in accordance with AASHTO M 105 from each heat. The required machine work shall not proceed until material being furnished has been approved. If cast steel is furnished in lieu of gray iron, the minimum tensile strength shall be 50,000 psi.

1080.2.9 Identification of Metals. The steel shall be stamped or stenciled and color striped with paint at the mill. Heat numbers shall be steel stamped or stenciled with paint at the mill. Separate markings and color codes shall be in accordance with ASTM A 6. The characteristic color stripes shall be placed on each part cut from the mill piece. For steels not covered by ASTM A 6, the fabricator shall furnish the engineer the color coding in writing before fabrication begins. Heat numbers shall be painted on all principal pieces and these pieces shall be so noted on the shop drawings. Principal pieces for this requirement shall include all beams, flanges, webs, splice plates, cover plates, bearings, bearing stiffener plates, load bearing members of end diaphragms, pin plates, hanger plates and others as may be directed by the engineer. Principal pieces shall include individual plates of all truss members, truss gusset plates, splice plates and floorbeam connection angles. The color code and heat number markings shall be placed on the material such that the markings are visible throughout the work of fabrication. Loss of identification on pieces or items will be cause for rejection of the pieces or items.

1080.2.9.1 Fracture Critical Members. Principal pieces requiring identification shall also include components of fracture critical members. Traceability of both heat numbers and impact serial numbers shall be maintained for fracture critical members and attachments.

1080.2.9.2 Direction of Rolling. Unless otherwise indicated in the contract documents, steel plates for main members and splice plates for flanges and main tension members shall be cut and fabricated such that the primary direction of rolling is parallel to the direction of the principal tensile or compressive stresses. The direction of rolling shall be maintained for all principal pieces during fabrication.

1080.2.10 Steel Stamping. Any metal die stamping of match marks and erection marks in structural steel members shall be limited to a position in the end 1 1/2 inches of flange plates and flange splice plates, the middle third of web plates and the outside edge of the middle third of web splice plates. Metal die stamping at other locations or for other purposes may be approved by the engineer provided low stress dies are used. Low stress dies will be defined as those manufactured to produce impressions that are rounded at the bottom rather than sharp edged. Metal die stamping on pin plates and hanger plates will not be permitted.

1080.3 Fabrication and Inspection.

1080.3.1 Quality Assurance Inspection. The engineer will be responsible for QA inspection to assure the quality of the fabricated material. QA inspection by the engineer will not relieve the contractor of the responsibility to provide fabricated structural steel items in accordance with the contract documents. Sufficient QC, as necessary to assure work being performed conforms to the contract documents, shall be the responsibility of the contractor and fabricator. Following adequate notification that QC inspections and testing by the fabricator have been performed, QA inspection will be at the option of the engineer. Regardless of the location and degree of QA inspection, material and workmanship not meeting specified performance criteria or conforming to the contract documents or recognized good practice may be rejected at any time prior to final acceptance of the work.

1080.3.1.1 Locations of Inspection. QA inspection of fabricated material will ordinarily be made in the shop for fabricating shops within the 48 contiguous States and for shops outside the U. S., but within 1,000 miles of Jefferson City, MO. High strength bolts, nuts and washers shall be presented for sampling at the fabrication shop performing the primary fabrication or at a location agreed to by Construction and Materials. In some cases, QA inspection in the fabrication shop may be waived and inspection made when the fabricated material is delivered to the project site. All costs of QA inspection at fabricating shops located both outside the 48 contiguous States and more than 1,000 miles from Jefferson City, shall be at the contractor's expense. In such cases, the contractor will be charged with transportation costs and expenses of QA inspectors for trips made from Jefferson City to locations to which the inspectors must travel for shop inspection work. These

transportation costs and expenses of QA inspectors will be deducted by the Commission from monies due the contractor.

1080.3.1.2 Notification of Inspection. The engineer shall be notified at least four working days prior to the beginning of the shop fabrication so a QA inspector may be present if so desired and to allow the QA inspector to make travel arrangements. If the fabricator notifies and requests inspection and the QA inspector arrives at the location of inspection to find the material is not ready for inspection as indicated in the request, any travel costs incurred by MoDOT for additional inspection shall be paid by the contractor.

1080.3.1.3 Access for Inspection. The engineer shall have full access to all parts of the shop or project site where material is being fabricated or assembled and shall be provided with every reasonable facility for determining the character of material and workmanship.

1080.3.1.4 Field Inspection. No increased time or compensation will be allowed for additional work, delays or additional costs as a result of QA inspection at the project site, including required repairs, including where samples were removed, refabrication, securing samples for chemical analysis and physical tests.

1080.3.1.5 Office Space. A suitable office area shall be provided for exclusive use by the engineer. The office may be enclosed or semi-enclosed as available at the location of QA inspection, but shall be suitable for use as determined by the engineer. The floor space shall be at least 120 square feet unless otherwise approved by the engineer, weatherproof, secure, insulated and lighted. The office space shall be adequately ventilated, heated and air conditioned. Electric outlets with 110-120 volt, 60 Hz current and a telephone with outside line, inter-plant and dial-up computer capabilities shall be provided. Office furniture consisting of a desk, a minimum of 30 x 60 inches with drawers, a swivel desk chair with arms and a storage/filing cabinet with lock hardware and key shall be provided. All office furniture will be subject to approval by the engineer. Should any furniture become unsatisfactory, the furniture shall be promptly repaired or replaced to the satisfaction of the engineer. Accessible parking shall be provided near the office any time the shop is in operation on MoDOT projects. No direct payment will be made for furnishing and maintaining an acceptable office area for QA inspection.

1080.3.1.6 Certifications. All structural steel fabricators performing work for the following listed components of steel structures shall be certified prior to the start of fabrication under the appropriate category of the AISC Certification Program for Steel Bridge Fabricators or the AISC Certification Program for Bridge and Highway Metal Component Manufacturers as follows:

(a) Fabricators of unspliced rolled beams and temporary bridges shall be certified to the Simple Bridge (SBr) requirements.

(b) Fabricators of straight or curved (radius over 500 feet) rolled beams with field or shop splices, built-up welded constant depth straight or curved (radius over 500 feet) I-shape plate girders, built-up welded variable depth straight or curved (radius over 1000 feet) I-shaped plate girders, and trusses with a total length less than 200 feet or substantially pre-assembled and shipped in no more than three sub-assemblies shall be certified to the Intermediate Bridge (IBr) requirements.

(c) Fabricators of bridges beyond the listed structures of 1080.3.1.6(a) or 1080.3.1.6(b) shall be certified to the Advanced Bridge (ABr) requirements.

(d) Fabricators of fracture-critical members indicated in the contract plans shall also meet the requirements for fracture-critical certification in addition to the other bridge certifications.

(e) Fabricators of overhead sign trusses, steel bearings, POT bearings, finger plate expansion devices, and flat plate expansion devices shall be certified to the Bridge and Highway Metal Component Manufacturers requirements unless the fabricator is certified to one of the Steel Bridge Fabricator levels (SBr, IBr, or ABr).

(f) AISC certification will not be required for manufacturers of simple laminated or elastomeric bearing pad assemblies or PTFE bearing pad assemblies.

(g) Fabricators that apply steel painted coatings in the fabrication shop shall be certified to the AISC Applicators of Complex Coatings Endorsement (SPE) or SSPC QP3 – Shop Painting Certification Program.

1080.3.2 Shop Drawings. Shop drawings for structural steel and miscellaneous metals shall be required and shall be prepared in strict accordance with the design details shown on the plans. If details are lacking, the details shall be supplied and shall conform to the design plans and specifications. All drawings shall be clear and complete and shall be thoroughly checked before submittal. Shop drawings shall be completely titled in accordance with the contract plans and shall pertain to only a single structure. Four sets of the shop drawings for railroad structures and two sets for other structures shall be submitted to Bridge for approval. The prints submitted shall be legible and shall have distinct details of sufficient contrast to be suitable for microfilming. Prints that do not have the desired clarity and contrast will be returned for corrective action. One set of prints will be returned marked reviewed or approved subject to noted corrections. The contractor shall promptly make necessary corrections and resubmit for final approval. When shop drawings are approved, the contractor shall furnish as many additional prints as requested. Reproductions on cloth or film of the original shop drawings shall be required for railroad structures and shall be delivered to the engineer prior to completion of the work. The approval of shop drawings will cover only the general design features and in no case shall this approval be considered to cover errors or omissions in shop details. The contractor shall be responsible for the accuracy of the shop drawings, the fabrication of material and the fit of all connections. All changes in the fabrication and erection work caused by errors in shop drawings and any changes in fabrication necessary for satisfactory results shall be at the contractor's expense. After shop drawings have been approved, no changes in dimensions or substitutions of sections shall be made without written approval from the engineer. Shop drawings shall be revised to show any authorized changes and the required number of prints shall be furnished to the engineer.

1080.3.2.1 Non-Domestic Shop Drawings. Shop drawings from fabricators located outside the 48 contiguous States, whether marked approved or approved subject to the corrections noted, will be returned to the contractor and the contractor shall be responsible for transmitting the drawings to the fabricator for further handling. Should such fabricator also be the contractor, all prints will be returned to the office located on the project.

1080.3.2.2 Weld Procedures. All welding procedures to be used shall be prepared by the manufacturer, contractor or fabricator as a written procedure specification. For new welding procedures, two copies shall be submitted for approval prior to submitting shop drawings. Approved weld procedures will be kept on file by Bridge and may be considered for use on multiple projects. Any changes to the parameters of an approved welding procedure shall require submittal for approval. The shop drawings submitted for approval shall indicate the welding procedure to be used for each joint.

1080.3.2.3 Verification of Work. By submission of shop drawings, the contractor represents to the Commission that all material, field measurements, construction requirements, performance criteria and similar data have been verified. The contractor further represents that the shop drawings have been coordinated and verified with the details of the work to be performed by other fabricators and entities on the project. No allowance for additional costs or delays will be made to the contractor for incorrect fabrication as a result of failure to coordinate or perform these verifications.

1080.3.3 Fabrication. Fabrication of all parts of the structure shall be carefully done in strict accordance with the approved shop drawings.

1080.3.3.1 Straightening. Straightening of any deformed structural material shall be performed by non-injurious methods prior to being worked in the shop. Sharp kinks and bends will be cause for rejection.

1080.3.3.2 Holes. Holes for connections of main members shall be subpunched or subdrilled and reamed while assembled in the shop or may be drilled from the solid with main members and each splice plate fully assembled in their final erected positions. Holes for floor beams and framed stringer connections shall be drilled or reamed to a steel template of sufficient thickness to center the drill accurately and all members to be secured through the same group of holes shall be drilled or reamed from the same template. Holes may be punched full size in secondary members such as lateral, longitudinal and sway bracing, lacing bars, stay plates and diaphragms. Stacking of web splice plates during drilling or reaming operations on straight girders will be permitted.

1080.3.3.3 Reaming and Finishing of Holes. Reaming or drilling full size from the solid shall be done while the truss, girder, continuous I-beam or other component as noted, is assembled, either in an upright position or on its side, properly adjusted for camber and sweep and after the connecting parts have been firmly fastened together. A minimum of one full span, from bearing to bearing, shall be fully assembled before reaming or drilling full size begins. Connecting parts assembled in the shop for the purpose of reaming or drilling holes for field or shop connections shall not be interchanged or reversed and shall be matchmarked. A diagram showing

such marks shall be detailed on the shop drawings. Burrs resulting from reaming, drilling or punching shall be removed. All connections shall be disassembled after drilling or reaming to make these holes accessible for deburring. Required cleaning and painting shall be done after disassembly. Reamed, drilled or punched holes shall be round and perpendicular to the member. Any hole out of round more than 1/16 inch will be cause for rejection of the plate. Eighty-five percent of the holes in any group shall not show an offset greater than 1/32 inch between adjacent thicknesses of metal after reaming or drilling. All holes shall be drilled or reamed and aligned such that a bolt of the specified diameter will enter the hole and the head and nut will seat on the metal before tensioning.

1080.3.3.4 Applicable Codes. All welding, oxygen cutting, shearing and clipping and dimensional tolerances shall be in accordance with the ANSI/AASHTO/AWS D1.5: 2002, Bridge Welding Code. Tubular steel structures shall be governed by the current edition of the AWS D1.1, Structural Welding Code - Steel, in effect at the time of the contract, unless specified otherwise. Aluminum structures shall be governed by the current edition of the AWS D1.2, Structural Welding Code - Aluminum, except as amended by Sec 903, unless otherwise indicated.

1080.3.3.5 Modifications to the Bridge Welding Code. The following modifications to the ANSI/AASHTO/AWS D1.5 2002, Bridge Welding Code (AWS), shall apply:

1080.3.3.5.1 AWS Sec 1.3 Paragraph 1.3.4 - Paragraph 1.3.4 shall be replaced with the following:

The gas metal arc welding process shall not be used on any structural components of bridges. Approved gas metal arc processes may be used for incidental, non-structural components as may be specifically approved by the engineer. Tack welding with an approved gas metal arc process will be permitted for joints that will subsequently be welded using an approved submerged arc automatic welding process.

1080.3.3.5.2 AWS Sec 1.3 Paragraph 1.3.7 - A new Paragraph 1.3.7 shall be added as follows:

All primary shop welds shall be made by approved submerged arc automatic welding processes. The automatic welding process shall be one in which the wire or electrode feed, speed of travel and guidance are all mechanically controlled. Noncompliance with this requirement will be cause for rejection of the welded material unless prior approval is granted by the engineer for welding the specified joints by the use of other processes. The automatic welding process requirement for primary shop welds shall be shown on the shop drawings for each joint. Primary shop welds will be defined as flange and web butt welded splices in
I-beams, box members and plate girders, plate girder or box flange to web fillet welds and cover plate to flange fillet welds.

1080.3.3.5.3 AWS Sec 2.8 Paragraph 2.8.1.1 - Paragraph 2.8.1.1 shall be replaced with the following:

The minimum fillet weld size, except for fillet welds used to reinforce groove welds, shall be as shown in the following table or as calculated using procedures established to prevent cracking in accordance with Paragraph 4.2.2. In both cases, the minimum size will apply if the size is sufficient to satisfy design requirements.

Material Thickness of Thicker Part Joined, in.	Minimum Size of Fillet Weld[a], in.
To 3/4	1/4[b]
Over 3/4 to 2 1/2	5/16[b]
Over 2 1/2	1/2

[a]Except that the weld size need not exceed the thickness of the thinner part joined.
[b]Single pass welds must be used.

1080.3.3.5.4. AWS Sec 3.2 Paragraph 3.2.2.2 (4) - A new Paragraph 3.2.2.2 (4) shall be added as follows:

Quenched and tempered steel plate may be thermally cut provided sufficient preheating is applied according to the steel producer's written recommendations. Procedures for thermal cutting of quenched and tempered steel plate, along with the steel producer's written report, shall be submitted to the engineer for approval prior to the start of such work.

1080.3.3.5.5 AWS Sec 3.2 Paragraph 3.2.3.4 - Paragraph 3.2.3.4 shall be replaced with the following:

The corrective procedures described in Table 3.1 shall not apply to discontinuities in rolled base-metal surfaces. Such discontinuities may be corrected by the fabricator in accordance with ASTM A 6, except that repair by welding will be permitted only when approved by the engineer. Approval will be limited to areas where there will be less than the maximum design stress in the finished structure. When surface imperfections in alloy, low alloy and carbon steel plates are repaired by grinding, the surfaces shall have edges faired to the plate surface with a maximum slope of 1 in 10.

1080.3.3.5.6 AWS Sec 3.2 Paragraph 3.2.11 - A new paragraph 3.2.11 shall be added as follows:

Sheared edges of plates not to be welded that are more than 5/8 inch thick and carrying calculated stress shall be planed to a depth of 1/4 inch.
1080.3.3.5.7 AWS Sec 3.3.8 - Sec 3.3.8 shall be replaced with the following:
Temporary welds shall be subject to the same WPS requirements as final welds. Temporary welds shall be removed unless otherwise permitted by the engineer and the surface shall be made flush with the original surface. Unless previously approved in writing by the engineer, there shall be no temporary welds for fabrication, transportation, erection or other purposes on main members except at locations more than 1/6 the depth of the web from the flanges of beams and girders. There shall be no temporary welds in tension zones of members of quenched and tempered steels. Temporary welds at other locations shall be shown on shop drawings and shall be made with approved consumables. Removal of temporary welds shall conform to Paragraphs 3.3.7.3 and 3.3.7.4.

1080.3.3.5.8 AWS Sec 3.4 Paragraph 3.4.6 - Paragraph 3.4.6 shall be replaced with the following:

All shop splices in each component part of a cover-plated beam or built-up member shall be made and all required nondestructive testing completed and approved by the engineer before the component part is welded to other component parts of the member. Long members or member sections may be made by shop-splicing subsections, each made in accordance with this subsection (See 2.17.6). All shop splices shall be made using full penetration welds that fully develop the capacity of the original member. Additional shop splices required due to length limits of available material may be used if detailed on the shop drawings and placed at locations approved by the engineer. No additional payment will be made for any additional shop splices placed in the members at the option of the contractor, including shop splices that may be required as a result of material limitations.

1080.3.3.5.9 AWS Sec 3.5 Paragraph 3.5.1.8.1 - A new Paragraph 3.5.1.8.1 shall be added as follows:

The maximum permissible variation from specified width for rolled or burned flange plates shall be -1/8 inch to +3/8 inch.

1080.3.3.5.10 AWS Sec 3.5 Paragraph 3.5.1.9 - Paragraph 3.5.1.9 shall be replaced with the following:

The bearing ends of bearing stiffeners shall be flush and square with the web and shall have at least 75 percent of this area in contact with the inner surface of the flanges. The remaining
25 percent of the area of the bearing stiffener shall be within 0.010 inch of the inner surface of the flanges. When bearing against a steel base or seat, all steel components shall fit within 0.010 inch for 75 percent of the projected area of web and stiffeners and not more than 1/32 inch for the remaining 25 percent of the projected area. Girders without stiffeners shall bear on the projected area of the web on the outer flange surface within 0.010 inch. The included angle between web and flange shall not exceed 90 degrees in the bearing length. The top surface of a flange or shelf plate supporting a steel bearing rocker shall be considered a flat surface with a tolerance of 0.003 inch per inch in any direction over the projected area of the rocker. The top surface of a flange or shelf plate in direct contact with elastomeric bearings shall not deviate from a true plane surface by more than 1/16 inch.

1080.3.3.5.11 AWS Sec 3.5 Paragraph 3.5.1.16 - A new Paragraph 3.5.1.16 shall be added as follows:

Permissible variation in length of assembled beams or girders between the centerline of bearing devices shall not exceed plus or minus 1/4 inch for any one span or plus or minus
1/2 inch for any two or more spans within the assembled unit. The actual centerline of any bearing device shall lie within the thickness of the bearing stiffener.

1080.3.3.5.12 AWS Sec 3.7 Paragraph 3.7.2.5 - A new Paragraph 3.7.2.5 shall be added as follows:

If, after three repairs to the same area of a weld requiring radiographic quality, there is any part of the original defect remaining or there is a new rejectable indication, the total joint shall be cut apart, all deposited weld metal removed, joint preparation made and the total joint rewelded.

1080.3.3.5.13 AWS Sec 3.7 Paragraph 3.7.2.6 - A new Paragraph 3.7.2.6 shall be added as follows:

The gas metal arc welding process shall not be used for the repair of welds except when repairing welds made with the GMAW process.

1080.3.3.5.14 AWS Sec 5.21 Paragraph 5.21.6.2 - A new Paragraph 5.21.6.2 shall be added as follows:

Any cost involved in qualifying welders, welding operators and tackers, including all material costs, finishing of test specimens, the physical testing of finished specimens and any radiography required shall be borne by the contractor. Required radiography and physical testing of finished specimens shall be performed at test facilities approved by the engineer.

1080.3.3.5.15 AWS Sec 6.6 Paragraph 6.6.5 - Paragraph 6.6.5 shall be replaced with the following:

If the engineer subsequently requests nondestructive testing, not specified in the original contract agreement, the contractor shall perform any requested testing or shall permit any requested testing to be performed. Handling, surface preparation, repair welds and any nondestructive testing requested by the engineer, as a result of weld repair, shall be at the contractor's expense. Payment for any non-destructive testing that does not indicate the need for repair to the tested weld will be in accordance with Sec 109.4.

1080.3.3.5.16 AWS Sec 6.7 Paragraphs 6.7.1, 6.7.1.1 and 6.7.1.2 - Paragraphs 6.7.1, 6.7.1.1 and 6.7.1.2 shall be replaced with the following:

Radiographic inspection shall be required for areas of both shop and field butt welds as specified herein. One hundred percent inspection shall be required for flanges of rolled beams and girders and 100 percent of transverse butt welds in webs for a distance of no less than one-sixth of the web depth from each flange and 25 percent of the remainder of the web depth. At least one-third of the length of all longitudinal web splices shall be radiographed at even intervals throughout the length of the splice. When a rejectable defect is found by radiography in any partially tested joint, either initially or in a later additional radiograph, tests shall be conducted on either side of and adjacent to the rejectable test area. If a rejectable defect is found in any additional areas, then 100 percent of vertical web splices and an additional 10 percent of total weld length in longitudinal web splices shall be tested. The location of these additional test areas shall be as directed by the engineer. All complete joint penetration groove welds in T- and corner joints shall be tested by ultrasonic testing.

1080.3.3.5.17 AWS Sec 6.10 Paragraph 6.10.3.4 - A new Paragraph 6.10.3.4 shall be added as follows:

Edge blocks shall be used when radiographing butt welds greater than 1/2 inch in thickness. The edge blocks shall have a length sufficient to extend beyond each side of the weld centerline for a minimum distance of 2 inches and shall have a thickness equal to the thickness of the weld, plus or minus 1/16 inch. The minimum width of the edge blocks shall be no less than 1 inch. The edge blocks shall be centered on the weld with a snug fit against the plate being radiographed, allowing no more than 1/16 inch gap. Edge blocks shall be made of radiographically clean steel and the surface shall have a finish of ANSI 125µin. or smoother (refer to ANSI/AWS D1.1-98 Structural Welding Code - Steel, Sec 6.17, Paragraph 6.17.13 and Figure 6.15).

1080.3.3.5.18 AWS Sec 6.10 Paragraph 6.10.11.2 - Paragraph 6.10.11.2 shall be replaced with the following:

If the greatest and least thickness of a weld connecting parts of different thickness cannot be rendered with adequate contrast on a single film with a single exposure, a dual film or dual exposure technique shall be used to obtain suitable density for both the greatest and the least thickness of the weld.

1080.3.3.5.19 AWS Sec 6.12 Paragraph 6.12.4 - A new Paragraph 6.12.4 shall be added as follows:

After completion of all radiographic inspection, the contractor shall submit to the engineer one set of drawing details showing the location and identification numbers of all radiographs taken.

1080.3.3.5.20 AWS Sec 6.26 Paragraph 6.26.2.1 - Paragraph 6.26.2.1 shall be replaced with the following:

For any welds, the greatest dimension of any porosity or fusion type discontinuity that is
1/16 inch or larger in greatest dimension shall not exceed the size, B, indicated in Figure 6.8 for the effective throat or weld size involved. The distance from any porosity or fusion type discontinuity described above to another such discontinuity, to an edge or to the toe or root of any intersecting flange-to-web weld shall not be less than the minimum clearance allowed, C, indicated in Figure 6.8 for the size of discontinuity under examination.

1080.3.3.5.21 AWS Sec 6.26 Paragraph 6.26.2.2 and Figure 6.9 - Delete paragraph 6.26.2.2 and Figure 6.9.

1080.3.3.5.22 AWS Sec 6.26 Paragraph 6.26.3.1 - Paragraph 6.26.3.1 shall be replaced with the following:

Welds subjected to ultrasonic testing in addition to visual inspection shall conform to the requirements of Table 6.3.

1080.3.3.6 Calibrated Tapes. When the contract involves fabrication of a bridge with a bearing-to-bearing span of 100 feet or more, certifications and identifying numbers of calibrated measuring tapes or numbered tapes matched to a calibrated master shall be kept on file for review by the engineer. Certification of the measuring tape to be used or certification of the master from which the tape was matched shall be traceable to the U. S. National Bureau of Standards. Certification of tapes for shop use shall be renewed at least every two years.

1080.3.3.7 Connection Angles. Connection angles for floor beams and stringers shall be flush and shall be correct as to position and length of member. If milling is required, no more than 1/16 inch shall be removed from the thickness of the angles.

1080.3.3.8 Longitudinal Stiffeners. Longitudinal girder web stiffeners shall be a single length if possible. If more than a single length is necessary, such lengths shall be joined by a full penetration butt weld. The location of these butt welds shall be shown on the shop drawings for each joint and shall be subject to approval by the engineer. Runoff plates in accordance with AWS Section 3.12 shall be used. The welds shall be radiographically tested and accepted in accordance with AWS Sec 6.10 prior to being attached to the web.

1080.3.3.9 Pins. Pins shall be furnished true to size and shall be straight, smooth and free from flaws. Pins shall be provided with hexagonal chamfered nuts. The screw ends shall be sufficiently long to permit burring the threads when members are connected. Pilot and driving nuts shall be furnished for each size of pins where required. Threads for all pins and bolts shall conform with the ANSI B1.1 Free Fit - Class 2 Series except that when recessed nuts are specified, pin ends requiring a threaded diameter of 1 3/8 inches or more shall have six threads per inch. If standard nuts are specified for this size pin, a minimum of four threads to the inch shall be used.

1080.3.3.10 Pin Holes. Pin holes shall be bored true to size, smooth and straight, at right angles to the axis of the member and parallel with each other. The boring shall be done after the member is assembled and welded. The center-to-center distance of pin holes shall be correct within 1/32 inch for an individual component or member. The diameter of pin holes shall not exceed that of the pin by more than 1/50 inch for pins 4 inches or less in diameter or no more than 1/32 inch for pins larger than 4 inches in diameter.

1080.3.3.11 Casting. Castings shall be free from inclusions of foreign material, casting faults, injurious blow holes or other defects which render the castings unsuitable for the service intended. Castings shall be properly filleted at re-entrant angles. No tolerance will be allowed below the dimensions shown on the plans for thicknesses over an appreciable area of the casting. A reasonable oversize will not be cause for rejection.

1080.3.3.12 Bent Plates. Bent plates shall be cold bent and taken from the stock plates such that the bend line will be at right angles to the direction of rolling. The radius of bends, measured to the concave face of the metal, shall be in accordance with the requirements as shown in the table below, in which "T" is the thickness of the plate. If a shorter radius is required, the plates shall be hot bent. Hot bent plates shall be bent at right angles to the direction of rolling. Before hot or cold bending, the corners of the plate shall be rounded to a radius of 1/16 inch throughout that portion of the plate at which the bending is to occur.

Angle Through Which Plate is Bent	Minimum Radius

61 degrees to 90 degrees	1.0 T
Over 90 degrees to 120 degrees	1.5 T
Over 120 degrees to 150 degrees	2.0 T

1080.3.3.13 Surface Finish. Bearing plates of rolled steel not requiring a surface finish shall be straightened to a plane surface. The surfaces of plates of rolled steel or cast material which are to be in contact shall be finished as shown on the plans and the final finish shall be prepared in a manner to give at least 50 percent contact as indicated by standard machinist's blue test. Rockers and pedestals made from rolled steel shall be finished after welding. If a flat surface is shown on the plans, the tolerance shall be 0.003 inch per inch in any direction. Flat surfaces in full contact shall be finished at right angles to each other. Bearing plates shall be assembled in sets. The surface finish of bearing and base plates and other bearing surfaces that are to come in contact with each other or with concrete shall meet the following surface roughness requirements as defined in ANSI B 46.1, Surface Roughness, Waviness and Lay, Part I:

Surface Roughness Requirements	Micro-inches, Max.
Steel Slabs	2,000
Heavy Plates in Contact in Shoes to be Welded	1,000
Milled Ends of Compression Members, Stiffeners and Fillers	500
Bridge Rollers and Rockers	250
Pins and Pin Holes	125
Sliding Bearings	125

1080.3.3.14 Horizontally Curved Rolled Beams and Plate Girders. If the plans show rolled beams or welded plate girders to be finished to a horizontal curvature, fabrication shall be as follows:

(a) Rolled beams shall be curved by the heat curving procedure.

(b) Welded plate girders may be fabricated by cutting the flanges to the specified curvature before the girders are attached to the webs or, if not prohibited by the contract, may be curved by the heat curving procedure.

(c) If the heat curving procedure is used, the procedure shall comply with the following requirements:

(1) Material. Heat curving of rolled beams and welded plate girders shall be limited to AASHTO M 270 Grade 36, AASHTO M 270 Grade 50, AASHTO M 270 Grade 50W and AASHTO M 270 Grade HPS 70W.

(2) Type of Heating. Beams and girders may be curved by either continuous or V-type heating.

(3) Temperature. The heat curving operation shall be conducted such that the temperature of the steel never exceeds 1,100 F as measured by temperature-indicating crayons or other suitable means applied before heating. The heating of the steel to a temperature greater than 1,200 F will be considered destructive heating and will be conclusive cause for rejection of the steel. Quenching with water or water and air, will not be permitted. Cooling with dry compressed air will be permitted after the steel has cooled to 600 F.

(4) Position for Heating. The girder may be heat curved with the web in either a vertical or a horizontal position, unless noted on the contract plans. When curved in the vertical position, the girder shall be braced or supported in such a manner that the tendency of the girder to deflect laterally during the heat curving process will not cause the girder to overturn. When curved in the horizontal position, the girder shall be supported near the ends and at intermediate points, if required, to obtain a uniform curvature. When the girder is positioned horizontally for heating, intermediate safety catch blocks shall be maintained at the mid-length of the girder within 2 inches of the flanges at all times during the heating process.

(5) Sequence of Operations. Heat curving shall be completed before the girder is painted. The contractor shall submit a curving procedure addressing the attachment of stiffeners, connection plates and cover plates for review prior to commencement of the heat curving

process.

1080.3.3.15 Shop Assembly.

1080.3.3.15.1 If required by the contract, the structural steel for bridges shall be completely shop assembled for inspection, supported only at points of bearing. Long bridges required to be entirely shop assembled may be divided into units for assembly with each unit extending from expansion device to expansion device.

1080.3.3.15.2 Beams and girders of all other bridges shall be assembled for inspection in line assemblies with a minimum length assembled of one complete span, from bearing to bearing.

1080.3.3.15.3 During shop assembly, connecting parts shall be firmly fastened together and held in alignment with a minimum of four drift pins and four make-up bolts per flange splice plate, web splice plate or similar connecting part, until assembly inspection is complete.

1080.3.3.15.4 All trusses, plate girders and continuous I-beams shall be assembled to permit inspection of all parts. QA inspection of the assembly will be at the option of the engineer.

1080.3.3.16 Shop Measurement of Curvature and Camber. Horizontal curvature and vertical camber will not be measured for QA inspection in the shop until all welding, drilling and heat curving operations have been completed and the flanges have cooled to a uniform temperature. For bridges not requiring complete shop assembly, the vertical camber will be checked with the girder in a horizontal position and the horizontal curvature will be checked with the girder in either a horizontal or vertical position. The shop drawings shall show the required offsets for both curvature and camber at approximately 10-foot intervals, measured along the girder. The permissible variation in specified sweep for horizontally curved beams and girders, measured in inches, but not to exceed 1/2 inch, shall be as follows:
1/8 inch x 0.1 x (number of feet from end bearing)

1080.3.4 Shear Connector Studs. Shear connector studs may be attached to the beams or girders either in the fabricating shop or in the field. All applicable requirements of the Occupational Safety and Health Administration (OSHA) shall be met. If the shear connector studs are to be attached in the field, the contractor shall notify the engineer no less than one week before the contractor begins welding shear connectors to the beams or girders so the engineer may inspect for approval the proposed welding procedure and equipment. Only welding procedures, equipment and operators meeting the requirements of Secs 1080.3.3.4, 1080.3.3.5 and 712 shall be used. Areas to which shear connectors are to be attached shall be cleaned of all foreign material, such as oil, grease or paint by a suitable method. Where a shop coat of inorganic zinc primer has been applied, removal shall be limited to the minimum area necessary to apply the studs. After completion of the welding operations, the primed area shall be touched up with a suitable inorganic zinc primer or epoxy mastic paint (non-aluminum). Where galvanized steel beams or girders are specified, galvanizing material shall be omitted or removed one inch clear of weld locations. The method used to omit or remove the galvanizing material shall be masking, grinding or other methods approved by the engineer. After completion of the welding operations, the ungalvanized areas of the beam or girders shall be coated with epoxy mastic paint (non-aluminum).

1080.3.5 Shipping. Fabricated material shall not be shipped before a "Fabrication Inspection Shipment Release" is issued by the engineer. All parts shall be loaded and protected to prevent damage in transit. Pins, nuts, bolts and other small parts shall be boxed or crated. The "Fabrication Inspection Shipment Release" shall be delivered by the contractor to the engineer at destination prior to erection of steel.

1080.4 Weathering Steel.

1080.4.1 Description. This section contains provisions that shall modify, supplement and expand the requirements of the contract plans and other provisions of Sec 1080 when the use of weathering steel is specified for structures. Weathering steel will be defined as structural steel specified under AASHTO M 270 Grades 50W, HPS 50W and HPS 70W that is intended to be primarily used in a bare, uncoated application for the structure.

1080.4.2 High Performance Steels.

1080.4.2.1 Material Requirements. All high performance steel shall be in accordance with the latest edition of AASHTO M 270 and supplements. As an option, HPS 50W and HPS 70W thermomechanical-controlled-

processing (TMCP) steel plates available from the manufacturer in limited thicknesses may be directly substituted for the quenched and tempered product.

1080.4.2.2 Fabrication Requirements. All fabrication shall be in accordance with the latest edition of the *AASHTO Guide Specifications for Highway Bridge Fabrication with HPS70W Steel*, an addendum to be used in conjunction with ANSI / AASHTO / AWS D1.5: 2002, except as modified by this section. Only fabricators meeting the requirements of the AISC Certification Program for Steel Bridge Fabricator Advanced Bridge (ABr) classification or approved equal may be used to fabricate HPS 50W and HPS 70W steel. Whenever magnetic particle testing is conducted, only the yoke technique will be permitted as described in Sec 6.7.6.2 of AWS D1.5: 2002, modified to test using alternating current only.

1080.4.2.3 Welding Requirements for HPS. All welding for high performance steel shall be in accordance with AASHTO / ANSI / AWS D1.5: 2002 Bridge Welding Code except as modified herein and by the latest edition of the AASHTO Guide Specifications for Highway Bridge Fabrication with HPS70W Steel. Only submerged arc and shielded metal arc welding processes shall be permitted when welding Grade HPS 70W steel. The matching submerged arc consumables using the ESAB electrode and Lincoln flux combinations, recommended in Appendix A of the guide specification shall not be allowed. Filler metals used for single pass fillet welds or for complete joint penetration groove welds connecting Grade HPS 70W plate to ASTM A 709 Grade HPS 50W or Grade 50W may conform to the matching or undermatching requirements from AWS D1.5: 2002 as indicated in the guide specification. Moisture resistant coating shall be required for all shielded metal arc welding. The contractor may request approval of alternate consumables in lieu of the filler metals listed in the guide specification for submerged arc welding in accordance with AWS D1.5 Table 4.1. The request for approval shall include documentation of successful welding and shall include diffusible hydrogen tests indicating the levels of diffusible hydrogen to meet the requirements of the guide specifications. Grade HPS 50W may be welded under the same requirements as ASTM A 709 Grade 50W.

1080.4.3 Cleaning. Except for the areas of the structure to be partially coated as described in Sec 1080.4.4, all surfaces of the structural steel shall be blast cleaned in the fabrication shop to meet the requirements of the Steel Structures Painting Council (SSPC) SSPC-SP6 and may be left uncoated. Faying surfaces of connections to be shop bolted shall be blast cleaned prior to permanent assembly of the connections. After blast cleaning, the steel shall be kept clean of all foreign material. If the steel becomes contaminated, the steel shall be cleaned with a method approved by the engineer. Girders contaminated with concrete or grout splatters shall be washed off before the material is allowed to dry.

1080.4.4 Partial Coating. The surfaces of all structural steel located under expansion joints, but not in contact with concrete, shall be coated with complete System H within a distance of 1 1/2 times the girder depth, but no less than 10 feet, from the centerline of all deck joints. Within this limit, items to be coated shall include all surfaces of beams, girders, diaphragms, stiffeners, bearings and miscellaneous structural steel items. The prime coat for the specified paint system shall be applied to the structural steel within the above limits in the fabrication shop. The intermediate and finish coats shall be applied in the field in accordance with Sec 1081.10.3.11. The color of the finish coat shall be brown. Portions of the structural steel embedded in or in contact with concrete, including but not limited to the top flanges of girders, shall be coated with no less than 2.0 mils of the prime coat for System H. Shear connectors may not be coated or protected from overspray.

1080.4.4.1 Surface Preparation. All surface preparation and application of the partial coating described herein shall be as specified in Sec 1081. Required work shall include blast cleaning for all areas to receive the specified prime coat to SSPC-SP-10 (Near White Blast Cleaning) in accordance with Sec 1081.10.3.3, except that areas to be primed that will be embedded in concrete may be prepared to no less than SSPC-SP-6. The limits of the areas to be shop and field coated shall be masked to provide crisp, straight lines to prevent overspray on adjacent areas.

1080.4.4.2 Drain Bracket Coating. The galvanized surfaces of drain support brackets shall be prepared according to the coating manufacturer's recommendation and field coated with a gray epoxy mastic primer (non-aluminum) within a distance of 6 inches from the point of connection to the weathering steel structure.

1080.4.5 Bolting and Fasteners. All fasteners, such as bolts, nuts and washers, that bolt directly to the weathering grade structural steel, including fasteners located in areas of the structure to be partially coated and fasteners for expansion device supports and similar items shall be high strength weathering fasteners with atmospheric corrosion resistance and weathering characteristics comparable with the A 709 weathering steel. Bolts shall be in accordance with ASTM A 325, Type 3. Nuts shall be in accordance with the requirements of

ASTM A 563 and shall be Grades C3 or DH3. Washers shall meet the requirements of ASTM F 436, Type 3. All other requirements of Secs 712 and 1080 relating to high strength fastener assemblies and fastener assembly installation shall remain in effect. Fasteners for slab drain brackets may be plain uncoated assemblies in accordance with Sec 1080.2.5 and coated in accordance with Sec 1080.4.5.1.

1080.4.5.1 Coated Connections. Weathering grade fasteners in contact with coated structural steel items or located in areas of the structure to be partially coated shall be initially prepared and coated in the field with a gray epoxy mastic (non-aluminum) after the erection of the structure in accordance with the same procedure specified in Sec 1081. The epoxy-primed fasteners shall be subsequently coated with the System H field coats specified for the structure in areas to be partially coated.

1080.4.5.2 Cleaning. Prior to field bolting connections of high strength fasteners, the faying surfaces shall be cleaned of loose rust by abrasive blast, power hand tools or other approved methods. Tightly adhering rust will not be required to be removed.

1080.4.6 Welding. All welds shall utilize welding processes and electrodes as required that will provide corrosion resistance and weathering characteristics for the welds comparable to the base metal, in accordance with the Section 4 of AWS D1.5: 2002 or as modified in Sec 1080.4.2.3.

1080.4.7 Bearings and Anchor Bolts. Steel bearings, plate steel for elastomeric and PTFE bearings, structural steel for POT bearings, anchor bolts, sole plates, masonry plates and associated items shall be in accordance with ASTM A 709 Grade 50W. Anchor bolt nuts shall be heavy hexagon nuts in accordance with ASTM A 563, Grades C3 or DH3. The exposed surfaces of all bearings for weathering steel structures under expansion joints shall be shop primed and field coated with the complete System H in accordance with Sec 1080.4.4 and 1081.

1080.4.8 Protection of Concrete Masonry. All substructure concrete shall be protected from the effects of rust staining during construction in accordance with Sec 711.

1080.4.9 Storage of Weathering Steel. Weathering steel shall be stored under conditions that will prevent unsightly, uneven weathering and excessive corrosion. If uneven weathering occurs, the contractor shall reclean the steel to the satisfaction of the engineer. If cleaning does not produce satisfactory uniformity in appearance or if in the judgment of the engineer, excessive corrosion or chemical contamination has occurred, the contractor shall replace the material at the contractor's expense. As a minimum, the following conditions shall be avoided and the contractor shall take additional precautions as deemed necessary:

(a) Storage in transit, open cars or trucks for an extended period of time.

(b) Standing water on material in storage or entrapment of moisture.

(c) Contact with chemically treated lumber used for blocking or other types of foreign matter.

(d) Exposure to chlorides or other chemical contamination.

1080.5 High Strength Bolt Installation. Shop installed high strength bolts shall be in accordance with Sec 712.

1080.6 Coating of Structural Steel. Shop coating of structural steel shall meet the requirements of Sec 1081.

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SECTION 1081
COATING OF STRUCTURAL STEEL

1081.10 Protective Paint Systems.

1081.10.1 Scope. This specification covers coating new and existing bridges and structures made of structural steel and miscellaneous metal with protective paint systems.

1081.10.2 Systems of Coatings. The required system and color or choice of systems and color will be specified on the plans. Each coat of the specified system shall be applied to all structural steel, unless the contract specifically delineates otherwise. The system and color of coating to be shop-applied shall be shown on the shop drawings. All coatings shall comply with local VOC (Volatile Organic Compound) regulations where the paint is applied. The system and color shall not vary for any portion of the entire structure, including material for field repairs and shall be compatible products of a single manufacturer. The contractor shall coordinate the various items of work to ensure compliance with the requirements of this section. Approved material specifications and dry film thickness for the coating systems shall be as indicated in the following table:

Paint Systems for Structural Steel		
System G (High Solids, Inorganic Zinc Silicate-Epoxy-Polyurethane)		
Coating	**Section**	**Dry Film Thickness, mils**
Prime Coat	1045.3	3.0 min. to 6.0 max.
Epoxy Intermediate Coat	1045.4	3.0 min. to 5.0 max.
Polyurethane Finish Coat, Gray or Brown	1045.5	2.0 min. to 4.0 max.
System H (High Solids, Inorganic Zinc Silicate-Waterborne Acrylic Intermediate-Waterborne Acrylic Finish)		
Coating	**Section**	**Dry Film Thickness, mils**
Prime Coat	1045.3	3.0 min. to 6.0 max.
Waterborne Acrylic, Intermediate Coat	1045.6	2.0 min. to 4.0 max.
Waterborne Acrylic, Finish Coat, Gray or Brown	1045.6	2.0 min. to 4.0 max.
System I (High Solids, Inorganic Zinc Silicate-Polysiloxane)		
Coating	**Section**	**Dry Film Thickness, mils**
Prime Coat	1045.3	3.0 min. to 6.0 max.
Polysiloxane Finish Coat	1045.7	3.0 min. to 6.0 max.
Calcium Sulfonate System		
Coating	**Section**	**Dry Film Thickness, mils**
Calcium Sulfonate Rust Penetrating Sealer	1045.10.2	1.0 min.
Calcium Sulfonate Primer	1045.10.3	4.0 min.
Calcium Sulfonate Topcoat	1045.10.4	5.0 min.
Aluminum & Gray Epoxy-Mastic Primer		
Coating	**Section**	**Dry Film Thickness mils**
Aluminum Epoxy-Mastic Primer	1045.8	5.0 min.
Gray Epoxy-Mastic Primer	1045.9	5.0 min

1081.10.3 Protective Coating of Structural Steel.

1081.10.3.1 Scope. This specification covers the preparation of previously uncoated structural steel surfaces, furnishing and applying specified coatings, protection and drying of coatings, furnishing protection from coating spatter and disfigurement, and final cleanup.

1081.10.3.2 Certification. Contractors performing coating operations for new structural steel shall be certified prior to the start of coating operations under the following SSPC Certified Contractor QP programs as follows:

(a) For field application of intermediate and finish coats, the contractor shall be certified to the SSPC QP1 – Field Application to Complex Industrial and Marine Structures.

(b) For shop application of any coats by the steel fabricator, the fabricator shall be certified in accordance with Sec 1080.3.1.6 (g).

(c) For field application of gray epoxy mastic primers to new steel and contact surfaces between the new steel and existing steel, no SSPC QP certification will be required.

1081.10.3.3 Surface Preparation.

1081.10.3.3.1 Cleaning. Oil, grease and other contaminants shall be removed in accordance with procedures from Steel Structures Painting Council specification SSPC-SP1 prior to blast cleaning. Where high strength bolts are installed prior to blast cleaning or finish coat, the lubricant on high strength bolt assemblies shall also be removed in accordance with SSPC-SP1. Surfaces to be prime coated shall be blast cleaned with abrasives in accordance with SSPC-SP10, producing a height of profile 1.5 mils minimum and 3.0 mils maximum for all systems. The appearance of the final blast cleaned surface shall be in accordance with SSPC-Vis1, Photograph A SP-10, B SP-10, C SP-10, or D SP-10. Conformance with the corresponding SP-5 photographs will also be acceptable. The blast profile shall be assessed with replica tape per ASTM D 4417, Method C. The contractor shall make available to the engineer access to all SSPC specifications referenced for cleaning and coating operations.

1081.10.3.3.2 Preparation for Coating. After blast cleaning, all surfaces shall be cleaned to remove any trace of blast products, dust or dirt from the surface and from all pockets and corners. Sharp fins resulting from the blast cleaning operation shall be removed with an approved method that will maintain the minimum anchor profile for the prime coat. The blast-cleaned surfaces shall be given the specified prime coat as soon as practical, but within 24 hours after blast cleaning. If blast cleaned surfaces rust before coating is accomplished, the surface shall be reblasted by the contractor at the contractor's expense. All rusted, damaged or uncoated areas, including ungalvanized nuts, bolts and washers to be prime coated in the field, shall be blast cleaned to the same degree as specified above for the applicable coating system. Care shall be exercised to ensure the blasted steel remains free of grease and oil during handling.

1081.10.3.3.3 Recleaning. When there is contamination of any blast-cleaned surface to be coated, the material shall be recleaned to the requirements of SSPC-SP10.

1081.10.3.4 Limits of Coating Application. Unless otherwise indicated on the plans, the application of the intermediate and finish coats for Systems G and H, and the application of the finish coat for System I, hereinafter referred to as field coats, shall be applied to the structure within the following limits.

1081.10.3.4.1 Bridges over Roadways. This section will not apply to bridges over railroads.

1081.10.3.4.1.1 The intermediate field coat for beam and girder spans shall be applied to the surfaces of all structural steel, except that areas of steel to be in contact with concrete shall not receive the intermediate coat. The intermediate coat shall also be applied to the bearings, except where bearings will be encased in concrete. The finish coating for beam and girder spans shall include the facia girder or beams. The limits of the facia girders or beams shall include the bottom of the top exterior flanges, top of the bottom exterior flanges, the exterior web area, the exterior face of the top and bottom flange and the bottom of the bottom flange. Areas of steel to be in contact with concrete shall not receive the finish coat. The finish coat shall also be applied to the exterior bearings, except where bearings will be encased in concrete.

1081.10.3.4.1.2 The surfaces of all structural steel located under expansion joints of beam and girder spans shall be field coated for a distance of 1 1/2 times the girder depth, but no less than 10 feet from the centerline of the joint. Within this limit, the items to be field coated shall include all surfaces of beams, girders, bearings, diaphragms, stiffeners and miscellaneous structural steel items. Areas of steel to be in contact with concrete shall not receive the field coats. The limits of the field coatings shall be masked to provide crisp, straight lines and to prevent overspray on adjacent areas.

1081.10.3.4.1.3 For all truss or steel box girder spans, the above limits will not apply and all structural steel for these span types shall be field coated, except the areas of steel to be in contact with concrete.

1081.10.3.4.1.4 Straps for steel stay-in-place forms shall be removed in areas where field coating shall be required in accordance with this Specification. Flame cutting will not be permitted. The contractor shall take care not to damage the structure or the shop coating during strap removal. Any damage to the shop coating as a result of the contractor's operations shall be repaired by the contractor in accordance with this Specification. Any damage to the rest of the structure shall be repaired as approved by the Engineer.

1081.10.3.4.1.5 When System I is specified on the plans for beam and girder spans, a System G intermediate coat shall be applied similarly in accordance with Sec 1081.10.3.4.1.1 intermediate field coating requirements

except that an intermediate coat will not be required to be applied to the beams and girders where the System I finish coat is to be applied. The contractor shall have the option to substitute the System I finish coat in place of a System G intermediate coat.

1081.10.3.4.2 Bridges Over Streams or Railroads.

1081.10.3.4.2.1 The field coating for beam and girder spans shall include the facia girders or beams. The limits of the facia girders or beams shall include the bottom of the top exterior flanges, top of bottom exterior flanges, the exterior web area, the exterior face of the top and bottom flange and the bottom of the bottom flange. Areas of steel to be in contact with concrete shall not receive the field coats. The field coatings shall also be applied to the exterior bearings, except where bearings will be encased in concrete. The interior beams or girders shall only have the prime coat applied with no other field coating required.

1081.10.3.4.2.2 The surfaces of all structural steel located under expansion joints of beam and girder spans shall be field coated for a distance of 1 1/2 times the girder depth, but no less than 10 feet from the centerline of the joint. Within this limit, the items to be field coated shall include all surfaces of beams, girders, bearings, diaphragms, stiffeners and miscellaneous structural steel items. Areas of steel to be in contact with concrete shall not receive the field coats. The limits of the field coatings shall be masked to provide crisp, straight lines and to prevent overspray on adjacent areas.

1081.10.3.4.2.3 For all truss or steel box girder spans, the above limits will not apply and all structural steel for these span types shall be field coated, except the areas of steel to be in contact with concrete.

1081.10.3.4.2.4 Straps for steel stay-in-place forms shall be removed in areas where field coating shall be required in accordance with this Specification. Flame cutting will not be permitted. The contractor shall take care not to damage the structure or the shop coating during strap removal. Any damage to the shop coating as a result of the contractor's operations shall be repaired by the contractor in accordance with this Specification. Any damage to the rest of the structure shall be repaired as approved by the Engineer.

1081.10.3.5 Coating Thickness Measurement. The dry film thickness of the coatings will be measured by magnetic-type gauges in accordance with Steel Structures Painting Council, specification SSPC-PA2. At the option of the engineer, the adhesion of the prime coat will be measured in accordance with ASTM D 3359, Test Method A. When the adhesion is tested, each test result shall equal or exceed scale 3A. Locations for adhesion tests shall be randomly selected. Test locations shall be in areas of least visibility in the completed structure and shall be touched up in an approved manner after completion of the test. When satisfactory test results are not obtained, additional adhesion tests shall be taken to determine the area of insufficient adhesion. For these areas, the surface shall be prepared in accordance with Sec 1081.10.3.3.1 and the area recoated in accordance with these specifications. If additional prime coat is required to provide the specified minimum thickness, the prime coat shall be applied as soon as possible, but within 24 hours of the initial application.

1081.10.3.6 Coating Material Storage. All coating material shall be stored in accordance with the coating manufacturer’s recommendations. Exposure to storage temperatures outside the range recommended in the manufacturer's specifications will be considered cause for rejection of the coating material.

1081.10.3.7 Weather Conditions.

1081.10.3.7.1 Temperature Limitations. The prime coat shall be applied in accordance with the manufacturer’s recommendations, except that the minimum air and steel temperature shall be no less than 34 F. Finish and intermediate coats applied over the prime coat shall be applied in accordance with the manufacturer's recommendations, which shall be furnished to the engineer. The minimums and maximums or additional requirements established by the coating manufacturer’s written specifications for recommended air or metal temperature or relative humidity will apply if those requirements are more restrictive than those specified in the contract documents.

1081.10.3.7.2 Moisture Limitations. Coatings shall not be applied in rain, snow, fog or mist, or when the steel surface temperature is less than 5 F above the dew point. The dew point shall be determined in accordance with MoDOT Test Method TM 38. Coatings shall not be applied to wet, damp, frosted or ice-coated surfaces.

1081.10.3.7.3 Application in Protected Areas. When coatings are applied in a protected area to eliminate the weather conditions, the coated steel shall remain in the protected area until the coatings are cured.

1081.10.3.7.4 Damaged Coatings. Any uncured coatings exposed to freezing, excess humidity, rain, snow, condensation or curing temperatures outside the range recommended by the manufacturer will be considered damaged. Damaged coatings shall be permitted to dry, then shall be removed and the surface blast cleaned and recoated at the contractor's expense.

1081.10.3.8 Thinning. Thinners will be permitted as recommended by the manufacturer's recommendations, provided VOC limits are not exceeded.

1081.10.3.9 Application. Coatings shall be applied in accordance with the Steel Structures Painting Council specification SSPC-PA1, unless otherwise specified by the product manufacturer. The manufacturer's written specifications for application, upon request, shall be submitted to the engineer for review prior to application.

1081.10.3.9.1 Application Repairs. If deficiencies in the quality of work or material result in rejection, the contractor shall submit a repair proposal for approval by the engineer.

1081.10.3.9.2 Curing of Coatings. Curing time for recoating shall be within the limits of the manufacturer's recommendations. Application of the finish coat over the intermediate coat shall be accomplished within the recoat time for proper adhesion established by the manufacturer's recommendations.

1081.10.3.10 Shop Coating. All surfaces of fabricated structural steel, including areas that will be inaccessible after assembly, contact surfaces of high strength bolted connections and all surfaces to be in contact with concrete in the completed structure shall be coated in the shop with the prime coat. The primer shall be of the type and thickness specified, except as modified by Secs 1081.10.3.10.1 and 1081.10.3.10.2. Structural steel sway bracing for the substructure may be prepared and coated in the field.

1081.10.3.10.1 Contact Surfaces. Contact surfaces of high strength bolted field splice and diaphragm connections shall be prime coated to produce a dry film thickness no less than 1.5 mils or more than 2.5 mils. The limits of the coating thickness for these surfaces shall be shown on the shop drawings. The maximum limit of 2.5 mils may be increased provided acceptable test results in accordance with the Testing Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints (AISC Specification for Structural Joints Using ASTM A 325 or A 490 Bolts, Appendix A) are submitted and approved by the engineer. Revised shop drawings will not be required upon acceptance of the test results. The tests shall meet the requirements for the slip coefficient and creep resistance for Class B coatings and shall be performed by a nationally recognized independent testing laboratory. Any change in the formulation of the coating will require retesting, except when thinned within the limits of manufacturer's recommendations. At the contractor's option, the contact surfaces of connections for all non-slab bearing diaphragms on non-curved girders may be prime coated with a dry film thickness of no less than 3.0 mils or more than 6.0 mils, unless noted otherwise on the plans.

1081.10.3.10.2 Inaccessible Surfaces. Surfaces that will not be in contact, but that will be inaccessible after assembly, shall be prime coated to produce a dry film thickness of no less than 3.0 mils and no more than 6.0 mils. Dry film thickness on surfaces that will be in contact with concrete may be reduced to 2.0 mils provided thorough and complete coverage is obtained. Although shear connectors need not be coated, protection of the connectors from overspray when coating other parts of the beam or girder will not be necessary. Coating thickness measurements will not be made on shear connections.

1081.10.3.10.3 Touch-up of Galvanized Bolts. The galvanized coating of nuts, bolts and washers damaged during shop installation shall be shop repaired in accordance with Secs 1081.10.3.11.1 and 1081.10.3.11.1.1.

1081.10.3.10.4 Inspection Prior to Coating. No coatings shall be applied before shop inspection of fabrication has been completed. Surfaces of steel within 2 inches of edges to be field welded shall not be coated in the shop.

1081.10.3.10.5 Erection Match Marks. Erection match marks shall not be visible in the completed structure.

1081.10.3.11 Field Coating. Intermediate and finish coats for the specified coating system shall be applied in the field. The contractor shall be responsible for final cleanup and field touch-up of any shop applied coating, including surface preparation and coating of field connections, welds or bolts, areas masked in the shop and all damaged or defective coating and rusted areas. Surface preparation for field touch-ups shall be performed in accordance with Sec 1081.10.3.3, unless otherwise approved by the engineer. The touch-up field coat shall consist of the same coating used for the shop-applied coat. Contact surfaces of high strength bolted connections

shall be protected from the intermediate and finish coats. Damage to the coating of galvanized bolts, nuts and washers where bare steel is exposed shall be repaired in accordance with these specifications or, the connection may be prepared as specified in Sec 1081.10.3.3, followed by a touch-up field coat application of the required coating system.

1081.10.3.11.1 Field Touch-up of Galvanized Bolts. The galvanized coating of nuts, bolts and washers damaged during installation shall be repaired. Lubricants shall be removed in accordance with SSPC-SP1. Rust shall be removed in accordance with SSPC-SP-2 or SSPC-SP-3. Touch-ups shall consist of the application of an approved gray epoxy mastic. The touch-up material shall be compatible with and from the same manufacturer as the coating system to be used for the structure. Prior to field coating operations, the contractor shall submit information on the specific products to be used, including compatibility data and applicable recoating times, to the engineer for review. Subsequent coatings shall be applied within the recoat time recommended by the manufacturer.

1081.10.3.11.1.1 Touch-up Color. For areas of the structure that will not receive a field coat, the color of the touch-up material for bolts specified in Sec 1081.10.3.11.1 shall be similar to galvanized metal.

1081.10.3.11.1.2 Previously Repaired Material. If repairs to the galvanized coating of shop-installed nuts, bolts and washers have previously been performed in accordance with Sec 1081.10.3.10.3 or if epoxy mastics are otherwise shop-applied to structural steel, the contractor shall be responsible for any special field preparation required for proper adhesion of subsequent field coats to the epoxy coating. Prior to field coating operations, the contractor shall submit the manufacturer's recommendations to the engineer.

1081.10.3.11.1.3 Masking. Previously coated or adjacent areas shall be masked or otherwise protected from material used to touch-up the galvanized coating of fasteners.

1081.10.3.11.2 Sequence of Work. Field coatings, except for touch-up and coating of inaccessible surfaces, shall not be applied until the concrete deck has been placed, the forms removed and all concrete spatter, foreign material and contaminants are removed from existing coatings, unless otherwise approved by the engineer. Prior to submittal of alternative application methods, the contractor shall present methods to be used to prevent damage to the intermediate and final field coatings. The sequence of work shall be arranged to provide ample time for each coat to cure before the next coat is applied. The intermediate field coats shall be free of all oil, grease, dust or dirt prior to application of the next coat. Intermediate or prime coats that have been exposed to chlorides used in snow removal operations shall be cleaned by power washing as defined in Sec 1081.10.5.4.2.2 prior to application of the subsequent intermediate or final coats. In no case shall a coat be applied until the previous coat has been approved by the engineer. Excessive rust streaks or coatings on concrete masonry shall be removed by sandblasting or by other approved methods without damage to the masonry.

1081.10.3.11.3 Work Under Stage Construction Contracts. If complete field coating is not included in the contract for erection of structural steel, the touch-up coating of newly erected work and the coating of surfaces that will be inaccessible after erection shall be included as part of the work to be performed under the contract for erection. Field coating under any contract that does not include the erection shall include cleaning, preparation of any previously applied coatings, repairs and spot application of coatings required at the time the work is performed. Prior to field coating structural steel that was erected under a previous contract, the contractor shall submit the manufacturer's recommendations to the engineer, outlining requirements for cleaning and preparation of all existing coatings. The manufacturer’s recommendations shall include requirements for preparation of epoxy mastics previously applied for touch-up or other purposes.

1081.10.3.11.4 Partial Applications. If partial applications of the field finish coats to a structure as provided in Sec 1081.10.3.4 is required or permitted, the contractor shall perform field touch-up coating to areas of the structural steel outside the limits to receive the intermediate and finish coats. Touch-up shall be in accordance with in Sec 1081.10.3.11 and at the contractor’s expense.

1081.10.3.12 Identification. The contractor shall, at the completion of the coating application, stencil in black paint on the structure the number of the bridge, the word "COATED", the system used and the month and year the coating was completed. The letters shall be capitals approximately 3 inches high. The legend shall be stenciled on the outside face of an outside stringer or girder near each end of the bridge as directed by the engineer.

1081.10.3.13 Property and Traffic Protection. The contractor shall protect pedestrian, vehicular, railroad and

other traffic, persons and property, upon, beneath and in the vicinity of the structure and all portions of the bridge against damage or disfigurement by blast media, blast residue, coatings, coating material, equipment or by any other operations.

1081.10.4 Recoating of Structural Steel (System G , H or I).

1081.10.4.1 Scope. This specification covers the field preparation of structural steel surfaces to be recoated, furnishing and applying specified coatings, protection and drying of coatings, furnishing protection from coating spatter and disfigurement, and final cleanup.

1081.10.4.2 Certification. Contractors performing coating operations for field applied recoating shall be certified prior to the start of the coating operations under the appropriate category of the SSPC Certified Contractor QP program as follows:

(a) For coating operations where there is no presence of lead, heavy metals, or other hazardous materials, the contractor shall be certified to the SSPC QP1 – Field Application to Complex Industrial and Marine Structures.

(b) For coating operations where lead, heavy metals, or other hazardous materials are present, the contractor shall be certified to the SSPC QP2 - Field Removal of Hazardous Coatings.

1081.10.4.3 Systems of Protective Coatings. All structural steel shall be recoated by the contractor in the field using one of the complete systems, including prime coats, in accordance with Sec 1081.10.2, unless noted otherwise. Recoating of structural steel, including surface preparation, weather conditions, application, touch-up and protection, shall be in accordance with all requirements of Sec 1081.10.3 unless in conflict with Sec 216, which shall control.

1081.10.4.4 Surface Preparation. Cleaning and coating of structural steel shall proceed in areas or sections as approved by the engineer, usually consisting of one or more complete spans. The cleaning and application of the coatings for each specified section shall be entirely completed and accepted by the engineer prior to proceeding with additional cleaning or coating. Surface preparation shall be in accordance with Sec 1081.10.3.3. All existing coatings and paint shall be removed by blast cleaning unless specifically indicated otherwise in the contract.

1081.10.4.4.1 Approved Blast Media. Only silica sand and steel abrasive shall be allowed for use as approved blast media for paint removal. A safety data sheet (SDS) for the blast media selected for use shall be submitted for approval at the pre-construction conference held with the contractor. The SDS shall be maintained on site by the contractor and shall be available for review upon request. All paint removed with approved blast media shall be sent to the Doe Run lead smelter for recycling and is not considered a solid or hazardous waste in accordance with 40 CFR 261.2(e)(1)(ii). Surface preparation areas cleaned with unapproved blast media shall be at the contractor's expense. The collected residue shall consist of media no larger than one inch and removed paint chips.

1081.10.4.4.2 Environmental Regulations. The paint removal operation shall comply with all local, state and federal regulations, including but not limited to, the EPA, OSHA Standards 29 CFR 1910 and 1926.62, and the Missouri Code of State Regulations, including 10 CSR 10 Air Conservation Commission, 10 CSR 20 Clean Water Commission, 10 CSR 25 Hazardous Waste Commission, and 10 CSR 80 Solid Waste Management. The contractor shall have all necessary licenses and certifications as required by the Missouri Department of Health including necessary licenses and certification for lead abatement/removal workers prior to commencement of the cleaning operation. If hazardous waste will be generated at the site, the contractor shall notify the engineer and Environmental Section in Design Division and comply with all applicable hazardous waste generator requirements.

1081.10.4.4.3 Containment and Collection of Blast Residue. A containment system, or enclosure, is required to prevent the release of blast media residue and other debris generated during surface preparation activities from entering the environment. Enclosures are typically made up of combinations of cover panels, scaffolds, supports, screens, and tarps. The complexity of any given enclosure will vary depending on the method of paint removal being employed and the degree of surface preparation that is specified. For a simple scraping operation ground-covering tarps may be sufficient while for a blasting operation, the enclosure could be a designed structure with a negative pressure ventilation system. The contractor shall collect all blast residue (paint residue/blast media) from the cleaning operations for recycling. All blast media and residue shall be contained

or collected; should an accidental release occur, the contractor shall complete all necessary cleanup efforts as directed by the Engineer. Blast residue shall be managed as a recyclable material. Container management shall be in accordance with Sec 1081.10.4.4.3.3. Analytical testing required for the disposal of blast residues shall be the responsibility of the contractor.

1081.10.4.4.3.1 Waste Solvent Management. All waste solvent generated from painting operations shall be containerized, sampled, and submitted for analytical testing to enable a hazardous waste determination.

1081.10.4.4.3.2 Hazardous Waste Notification. The contractor shall submit a "Notification of Regulated Waste Activity" form to MDNR Hazardous Waste Program to obtain the EPA identification number. Requests shall be submitted as soon as hazardous waste is determined or at least 30 days prior to shipping hazardous waste. The cost of obtaining the EPA identification number will be considered as part of the surface preparation cost and the engineer will subtract the cost from the contract. Hazardous waste shall not be shipped offsite until the EPA identification number has been received. The contractor will file the quarterly and annual hazardous waste reports in accordance with 10 CSR 25-5.262(2)(D)1 and will deactivate the EPA identification number upon contract completion. The contractor shall submit copies of all hazardous waste manifests and quarterly/annual reports to MoDOT's Environmental Section.

1081.10.4.4.3.3 Container Management.

1081.10.4.4.3.3.1 The blast residue from cleaning operations shall be stored in contractor furnished, watertight 55-gallon steel drum containers stacked on wooden pallets with labels facing outward. The containers shall be free of structural defects and all other materials including but not limited to construction debris, solvents, flammables, aluminum, magnesium, aerosol cans, rags and any ferrous or non-ferrous metals larger than one cubic inch. The containers shall have removable lids complete with a bolt ring, bolt and nut. Containers shall remain closed at all times, except when necessary to add blast residue. Material other than the blast residue from the cleaning operations shall not be placed in the containers. At the end of each day's work, the containers shall be stored outside the 100-year floodplain in a secure area as approved by the engineer. Containers of approved blast residue destined for recycling, shall be marked with a "Blast Residue" label provided by the Engineer or Environmental Section in the Design Division and marked with the following information:

(a) Blast Residue.

(b) Marked with one of the following:

(1) Contains Heavy Metals/Lead Compounds.

(2) Contains Non-Lead Compounds.

(c) Generator: MoDOT.

(d) Bridge Site Number.

(e) Date Container was Filled.

1081.10.4.4.3.3.2 Containers of hazardous waste shall be packaged, marked and labeled according to hazardous waste regulations 10 CSR 25-5.262(2)(C)1. Containers of hazardous waste shall be stored separate from containers of non-hazardous waste and approved blast media destined for recycling. The contractor shall maintain an inventory of the quantity of the containers stored at the site and the quantity delivered to an approved facility. All containers shall be delivered to the approved facility within 30 days upon completion of the surface preparation. Copies of container inventories, all test results, shipping papers, hazardous waste manifest signed by the receiving facility, solid waste disposal request, recycling certificates and any other disposal documentation shall be submitted to the engineer with a copy to the Environmental Section in the Design Division within 30 days upon delivery to the approved facility.

1081.10.4.4.3.4 Shipment of Residue. Approved blast media containing paint residue shall be shipped with a bill of lading to the Doe Run smelter for recycling. The contractor shall obtain appropriate shipping papers (bill of lading), if required, from the Engineer or Environmental Section in the Design Division. These shipping forms shall be completed prior to shipment. The Doe Run smelter will reject any shipment received without the proper shipping papers. The contractor shall notify the Doe Run smelter at least 2 days prior to shipment to

ensure the receiving facility will be able to accept the material.

1081.10.4.4.3.5 Personal Protective Equipment. Clothing, tarps, hoses and other cleaning material containing blast residue shall be managed as a hazardous waste unless determined non-hazardous. Personal protective equipment being disposed, such as tyvek suits, respirator cartridges, boots, etc. but not tarps, shall be placed into 55-gallon steel drums. Spent tarps shall be placed into DOT approved cardboard boxes and stacked on wooden pallets. Container management shall be in accordance with Sec 1081.10.4.4.3.3.

1081.10.4.4.3.6 Invoices and Payment. The contractor shall dispose of all paint residue/blast media and personal protective equipment in accordance with all Federal and State regulations at the Doe Run smelter. Spent solvents shall be disposed of at an EPA approved hazardous waste treatment, storage and disposal facility. Transporting and disposal cost shall be the contractor's responsibility. A copy of the disposal manifest and paid receipt shall be given to the engineer. Failure to provide proper documentation will result in withholding payment. For more information concerning management of blast residue or approved hazardous waste treatment, storage and disposal facilities, contact the Environmental Section in the Design Division.

1081.10.4.5 Joints. All seams and joints that cannot be satisfactorily sealed or coated shall be adequately caulked with compounds compatible with the coating system being applied. Caulking material shall be in accordance with the coating manufacturer's recommendations and shall meet the approval of the engineer. Caulking shall be satisfactorily completed for an entire joint or seam after application of the prime coat and before application of any specified finish or intermediate coats.

1081.10.4.6 Identification. At the completion of recoating, the contractor shall stencil in black paint on the structure the number of the bridge, the word "RECOATED", the system used and the month and year the coating was completed. The letters shall be capitals approximately
3 inches high. The legend shall be stenciled on the outside face of an outside stringer or girder near each end of the bridge as directed by the engineer.

1081.10.4.7 Property and Traffic Protection. The contractor shall provide protection in accordance with Sec 1081.10.3.13.

1081.10.5 Overcoating of Structural Steel (Calcium Sulfonate System).

1081.10.5.1 Scope. This specification covers the field preparation of structural steel surfaces to be overcoated, disposal of paint residues and power washing water, furnishing and applying the specified coatings, protection and drying of the coatings, furnishing protection from coating spatter or disfigurement and final cleanup.

1081.10.5.2 Certification. Contractors performing coating operations for field applied overcoating shall be certified prior to the start of the coating operations under the appropriate category of the SSPC Certified Contractor QP program as follows:

(a) For coating operations where there is no presence of lead, heavy metals, or other hazardous materials, the contractor shall be certified to the SSPC QP1 – Field Application to Complex Industrial and Marine Structures.

(b) For coating operations where lead, heavy metals, or other hazardous materials are present, the contractor shall be certified to the SSPC QP2 - Field Removal of Hazardous Coatings.

1081.10.5.3 System of Protective Coatings. All exposed and accessible surfaces of structural steel and steel bearings shall be coated with the Calcium Sulfonate paint system in accordance with Sec. 1081.10.2 unless otherwise noted. The color of the topcoat shall be as shown on the plans. Overcoating of structural steel shall be in accordance with all requirements of Sec 1081.10.3 except surface preparation and unless in conflict with Sec 216, which shall control.

1081.10.5.4 Surface Preparation. Surface preparation shall be in accordance with Sec 1081.10.4.4, except that blast cleaning will not be required.

1081.10.5.4.1 Removal of Existing Paint. The existing steel shall be cleaned by approved methods in accordance with Sec 1081.10.5.4.2.

1081.10.5.4.1.1 Environmental Regulations. The paint removal operation shall be in accordance with all local,

state and federal regulations, including those defined in Sec 1081.10.4.4.2.

1081.10.5.4.1.2 Water for Power Washing. The water used for power washing shall be clean, potable water, free from contaminants. During power washing operation, solids shall be contained or removed, but collection of wash water is not required for this activity.

1081.10.5.4.1.3 Collection of Residue. Collection of all paint residue shall be in accordance with the following requirements. The containers shall remain closed at all times, except when necessary to add additional residue. Material other than the residue from the cleaning operations shall not be placed in the containers. Any testing required for the disposal of the residues shall be the responsibility of the contractor. Copies of the inventory, all testing data, required certifications and shipping manifests shall be provided to the engineer and to the Environmental Section in Design Division in accordance with Sec 1081.10.4.4.3.3.2.

1081.10.5.4.1.4 Testing of Paint Residue. At the conclusion of the power washing operation, the contractor shall obtain samples of the paint residue in the presence of the engineer. The samples shall be analyzed by an independent testing laboratory for Toxicity Characteristic Leaching Procedure (TCLP) heavy metals. Samples shall be collected and analyzed in accordance with EPA approved methods. Copies of all test reports shall be supplied to the engineer and the Environmental Section in Design Division. Any additional testing required to comply with any federal, state or local regulations shall be provided by the contractor. If TCLP heavy metals test results exceed the regulatory limits, the contractor shall handle and dispose of the material in accordance with hazardous waste regulations at an EPA-approved RCRA treatment, storage, or disposal (TSD) facility. If test results indicate levels below the regulatory limits, then the material shall be disposed of as a solid waste at a sanitary landfill.

1081.10.5.4.2 Cleaning of Structural Steel. All exposed steel surfaces shall be mechanically cleaned in accordance with Sec 1081.10.5.4.2.1 and in accordance with the paint manufacturer's recommendations prior to application of the coating. Power washing will not be required. However, the contractor may use power wash cleaning if desired during surface preparation. All surfaces cleaned shall be approved by the engineer prior to application of the coating.

1081.10.5.4.2.1 Mechanical Cleaning. Exposed structural steel where mechanical cleaning is required shall be cleaned in accordance with SSPC-SP2 or SSPC-SP3. Blast cleaning as a substitute cleaning method will be acceptable. Mechanical cleaning will be required for areas of rusted steel, loose, cracked or brittle paint or areas indicated by the engineer. The cleaning shall be performed 2 inches beyond the areas of rust or defective paint in all direction or until tightly adhered paint is obtained with no rust or blisters. Edges between the bare steel and the paint shall be feathered. Collection of the residue removed shall be in accordance with Sec 1081.10.5.4.1.3.

1081.10.5.4.2.2 Power Wash Cleaning. The contractor may clean the steel by a low-pressure power wash to remove loose paint, dirt and other loose deleterious material. The maximum pressure for the power washing shall be 1,500 psi. Construction of a containment system around the work area is required and shall consist of wooden framed construction, installation of a drip tarps consisting of #100 sieve filter fabric, or other alternative method that effectively filters the water and captures solids, as approved by the Engineer. If necessary, solvent cleaning in accordance with SSPC-SP1 shall be employed to augment the power washing. Collection of the residues from the power washing operation shall be in accordance with Sec 1081.10.5.4.1.2. After the power washing operation, areas that have remaining rust or loose paint shall be recleaned in accordance with Sec 1081.10.5.4.2.1, except that vacuum power tools will be required for power tool cleaning. All surfaces washed shall be completely free of all foreign matter, surface dry and approved by the engineer prior to application of the coating.

1081.10.5.5 Application. Coating shall be applied in accordance with Sec 1081.10.3 and the manufacturer's recommendations. The steel shall be free of all cleaning residues prior to coating. Areas that have been cleaned to bare steel shall be prime coated on the same day as the cleaning. Any areas that rust prior to application of the prime coat shall be recleaned. The prime coat and topcoat shall be applied to all steel surfaces with the exception of steel encased in concrete. Any existing paint that curls or lifts after application of the Calcium Sulfonate system shall be removed, the area recleaned and the coating reapplied. Application of the rust penetrating sealer will only be required if specified in the contract documents or as determined by the engineer. Application of the rust penetrating sealer shall be in accordance with the rust penetrating sealer manufacturer's recommendations.

1081.10.5.6 Identification. At the completion of the final coating application, the contractor shall, stencil in

black paint on the structure the number of the bridge, the words "OVERCOATED – Calcium Sulfonate" and the month and year the coating was completed. The letters shall be capitals approximately 3 inches high. The legend shall be stenciled on the outside face of an outside girder near each end of the bridge as directed by the engineer.

1081.10.5.7 Property and Traffic Protection. The contractor shall provide protection in accordance with Sec 1081.10.3.13.

1081.10.6 Aluminum & Gray Epoxy-Mastic Primer.

1081.10.6.1 Scope. This specification covers the application of other approved primer coatings for touch-up and other repair applications.

1081.10.6.2 Surface Preparation. The epoxy-mastic shall be applied over an SSPC-SP2, SSPC-SP3 or SSPC-SP6 surface preparation, including removal of all rust scale, loose rust, loose mill scale and loose or non-adherent paint. Oil and grease shall be removed in accordance with SSPC-SP1 Solvent Cleaning. Areas adjacent to required areas will not be required to be masked to prevent overspray.

1081.10.6.2.1 Environmental Regulations. The surface preparation operation shall be in accordance with all local, state and federal regulations, including those defined in Sec 1081.10.4.4.2.

1081.10.6.2.2 Collection of Residue. The collection of residue shall be in accordance with Sec 1081.10.4.4.3 and 1081.10.5.4.1.3.

1081.10.6.3 Application. Material application methods, air and surface temperatures and relative humidity shall be in accordance with the manufacturer's written instructions and Sec 1081.10.3. The most restrictive application and environmental requirements for the epoxy-mastic shall be used when applying the primer to the steel.

1081.20 Galvanizing of Structural Steel.

1081.20.1 Scope. This specification covers galvanizing new and existing bridges and structures made of structural steel and miscellaneous metals.

1081.20.2 Material. All material shall be in accordance with Division 1000, Material Details, and in conjunction with:

Item	Specification
Galvanizing	ASTM A 123
Galvanizing Repair	ASTM A 780

1081.20.3 Galvanized Metal. Structural steel beams or girders, bracing and diaphragms shall be galvanized as shown on the plans and in accordance with this specification. Galvanizing shall be applied after fabrication. Galvanized material on which the galvanizing has been damaged will be rejected or may, with approval from the engineer, be repaired in the field, fabrication shop, or at the galvanizing facility by the zinc alloy stick method in accordance with this specification. Required field welds and adjacent areas on which galvanizing has been damaged shall be galvanized by this same repair method. The area to be regalvanized shall be thoroughly cleaned, including the removal of slag on welds. Touch-up of galvanizing of sheet material less than 3/16 inch may be completed by the use of an approved aluminum epoxy mastic coating if the material will not be in direct contact with concrete or with an approved non-aluminum epoxy mastic coating if the material will be in direct contact with concrete. Other protective coatings specified in ASTM A780 will not be permitted for galvanized beams, girders, bracing and diaphragms.

1081.20.4 Acceptance Criteria. All galvanized steel products shall be free from any bare steel, blisters, flux deposits, and dross inclusions. The minimum average coating thickness shall be 3.9 mils and the maximum average coating thickness shall be 25 mils. The finished galvanized product shall be uniform in appearance with no lumps, projections, indentations, globules, runs, sags, or heavy build-up at welded joints.

SECTION 1091
LIGHTING EQUIPMENT

1091.1 Lighting Poles.

1091.1.1 Pre-Approval. Fabricators shall submit two copies of shop drawings to Traffic. Submittals shall be approved by Traffic in writing prior to fabrication of the lighting poles. Shop drawings shall indicate design details required for pole fabrication, including material grades and thicknesses, welding and orientation of any longitudinal seams. Shop drawings shall provide pole installation and hardware details. Design details for all possible pole combinations shown on the plans may be submitted. Shop drawings stress calculations shall be signed and sealed by a registered professional engineer in the State of Missouri. Upon written approval, pre-approved drawings may be used on any project where the design conditions of the shop drawings are not exceeded.

1091.1.2 Requirements. Lighting poles shall be steel or aluminum in accordance with the contract and shall be of the same material and design throughout the project. Poles shall be of the type shown on the plans. The fabricator may furnish poles with other shapes, gages and dimensions meeting or exceeding those shown on the plans and specifications. The mounting height of the slipfitter above the pavement and the pole design numbers will be specified by numbers following the pole type designation. Clamps shall be provided for connecting bracket arms to poles to obtain the specified mounting height. All poles shall have removable raintight metal pole caps. All handhole covers and pole caps shall be attached to the pole with a chain constructed of the same material as the pole and shall be held in place by screws. The screws shall penetrate through the metal cap or cover and pole securely attaching the cap or cover to the pole. The chain shall be capable of supporting at least six times the weight of the cover or cap and be securely attached to the inside of the pole and of sufficient length to allow removal of the cover or cap for maintenance access. An aluminum or stainless steel identification tag with embossed or engraved letters and numbers shall be provided with all poles as shown on the plans. The tag shall be attached to the pole 6 inches above the top of the handhole or 18 inches above the base plate over the transformer base door. Shims may be used between the pole base or transformer base and the foundation for leveling purposes. Four copies of applicable pre-approved drawings shall be supplied with the poles and shall be provided to the engineer.

1091.1.2.1 Type AT. Each Type AT pole shall be provided with a transformer base in accordance with Sec 901. A grounding conductor shall be attached to the ground lug in each transformer base as shown on the plans.

1091.1.2.2 Type B and MB. Each Type B and MB pole shall have a wiring handhole with a suitable metal cover near the base using a grounding lug inside the pole as shown on the plans. A grounding conductor shall be attached to the ground lug in each pole as shown on the plans.

1091.1.2.3 Steel. Steel lighting poles shall be round or octagonal shaft poles. The shaft section shall be fabricated from basic oxygen or open hearth steel sheet, No. 11 gage, as one continuous shaft or as individual segments no less than 10 feet in length, joined together using electrically welded, intermediate, transverse, full penetration, circumferential joints. Each sheet shall be formed into a tube with one continuous-welded longitudinal seam. After manufacture, the material shall have a minimum yield strength of 48,000 psi, including the weld. Poles shall be manufactured with steel shoe bases or base plates attached to the lower end of the shafts and arranged for bolting to a transformer base or to a foundation. All base plates and shoe bases shall be equipped with four cast steel or cast iron nut covers in accordance with AASHTO M 103 or M 105 or four aluminum nut covers and shall have four galvanized or stainless steel screws for securing covers to the pole. Welding and fabrication of the assemblies shall be in accordance with the ANSI/AWS D1.1 Structural Welding Code-Steel. All poles, shoe bases, base plates and cast steel or cast iron nut covers shall be fully galvanized after fabrication.

1091.1.2.3.1 For shoe base-type poles, each shoe base shall be a one-piece casting in accordance with AASHTO M 103, Grade 65-35 with four anchor bolt holes. Each shoe base shall consist of a collar, flange and gussets, all integrally cast. Ample fillet radii shall be provided at the juncture of these components to reduce the effects of stress concentration. The flange of the base shall be flat and continuous around the outside of the collar. The base shall telescope from the shaft and be secured by two continuous welds. One weld shall be on the inside of the base at the end of the shaft and the other weld shall be on the outside at the top of the base. The shoe base shall be arranged for bolting to a transformer base or to a foundation.

1091.1.2.3.2 For base plate-type poles, the base plate shall be no less than 13 inches square and no less than 1

1/4 inches thick.

1091.1.2.4 Aluminum.

1091.1.2.4.1 Aluminum lighting poles shall be round shaft poles. Each shaft shall be manufactured as a two-piece pole by the spun drawn method from seamless extruded aluminum tubing, ASTM B 221, Alloy 6063-T6 and shall have a nominal wall thickness for the lower section of 0.250 inch and a nominal wall thickness for the upper section of 0.188 inch. The one-piece shaft for 30-foot mounting height shall have a nominal wall thickness of 0.188 inch, except those with twin-truss type arms shall have a nominal wall thickness of 0.250 inch. Shoe base-type poles shall be manufactured with heavy cast aluminum shoe bases attached to the lower ends of the shafts. Each shoe base shall be a permanent mold casting in accordance with ASTM B 108, Alloy 356.0-T6 and shall be free from cracks, pits and blowholes. The shoe base shall be arranged for bolting to a transformer base or to a foundation. The base shall have four anchor bolt holes, shall be equipped with four cast aluminum bolt covers and shall have four stainless steel fasteners for securing covers to the shoe base. Each shoe base shall consist of a collar, flange and gussets, all integrally cast. Ample fillet radii shall be provided at the juncture of these components to reduce the effects of stress concentration. The flange of the base shall be flat and continuous completely around the outside of the collar. The base shall telescope from the shaft and be secured by two continuous welds. One weld shall be on the inside of the base at the end of the shaft and the other weld shall be on the outside at the top of the base. The base and shaft shall be welded in the T4 temper with filler alloy 4043 and precipitation heat treated, artificially aged, to the T6 temper by an approved method after welding. Welding shall be in accordance with Article 6.9 of AASHTO's Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

1091.1.2.4.2 At the fabricator's option, the shafts for aluminum lighting poles may be formed from one piece of aluminum sheet, ASTM B 209, Alloy 5086-H34, having one continuous weld. The one-piece shaft for the 30-foot mounting height shall have a 9-inch diameter at the base and a nominal wall thickness of 0.135 inch. Shafts for 35 to 55-foot mounting heights shall have a 13.4-inch diameter at the base and a nominal wall thickness of 0.135 inch for both sections. Each shoe base shall be a permanent mold casting having an integral cast aluminum riser and shall be in accordance with ASTM B 108, Alloy 356.0-T6 and shall be free from cracks, pits and blow holes. The integral riser shall be designed to slip-fit into the pole shaft a sufficient distance to develop the full strength of the pole. The riser shall be bonded to the shaft with a structural epoxy adhesive that shall develop the strength of the pole. The epoxy shall develop a minimum of 1,200 psi in shear when tested in accordance with ASTM D 1002. The shoe base shall have four anchor bolt holes, shall be equipped with four cast aluminum bolt covers and shall have four stainless steel fasteners for securing the covers to the shoe base. Each shoe base shall consist of a collar, flange and gussets, all integrally cast. The flange of the shoe base shall be flat.

1091.2 Transformer Bases. Transformer bases shall be permanent mold castings in accordance with ASTM B 108, Alloy 356.0-T6 and shall be free from cracks, pits and blow holes. The transformer base shall be designed to accommodate and provide access to electrical equipment. The base shall have internal lugs for mounting on a foundation and shall be designed for bolting to the base plate of the lighting pole using flat and lock washers. A grounding lug shall be provided in each base. The access opening shall have a hinged fiberglass or plastic door with a tamper-resistant fastening device. The outside of the door shall be imprinted or adequately labeled with the warning, "DANGER - HIGH VOLTAGE". No direct payment will be made for transformer bases.

1091.3 Circular Steel Pile Foundations. Circular steel pile foundations, the steel connector plate and steel closure plate shall be of the dimensions shown on the plans. The slotted hole may be saw cut or flame cut. All sharp edges shall be ground smooth. The steel connector plate and steel closure plate shall be welded to the steel pile foundation. The foundation assembly shall be fully galvanized after fabrication. Bolts shall project no less than 1/4 inch nor more than 5/8 inch beyond the nut when properly tensioned. Flat and lock washers shall be used for attachment.

1091.4 Steel H-Pile Foundations. Steel H-pile foundations and steel connector plates shall be of the dimensions shown on the plans. The steel connector plates shall be welded to the H-pile foundation. The foundation assembly shall be fully galvanized after fabrication. Bolts shall project no less than 1/4 inch or more than 5/8 inch beyond the nut when properly tensioned. Flat and lock washers shall be used for attachment.

1091.5 Screw Anchor Foundations. Screw anchor foundations and steel connector plates shall be of the dimensions shown on the plans. The slotted hole may be saw cut or flame cut. All sharp edges shall be ground smooth. The steel connector plates shall be welded to the screw anchor shaft. The foundation assembly shall be

fully galvanized after fabrication. Bolts shall project no less than 1/4 inch nor more than 5/8 inch beyond the nut when properly tensioned. Flat and lock washers shall be used for attachment.

1091.5.1 Fabricators for screw anchor foundations shall submit four copies of shop drawings to Traffic. Shop drawings shall indicate complete design details required for fabrication, including material grades, dimensions, thicknesses and welding. Shop drawings shall provide installation procedures and indicate the maximum torque ratings of the foundations.

1091.5.2 Submittals shall be approved by Traffic in writing prior to fabrication. Upon written approval, pre-approved drawings may be used on any project where the design conditions of the shop drawings are not exceeded.

1091.6 Bracket Arms. Bracket arms shall be similar in design to those shown on the plans, arranged for 2-inch slipfitter luminaire mounting, and shall be attached to the poles as shown on the plans. Bracket arms shall be of the same material as the pole. Bracket arm mounting plates shall match the shape of the pole. A one-inch pipe nipple shall be welded in place in the wire entrance hole on the mounting plate. The welds shall be placed on the side of the plate away from the pole. Flat and lock washers shall be used for attachment.

1091.7 Luminaires.

1091.7.1 Pre-Approval. Manufacturers of LED luminaires shall submit a completed New Product Evaluation Form. Family grouping in accordance with LED Lighting Facts is permitted, provided this is clearly indicated on the submittal form, and clearly communicated via a letter that includes detailed calculations relating the tested product to the submitted product. The luminaire size shall be as specified in the contract. A pipe stop shall be included in the assembly to locate the luminaire properly on the bracket arm. Product cutsheets shall be submitted for luminaire, LED light source, LED driver and surge protection device, if applicable. If dimmable LED driver is specified, provide diagrams illustrating light output and input power as a function of control signal. Instructions for installation and maintenance of LED luminaires shall be provided. Summary of luminaire recycled content and recyclability in accordance with the FTC Green Guides, expressed as a percentage of luminaire weight. IES LM-79 luminaire photometric report shall be produced by a test laboratory that satisfies LED Lighting Facts accreditation requirements. The report shall include, name of test laboratory, report number, date, complete luminaire catalog number, description of luminaire, LED light source, LED driver, and Goniophotometry. IES TM-15 Backlight-Uplight-Glare (BUG) ratings shall be for initial (worst-case) values, i.e., Light Loss Factor (LLF) = 1.0. If luminaires are tilted upward for Energy Star TM-21 calculations, BUG ratings shall correspond to the same angle of tilt.

1091.7.1.1. Lumen maintenance calculations and supporting test data shall be in accordance with LED Lighting Facts guidance, with the exception calculations shall be based on 50,000 cumulative hours of operation and an ambient temperature range of max. 40°C (104°F) to min.-20°C (-4°F). Submit completed ENERGY STAR TM-21 Calculator as an electronic excel file. Provide computer-generated point-by-point photometric analysis of maintained light levels. Calculation/measurement points shall be per IES RP-8. Separated vehicular lanes, bikeways, and walkways shall be evaluated separately. Calculations shall be for maintained values, i.e. Light Loss Factor (LLF) < 1.0, where LLF = LLD x LDD x LATF. Lamp Lumen Depreciation (LLD) shall be 0.90 or the value calculated in the Energy Star TM-21 calculations, whichever is lower. Luminaire Dirt Depreciation (LDD) shall = 0.90 and Luminaire Ambient Temperature Factor (LATF) shall = 0.96. Mesopic multipliers (i.e., effective luminance factors) shall not be used. All values shall assume photopic visual adaptation. Submit IES LM-63 format electronic file containing luminous intensity data associated with submitted LM-79 report(s) and used for point-by-point calculations. Summary of Joint Electron Devices Engineering Council (JEDEC) or Japan Electronics and Information Technology Industries (JEITA) reliability testing performed for LED packages. Summary of reliability testing performed for LED driver(s). Safety certification and file number indicating compliance with UL 1598. Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratory). Documentation supporting any U.S. origin claims for the product, in accordance with FTC guidance.

1091.7.1.2. Before approval and purchase, vendor shall supply luminaire sample(s) identical to product configuration(s) submitted for inspection. Commission may request IES LM-79 testing of luminaire sample(s) to verify performance is within manufacturer-reported tolerances. Electrically test fully assembled luminaires before shipment from factory. After installation, Commission may perform IES LM-50 field measurements to verify performance requirements, giving consideration to manufacturing tolerances and measurement

uncertainties as outlined in IES LM-61 and NEMA LSD 63.

1091.7.1.3. Written product warranty shall be of the minimum duration of ten years, and shall cover maintained integrity and functionality of luminaire housing, wiring, connections, LED light source(s) and LED driver(s). Negligible light output from more than 10 percent of the LED packages constitutes luminaire failure. Warranty period shall begin 90 days after date of invoice, or as negotiated by Commission such as in the case of an auditable asset management system. Manufacturer or local sales representative shall provide installation and troubleshooting support via telephone and/or email.

1091.7.2 Requirements.

1091.7.2.1. Roadway. Luminaire shall be designed for ease of component replacement and end-of-life disassembly. Type III medium distribution, semi-cutoff light distribution shall be set in accordance with the manufacturer's recommendations unless otherwise directed by the engineer, or shown on the plans. Transmissive optical components shall be applied in accordance with OEM design guidelines to ensure suitability for the environment (e.g., electromagnetic, thermal, mechanical, chemical). LED light source(s) and driver(s) shall be RoHS compliant. Nominal luminaire input wattage shall account for nominal applied voltage and any reduction in driver efficiency due to sub-optimal driver loading. Luminaire shall accept the voltage or voltage range specified at 50/60 Hz, and shall operate normally for input voltage fluctuations of plus or minus 10 percent. All internal components shall be assembled and pre-wired using modular electrical connections. The following shall be in accordance with corresponding sections of ANSI C136.37, wiring and grounding, terminal blocks for incoming AC lines (electrical mains wires), photocontrol receptacle, latching and hinging, mounting provisions, and ingress protection.

1091.7.2.1.1.Underpass. Luminaires for underpass lighting shall be high-pressure sodium The luminaires shall consist of a pre-wired unit for wall mounting, with raintight cast aluminum housing, cast aluminum door with integral cast guard, heat-resistant glass prismatic refractor, asymmetric aluminum reflector and socket for horizontal lamp position, complete with 150-watt lamp and 240-volt or 480-volt ballast as required. Type IV short distribution, non- cutoff light distribution shall be set in accordance with the manufacturer's recommendations, unless otherwise directed by the engineer or shown on the plans. The door shall have a stainless steel hinge along the bottom, stainless steel latches at the top and non-ferrous metal or stainless steel safety chains. Provisions shall be made for attaching the unit directly to a wall or to an outlet box stud with non-ferrous metal or stainless steel hardware. Ballasts for underpass luminaires shall be in accordance with Sec 901. The ballast power cables shall be individually fused with in-line fuse holders between the line and load, in the junction box or the luminaire housing if no junction box is shown on the plans. The fuse rating shall be three amps unless otherwise shown on the plans.

1091.7.2.2. Painted or finished luminaire surfaces exposed to the environment shall exceed a rating of six per ASTM D1654 after 1000 hours of testing per ASTM B117. Each luminaire shall have aluminum housing with two 2-inch slipfitters or one 4-bolt slipfitter or one 2-inch slipfitter with a longitudinal leveling system. The housing shall have a natural aluminum or gray baked enamel finish. The coating shall exhibit no greater than 30% reduction of gloss per ASTM D523, after 500 hours of QUV testing at ASTM G154 Cycle 6. All metal parts, such as springs on the latches and hinges, U-bolts and screws shall be made from non-ferrous metal or stainless steel. All parts of the luminaire shall be fabricated from corrosion resistant material.

1091.7.2.3. Luminaire shall start and operate in ambient temperature range specified. Maximum rated case temperature of driver and other internal components shall not be exceeded when luminaire is operated in ambient temperature range specified. Wiring inside the luminaire housing shall be protected by suitable heat resistant insulating material. Mechanical design of protruding external surfaces (heat sink fins) shall facilitate hose-down cleaning and discourage debris accumulation. Liquids or other moving parts shall be clearly indicated in submittals, shall be consistent with product testing, and shall be subject to review by Commission. Luminaire designation indicated “ANSI C136.41, 7-pin” on New Product Evaluation Form shall be fully prewired and shall incorporate an ANSI C136.41 compliant receptacle. If a dimmable LED driver is specified, the 0-10V or DALI control wires shall be connected to the receptacle pads as specified in ANSI C136.41; connection of the two remaining pads shall be by Manufacturer, as directed by Commission.

1091.7.2.4. Luminaire shall be listed for wet locations by a U.S. Occupational Safety Health Administration (OSHA) Nationally Recognized Testing Laboratory (NRTL), shall have locality-appropriate governing mark and certification, and shall meet the performance requirements specified in ANSI C136.2 for dielectric withstand, using the DC test level and configuration. Luminaire shall meet the performance requirements

specified in ANSI C136.2 for electrical immunity, using the combination Enhanced Wave Test Level (10kV/5kA) for whether failure of the electrical immunity system can possibly result in disconnect of power to luminaire. Luminaire shall comply with FCC 47 CFR part 15 interference criteria for Class A (non-residential) digital devices, and shall comply with section 5.2.5 (luminaires rated for outdoor use) of ANSI C82.77 at full input power and across specified voltage range.

1091.7.2.5. Color Rendering Index (CRI) shall be no less than 50. Nominal Correlated Color Temperature (CCT) shall be 3000k with allowable IES LM-79 Chromaticity Values of 2870 to 3220 measured CCT (k) and -0.006 to 0.006 Measured Duv. Luminaire shall have an external label per ANSI C136.15 and shall have an internal label per ANSI C136.22.

1091.7.3 Navigation. All lanterns shall be weatherproof and operate on a 120-volt system. Lanterns shall be of the fresnel lens-type and shall be fabricated from a corrosion-resistant material. Each lantern shall provide an LED or a standard service lamp with at least four standby lamps controlled by a lampchanger mechanism capable of illuminating the standby lamp after each lamp burnout. Mounting brackets and all accessories shall be provided with each lantern. A swing arm and retrieval chain shall be provided for main channel lanterns to hold the fixture in proper operating position. The swing arm and retrieval chain shall be capable of being locked in both the upright and inverted positions. Mounting brackets shall be fully galvanized or stainless steel, and all hardware shall be stainless steel.

1091.8 Control Stations. Control stations shall consist of all equipment and material necessary for the distribution of secondary electrical power as shown on the plans. Control stations will be specified by the secondary voltage.

1091.8.1 Cabinets. Control cabinets shall be of sufficient size to house all equipment as shown on the plans. All equipment such as circuit breakers, switches, contactors, fuses, photoelectric controls and terminal blocks shall be installed on the panel as shown on the plans. Control cabinets shall have a control panel constructed of the same material as the cabinet. Cabinets shall be NEMA 4, dust-tight, watertight and constructed of 0.125-inch minimum reinforced sheet aluminum alloy and be of clean-cut design and appearance. All hinges, catches and other hardware shall be non-ferrous metal or stainless steel. Cabinets shall have a No. 2 Corbin cabinet lock and provisions for locking with a padlock. Two keys for cabinet locks shall be furnished by the contractor. Mounting shall be as shown on the plans.

1091.8.2 Lightning Arrestors. Lightning arrestors shall be of the rated voltage as shown on the plans.

1091.8.3 Photoelectric Controls. Photoelectric controls shall be of the cadmium-sulfide or solid-state type operating on 120 volts or 240 volts, as shown on the plans and shall operate on a line supply of 50 to 60 hertz. The load capacity of the photoelectric cell relays shall be a minimum of 1,000 watts. Photoelectric cells shall operate a lighting system through mercury load relays or contactors as shown on the plans. The photoelectric cell circuitry shall be designed to be normally closed at night. The photoelectric cell shall be configured such that in the event of failure, the lights shall be on. The turn-on range shall be adjustable from 1.0 to 3.0 footcandle. A turn-on setting of 1.0 footcandle and a turn-off setting of 2.0 footcandles shall be made at the factory. The photoelectric cell shall have a time delay to avoid operation due to lightning and transient light. A suitable bracket for mounting the photoelectric cell shall be provided. The photoelectric cell shall be mounted into a three-prong twist lock socket. All top mount photoelectric controls shall face an open sky and side mount photoelectric controls shall face north. Each photoelectric control unit shall include a lightning arrestor. Test switches used with photoelectric controls shall be three-position switches or two single-pole breakers as shown on the plans. Test switches shall be clearly labeled and mounted in the control cabinet.

1091.8.4 Contactors. Contactors shall be NEMA Type 1 enclosed, magnetic-type, two-pole, single phase for 600 volts, 60-hertz service. The operating coil shall be designed for 120-volt or 240-volt operation as shown on the plans. The contactor shall be electrically held, have the minimum rating and shall be housed in the control cabinet as shown on the plans. Mercury load relays shall be two-pole, normally-open, mercury contact, magnetic-type with load capacity as shown on the plans.

1091.8.5 Circuit Breakers. All circuit breakers shall be molded-case thermal-magnetic circuit breakers. The number and trip rating of circuit breakers shall be as shown on the plans. All breakers shall be designed for panel mounting with cable connections on the line and load sides.

1091.8.5.1 Type A Circuit Breakers. Type A circuit breakers shall have a minimum of 18,000 amps alternating

current interrupting rating at 240 volts alternating current and 14,000 amps alternating current interrupting rating at 480 volts alternating current. Breakers shall be full-size and designed to accept wire sizes up to 2/0 AWG. Terminals shall be provided for the wire sizes as shown on the plans.

1091.8.5.2 Type B Circuit Breakers. Type B circuit breakers shall have a minimum of 10,000 amps alternating current interrupting rating at 240 volts alternating current. Type B circuit breakers shall have a nominal size no greater than one inch wide by 4 inches high by
3 inches deep. Terminals shall be configured for the wire sizes as shown on the plans. If the breaker terminals are not designed for the required wire sizes, suitable terminal adapters, connectors or terminal blocks shall be used to convert the wire sizes.

1091.9 Power Supply Assembly.

1091.9.1 Disconnect cabinets shall be NEMA 4, dust-tight and watertight. The operating handle shall have full cover interlock to prevent the door from opening when the breaker is on. The enclosure shall have provisions for padlocking the enclosure and for padlocking the switch in the on or off position.

1091.9.2 Meter boxes shall be NEMA 3R or NEMA 4.

1091.10 Cable Splicing.

1091.10.1 Splice blocks shall be designed for the wire size used, shall have one port per wire and the wires secured with set screws. The set screw holes shall be protected with removable plugs.

1091.10.2 Resin splice kits shall consist of a protective plastic case designed for the type of connector used, filled with a resin insulating compound mixed in accordance with the manufacturer's recommendations.

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SECTION 1092
SIGNAL EQUIPMENT

1092.1 Signal Heads. Signal heads shall meet the following requirements:

(a) All signal heads shall be weatherproof and black in color in accordance with Sec 1092.1.1. All indications shall be 12 inches unless specified otherwise.

(b) All signal indications in conventional signal heads shall be illuminated with LED modules. All LED modules, shall be in accordance with ITE Vehicle Traffic Control Signal Heads: Light Emitting Diode (LED) Circular Signal Supplement dated Jun 27, 2005, shall be Intertek ETL verified and shall be in accordance with the following:

(1) The lens of each green indication shall be clear. If a polymeric lens is supplied, a surface coating shall be applied to provide abrasion resistance.

(2) The LED modules shall not contain Aluminum Gallium Arsenide (AlGaAs).

(3) The LED modules shall provide constant light output under power. Modules with dimming capabilities shall have the option disabled or shall be set on a non-dimming operation.

(4) Module shall be labeled with “Manufactured in conformance with the ITE LED Circular Signal Supplement”.

(5) Provided with spade adapters.

(c) All arrow LED modules shall be in accordance with ITE Vehicle Traffic Control Signal Heads. Light Emitting Diodes (LED) Vehicle Arrow Traffic Signal Supplement dated July 1, 2007, shall be Intertek ETL verified and shall be in accordance with the following.

(1) Be omni-directional.

(2) The lens of each green arrow indication shall be clear.

(3) Module shall be labeled with "Manufactured in conformance with the ITE LED Vehicle Arrow Traffic Signal Supplement".

(4) Provided with spade adapters.

1092.1.1 Housing, Door and Visor. All new signal sections shall be clean, smooth and free from imperfections. The connection between signal housings shall be weatherproof. Housings shall be rigidly fastened together by a three- or four-bolt assembly or other connectors approved by the engineer. Doors that will exclude dust and moisture shall be used to ensure a weatherproof unit. A tunnel visor shall be supplied with each signal section and each door shall have provisions for attachment of the tunnel visor. All visors shall be held in place by four stainless steel fastening screws or bolts and shall be capable of being removed without opening the signal head door. Internal bosses or inserts shall be provided, in each housing, for mounting a terminal block and for the attachment of back plates. The top and bottom exterior of the housing shall be flat to ensure perfect alignment of assembled sections. The housing of each section shall be one piece with sides, back, top and bottom integrally molded. The design of the housing shall be such that, with the aid of simple tools and the addition of standard parts, it shall be possible to make any assembly consisting of one or more signal sections and, with the addition of standard bracket assemblies, assemble signal faces into multi-way traffic signal head configurations. The housings shall be polycarbonate. All material used in construction of polycarbonate signal heads shall be of ultraviolet stabilized color-impregnated polycarbonate resin. The housing shall have a minimum thickness of 0.09 inch and shall be ribbed or plated to produce added strength. If signal housings are not ribbed, minimum 0.10-inch aluminum plates shall be furnished and installed inside and outside the section housing at all points of attachment of the pipe bracket.

1092.1.2 Louvers. The degree of cut-off shall be stamped on the louver or printed on a decal on the front of the louver and shall be visible after installation.

1092.1.2.1 Fixed louvers shall be formed of 0.025-inch sheet aluminum. The top and bottom bends of each fin shall be securely fastened to the inside of the supporting ring. The angles of cut-off from either side of the center axis of the light beam shall be provided by six types of louvers: Type A - 3 degrees, Type B - 7 degrees, Type C - 10 1/2 degrees, Type D - 14 degrees, Type E - 18 1/2 degrees and Type F - 26 1/2 degrees.

1092.1.2.2 Adjustable louver units shall be composed of an acrylonitrile butadiene styrene (ABS) plastic housing and polycarbonate baffles. The unit shall be designed to prevent light leakage between the housing and the visor, and shall have an adjustable view range of 7 to
42 degrees. All plastic material shall be ultraviolet stabilized. All hardware shall be brass or stainless steel.

1092.1.3 Hardware. Hardware shall be 1 1/2-inch galvanized steel or unfinished aluminum, except aluminum pipe brackets and side mount brackets. Aluminum pipe brackets shall have a spun finish. Side mount brackets may be constructed of molded, glass-impregnated polycarbonate no greater than 12 inches in length. Elbows, tees and crosses shall be straight threaded and furnished with a square head set screw at each connection point to ensure rigid mounting. Fittings attached to the signal housing shall incorporate serrations or, by the use of an adapter ring, shall be compatible with the serrations on the signal housing.

1092.1.4 Backplates. Backplates shall be provided on all signal heads as shown on the plans. Backplates shall be black in color and constructed of flat pre-cut or preformed thermoplastic. Flat pre-cut thermoplastic backplates shall have a minimum thickness of 0.250 inch. Preformed thermoplastic backplates shall have rolled out edges and a minimum final thickness of 0.10 inch. When as indicated in the plans, a retroreflective strip shall be placed along the perimeter of the backplate. The retroreflective strip shall be made from yellow sheeting in accordance with Section 1042. The retroreflective strip shall be adhered to the backplate as shown in the plan.

1092.1.5 Optically Limiting Signal Heads. All signal sections shall meet the following:

(a) Each signal housing shall be die cast aluminum having a chromate preparatory treatment. The signal housing and lens holder shall be predrilled for backplates and visors. All access openings shall be sealed with weather resistant gaskets. Hinge and latch pins shall be non-ferrous metal or stainless steel. The lens holder and interior of the housing shall be optical black. The housing shall mount to standard 1 1/2-inch fittings as a single section, as a multiple section face or in combination with conventional signals. The signal housing shall be provided with an adjustable connection that permits incremental tilting from zero to 10 degrees above or below the horizontal while maintaining a common vertical axis through the mounting assembly. The housing connection shall permit external adjustment about the mounting axis in 5-degree increments. Attachments such as visors, backplates or adapters shall readily fasten to mounting surfaces without affecting the weatherproof characteristics and light integrity of the signal.

(b) The optical system shall consist of an objective lens, optical limiter-diffuser, lamp, lamp fixture and optical masking tape.

(1) The objective lens shall be a high-resolution planar incremental lens, hermetically sealed within a flat laminate of weather-resistant acrylic or approved equivalent. The lens shall be symmetrical in outline and if rotated to any 90-degree orientation about the optical axis, shall not displace the primary image.

(2) The optical limiter-diffuser shall provide an accessible imaging surface at focus on the optical axis for objects up to 1,200 feet distant and shall permit an effective veiling mask to be applied as determined by the desired visibility zone. The optical limiter-diffuser shall be provided with positive positioning and shall be composed of heat resistant glass.

(3) The lamp shall be in accordance with Sec 1092.1, and shall have an integral reflector. The lamp shall be attached to the diffusing element with a collar having a specular inner surface.

(4) The lamp fixture shall consist of a separately accessible housing and integral lamp support, an adjustable ceramic socket and a self-aligning, quick release lamp retainer. Electrical connection between section housing and lamp housing shall be accomplished with an interlock assembly that disconnects the lamp holder when the door is opened.

(5) A signal lamp intensity control shall be supplied in each signal section to provide dimming of the signal lamp as the ambient light intensity drops below approximately 3 footcandles.

1092.1.6 Pedestrian LED Countdown Signal Heads. Pedestrian LED countdown signal heads shall include two LED signal modules, one indicating a "WALKING PERSON" and "UPRAISED HAND" icon and the second a two digit numeric pedestrian change interval countdown display to inform pedestrians of the number of seconds remaining in the pedestrian change interval and any array of LEDs and related power supplies and any required lenses which, when connected to appropriate power, provides a single pedestrian signal indication and a countdown signal in a single housing unit. LED pedestrian signal countdown heads shall be in accordance with ITE specifications and standards for Pedestrian Traffic Control Signal Indicators: Light Emitting Diode (LED) Signal Modules dated August 4, 2010 and the following:

(a) Pedestrian LED countdown signal head housings shall be constructed of a black, one-piece, 0.250-inch thick, polycarbonate material as shown on the plans. The housing shall include an integral mounting bracket designed for mounting on the side of the pole on all makes of signal poles with a terminal compartment and minimum 5-position, double-row terminal block.

(1) The door, lens and any openings in the housing shall have gaskets or seals to exclude dust and moisture from the inside of the compartment.

(2) Lenses shall be constructed of polycarbonate material and reduce glare.

(3) Lenses shall be hard coated or otherwise made to comply with the UV material exposure effects of the Society of Automotive Engineers (SAE) J576.

(4) Lenses shall be a replaceable part, without the need to replace the complete LED signal housing.

(5) Pedestrian LED countdown signal head housing shall be provided with a manufactured, preformed rectangular visor or screen-type louver.

(b) Indications on LED signal modules shall be ITE Class 3 for icons and countdown display digits Icon and countdown modules shall be Intertek ETL verified and be in accordance with the following:

(1) The LED module lenses shall use transparent film or materials with similar characteristics.

(2) Modules, conforming to this specification, shall be labeled with the following statement, "Manufactured in Conformance with the ITE Pedestrian Traffic Control Signal Indicators: Light Emitting Diode (LED) Signal Modules".

(3) Modules with dimming capabilities shall have the option disabled or shall be set on a non-dimming operation.

(4) LED signal modules displaying ITE Class 3 icons shall be constructed such that both the "WALKING PERSON" icon and the "UPRAISED HAND" icon are displayed from the same module on the same rectangular surface area. The illumination of one icon shall not result in the illumination of the other icon.

(5) Supplied with spade adapters.

(c) If the pedestrian change interval is interrupted or shortened as part of the transition into a preemption sequence the countdown pedestrian signal display should be discontinued and go dark upon activation of the preemption transition.

(d) The countdown learning cycle shall only be initiated after the initial installation, a return from a power failure greater than 2 seconds, a repeated demand to change programming, or after preemption. During the learning cycle, the countdown display shall remain blank. The learning cycle shall not last more than two complete cycles.

1092.1.7 Finishing. Mounting brackets and hardware, except the aluminum pipe brackets and polycarbonate side mounted brackets, shall be galvanized steel or unfinished aluminum. Aluminum pipe brackets shall have a spun finish. Painting of the mounting brackets and hardware will not be permitted.

1092.2 Posts and Mast Arms. A grounding lug shall be provided for all units. A grounding conductor shall provide grounding continuity for all metallic, noncurrent carrying poles in one circuit.

1092.2.1 Steel Pedestal Posts. Steel pedestal posts shall be 4 1/2-inch outside diameter schedule 40 steel pipe. The base shall be cast iron, free from imperfections, and shall be provided with a suitable plastic, fiberglass or cast door for wiring access. The grounding lug shall be inside the base. The bolt circle and hole diameter shall be as shown on the plans. After fabrication, posts and bases shall be fully galvanized.

1092.2.2 Aluminum Pedestal Posts. Aluminum pedestal posts shall be schedule 80 straight tubing of 6063-T6 aluminum alloy in accordance with ASTM B 210, with a 4 1/2-inch outside diameter. The pedestal base casting shall be either permanent mold casting of Alloy 356.0 F, in accordance with ASTM B 108, or sand castings of Alloy 356.0 F, in accordance with ASTM B 26. The base shall be free from imperfections and shall be provided with a suitable door for wiring access. The base and post shall be joined by a threaded connection. Welded connections will not be permitted. The grounding lug shall be provided inside the base. All hardware shall be non-ferrous metal or stainless steel.

1092.2.3 Signal Post and Mast Arm Pre-Approval. Fabricators shall submit six copies of shop drawings and supporting calculations to Traffic. Submittals shall be approved by Traffic in writing prior to fabrication of the signal posts and mast arms. Shop drawings shall indicate complete design details required for post and mast arm fabrication, including material grades and thicknesses, welding and orientation of any longitudinal seams. The projected areas and weights of signs and signals used in the design of the post and mast arms shall be shown on the shop drawings. Design details for all possible post and mast arm combinations shown on the plans may be submitted. Shop drawings shall provide post and mast arm installation and hardware details. All welding procedures shall be prepared by the manufacturer as a written procedure specification and shall be submitted with the shop drawings for approval. Approval of the weld procedures will be required before approval of the shop drawings. Shop drawings shall indicate the specific approved welding procedure to be used for each joint. Shop drawings and supporting stress calculations shall be signed and sealed by a registered professional engineer in the State of Missouri. Manufacturers shall submit all required documentation, in accordance with Sec 1092.2.4.3. Upon written approval, pre-approved drawings may be used on any project where the design conditions of the shop drawings are not exceeded.

1092.2.4 Steel Posts and Mast Arms. Steel posts and mast arms shall be continuously tapered, hollow shafts fabricated as one continuous shaft or as individual segments at least 10 feet long, joined together using electrically welded, intermediate, transverse, full penetration, circumferential joints. Steel posts and mast arms shall be fabricated from basic oxygen or open-hearth steel sheet. The continuous, tapered, hollow shafts or individual segments shall be manufactured from one or two lengths of steel sheet, with one or two continuous, welded, longitudinal seams. The longitudinal seams in the mast arm shall be located outside of the upper half of the cross section of the member. Where transverse, full penetration, circumferential welds are used, the fabricator shall furnish to the engineer written certification that 100 percent of all such welds have been radiographed or ultrasonic tested by an independent testing agency using a qualified non-destructive testing technician, as described in Section 6.14.7 of ANSI/AWS D1.1 Structural Welding Code-Steel and equipment calibrated annually. The testing agency shall be approved by the engineer prior to fabrication. Post base and mast arm attachment plates shall be plate steel attached to the larger end of the shafts by continuous welds on the inside and outside of the shaft. After manufacture, the material shall have a minimum yield strength of 48,000 psi.

1092.2.4.1 A handhole equipped with a suitable metal cover shall be provided in the post near the base, and 12 inches above the mast arm connection if luminaire mounting is specified. A grounding lug or connector shall be provided inside the post near the handhole. A removable raintight metal pole cap shall be provided on the top of the post and on the small end of each mast arm. All handhole covers and metal caps shall include a galvanized steel chain. The chain shall be capable of supporting at least six times the weight of the cover or cap and be securely attached to the inside of the post or arm, with sufficient length to allow removal of the cover or cap for maintenance access.. The pole caps and handhole covers shall be securely attached to the post with screws that penetrates through the cap or cover and the post or arm. An aluminum or stainless steel identification tag shall be provided with all posts and mast arms as shown on the plans. The letters and numbers on the tag shall be

embossed or engraved. The post tag shall be attached to the pole 6 inches above the top of the handhole. The mast arm tag shall be attached 3 inches from the base of the end cap. The base plate shall be equipped with four cast steel or cast iron nut covers in accordance with AASHTO M 103 or M 105, or four aluminum nut covers and shall have four galvanized or stainless steel screws for securing covers to the pole. All poles, shoe bases, base plates and cast steel or cast iron nut covers shall be fully galvanized after fabrication. All anchor bolt nuts shall be completely covered by nut covers. Luminaire bracket arms, when specified, shall be included with the post and mast arm. The contractor may furnish posts with the shape, gage and dimensions meeting or exceeding those required by the plans and specifications, provided shop drawings are submitted and approved in accordance with Sec 1092.2.3.

1092.2.4.2 Welding and fabrication of the assemblies shall be in accordance with the ANSI/AWS D1.1 Structural Welding Code-Steel. All requirements of the welding code for tubular structures will apply to the fabrication for the post and mast arm shafts and shall include any welds used to attach these members to plates or other hardware. The manufacturer shall employ qualified personnel to perform all visual and nondestructive testing (NDT) required. In addition to the visual inspections and NDT that may otherwise be required by the welding code, the manufacturer shall perform 100 percent magnetic particle (MT) testing of circumferential fillet welds used to attach the flange plate to the larger end of the mast arm shaft. NDT personnel shall be qualified as set forth in paragraph 6.14.7 of ANSI/AWS D1.1 Structural Welding Code-Steel. Qualifications of NDT personnel shall be submitted to the engineer for approval.

1092.2.4.3 The post and mast arm manufacturer shall be certified under the AISC certification program, Conventional Steel Building, or higher category. Evidence of current AISC certification will be required prior to the approval of shop drawings, and lapsing of the certification will be cause for the manufacturer's removal from the approved list of suppliers.

1092.2.4.4 Steel posts, luminaire bracket arms, mast arms, nut covers and plate steel bases shall be hot-dip galvanized inside and out after fabrication, visual inspections and NDT testing. Galvanized material shall be handled in such a manner to avoid damage to the surface. Any galvanized material on which the coating has been damaged will be rejected or may, with approval from the engineer, be repaired in accordance with Sec 1081.

1092.2.5 Fabricator's Certification. Prior to erection of the posts and mast arms, the contractor shall furnish to the engineer a fabricator's certification. The certification shall specifically state the fabricated posts and mast arms have been quality control inspected by the fabricator and all material and manufacturing processes used were in full compliance with the specification requirements and the approved shop drawings and weld procedures. Certification shall be accompanied by supporting documentation, including the results of the visual inspections and NDT in accordance with Sec 1092.2.4.2 and copies of the pre-approved drawings required by Sec 1092.2.3.

1092.3 Lighting Control Cabinet. The lighting control cabinet shall contain a control panel constructed of the same material as the cabinet. Circuit breakers, the photoelectric switch, a contactor, if specified, and any other specified equipment for luminaire control shall be installed on the panel. Control cabinets shall be of sufficient size to house all equipment shown on the plans. Cabinets shall be dust tight, watertight, NEMA 4 and constructed of aluminum or stainless steel. All hinges, catches and other hardware shall be stainless steel. Cabinets shall have a No. 2 Corbin cabinet lock. Photoelectric switches and contactors shall be in accordance with Sec 901. Circuit breakers shall be Type B circuit breakers in accordance with Sec 901.

1092.4 Traffic Controller Assemblies. Traffic controller assemblies will be defined as the complete assembly of all required equipment and components for control of traffic signal indications. The type of controller assembly required for each location shall be as specified in the contract documents.

1092.4.1 NEMA TS1. Each NEMA TS1 controller assembly shall consist of a controller cabinet, signal controller, back panel, conflict monitor, card rack assembly, all required wiring, switches and connectors and all other equipment as defined in these specifications and as shown on the plans. Double controller assemblies to control two intersections shall consist of a controller cabinet, two signal controllers, two back panels, two conflict monitors, two card rack assemblies, all required wiring, switches and connectors and all other equipment as defined in these specifications and as shown on the plans.

(a) Each controller and associated equipment shall be designed to operate on 120 volts, 60 hertz, single phase, alternating current.

(b) Variations in the voltage of the power supply of ± 10 percent or sustained temperatures inside the cabinet between -20 and 165 F shall not change the total time cycle of pretimed controllers or the length of any interval, portion, period or unit extension of actuated controllers by more than five percent or cause electrical or mechanical damage. Heater elements shall not be used to attain compliance with these requirements.

(c) Vibration shall not affect normal operation of any equipment.

(d) All controllers and other specified auxiliary equipment shall be properly protected with fuses on each applicable unit. Fuses shall be installed in 1/4-twist or screw-in type fuse holders. Pop-out fuse holders will not be permitted.

1092.4.1.1 Controller Cabinets. Controller cabinets shall be cast aluminum or 0.125 inch reinforced sheet aluminum alloy and shall be of clean-cut design and appearance. The cabinet shall provide ample space for housing all equipment and components. Controller cabinets housing solid state controllers shall be furnished with unused cabinet space measuring 18 inches wide by 12 inches high by 12 inches deep, unless coordination equipment is specified on the plans. For pretimed and actuated NEMA controllers, the cabinet shall support a sixteen-position back panel. Double controller cabinets for two controllers shall support two sixteen-position back panels. All double cabinets shall have two doors that are hinged on the outside corners of the cabinet such that the doors open away from each other. Double cabinets shall have a divider between the two halves of the cabinet with an 8-inch opening between the compartments at the bottom of the divider for wiring between the compartments. The cabinet shall contain a rigid mounting table, sliding ways or hinged support of such construction that the controller and auxiliary equipment may be withdrawn from the cabinet without breaking any electrical connections or interrupting normal controller operation. Hinged supports shall be welded to the controller cabinet. Electrical connectors on the controller and auxiliary equipment to all circuits shall be NEMA 1/4 twist or MS type. Components of controller cabinets shall meet the following requirements.

(a) A hinged door or doors shall provide complete access to the interior of the cabinet. Door holds shall secure the door in an open position at least 90 degrees from the closed position and shall be furnished with each cabinet. The doors shall fit against a raintight gasket. Each door shall have a stamped or raised outside designation, "Traffic Control" or other approved identification. Each main cabinet door shall have a No. 2 Corbin cabinet lock and provisions for locking with a padlock. The handles for each door shall swing outward. An auxiliary door, positioned on each main cabinet door, equipped with a raintight gasket, shall allow access to a police panel and shall be equipped with a lock whose key will not unlock the main door. Two keys shall be furnished for each type lock used. The door hinges and pins shall be of corrosion-resistant metal. Pins shall be rolled or solid rod, at least 1/8 inch in diameter, except if continuous hinges are furnished, the pins shall be continuous the full length of the hinges, and shall be no less than 1/16 inch in diameter.

(b) The back panel in all controller cabinets shall be hinged at the bottom to permit the top of the panel to be rotated forward and down to an angle of no less than 45 degrees with all components, including load switches, attached for maintenance purposes. The bottom of the back panel shall be no less than 6 inches above the bottom of the cabinet.

(c) Cabinets housing solid state controllers shall have a thermostatically controlled ventilating fan with exhausting capability in an enclosure of at least 150 cubic feet per minute for cabinets up to 30.5 cubic feet and at least 250 cubic feet per minute for cabinets 30.5 cubic feet and more, installed in the top of the cabinet. Cabinets shall be supplied with a replaceable furnace-type fiberglass filter of at least one square foot area mounted behind louvers in the lower one-fourth of the door.

(d) Each controller cabinet shall be furnished with a clearly labeled switch mounted in the access or police panel to place the signals on flash. Operation of this switch shall not affect the electrical power supply to the controller. This shall be the only control switch accessible from the police panel.

(e) Each cabinet shall be provided with a grounded service outlet and a switch-controlled lamp receptacle.

(f) Each cabinet shall contain a separate aluminum power panel containing the following equipment.

(1) Two Type B circuit breakers in accordance with Sec 901. One breaker shall interrupt power to the controller and signals. The frame size and trip rating will be shown on the traffic signal plans or designated in the contract. The second Type B circuit breaker shall be an auxiliary breaker that interrupts power to the cabinet lamp and receptacle. The frame size and trip rating shall be 15 amperes.

(2) One mercury contactor controlling power to the signal bus.

(3) One radio frequency line filter.

(4) One line surge protector.

(5) One terminal block for alternating current power input.

(6) One ground bus terminal block.

(7) One isolated neutral bus terminal block.

(g) If specified, a manual operation push button shall be installed in the police panel. The push button shall be wired for manual operation of the signals. The push button shall be water-resistant, designed to protect the user against electrical shock, and shall be supplied with a coiled cord with a nominal 6-foot stretched length. A clearly labeled switch shall also be installed in the police panel to switch between manual or automatic operation of the controller.

1092.4.1.2 Flasher Unit. Each controller, through terminal options, shall permit yellow-red or red-red flash operation. Indications shall be flashed at no less than 50 or more than 60 flashes per minute, with approximately 50 percent dwell time. A two-circuit flasher, alternate flash and three flasher field circuits for each of the two flasher circuits will be required. A separate flasher shall provide flashing pedestrian indications when required by the contract. The timing of flashing pedestrian intervals shall be separately adjustable from all other timed intervals. The flasher shall be solid state with ratings of at least 15 amperes per circuit and shall comply with the latest revision of NEMA Standards Publication TS. The flasher units shall have a 150-volt metal oxide varistor (MOV) placed on each output flash terminal. Uniform code flash circuitry will be required for each controller. Flashing operation shall be in accordance with the MUTCD.

1092.4.1.3 External Time Switches. External time switches shall be solid state, keyboard entry and shall contain filtering and shielding circuitry to protect the unit's operation against electrical interference. Timing shall be based on the 60-hertz power supply frequency. Each unit shall contain a programmable automatic central daylight time compensation feature and a back-up power source to maintain time and memory functions during loss of alternating current power. Each unit shall provide a weekly program with at least 20 event changes per week.

1092.4.1.4 Wiring. The controller cabinet shall be equipped with a 600-volt heavy-duty one-piece mechanical screw connector offset tang assembly attached to a barrier terminal strip for terminating field conductors. Each mechanical screw connector shall accommodate up to four No. 12 AWG conductors. The connector shall be mounted horizontally on the inside back of the cabinet, approximately 6 inches from the bottom of the cabinet. All wiring to the terminal strips, except the incoming field circuits, shall be performed by the controller manufacturer. The terminal strips shall accommodate at least:

(a) Two terminals for the power supply.

(b) An unfused terminal for neutral side of power supply line.

(c) One terminal for each signal lamp circuit and one terminal for the common return from each signal face.

(d) If detectors are used:

(1) Two terminals for each detector.

(2) Screw terminal strips mounted vertically on the side of the cabinet approximately 6 inches

from the bottom of the cabinet.

(3) All inductive loop detector inputs shall be protected with two 30-volt MOVs with a 30-j rating. An MOV shall be connected between each field terminal and cabinet ground.

(e) Terminals for interconnect cable when the controller is to be hard-wire interconnected shall be fused and provided with a 150-volt MOV with an 80 j rating.

(f) Terminals for closed loop system interconnect cable shall be fused and provided with a 30-volt MOV with a 30 j rating.

1092.4.1.5 Back Panel Wiring. Regardless of the number of phases specified on the plans, all load switch positions shall be completely wired for use. If pedestrian phases are not specified, twelve-position back panels for actuated NEMA controllers shall be configured for operation of eight phases and four overlaps. If pedestrian phases are specified, 12-position back panels shall be configured for operation of eight phases and four pedestrian phases or a combination of overlaps and pedestrian phases if specified on the plans. If flashing yellow arrow operation is called for, the appropriate load switches shall be configured as specified on the plans. Twelve-position back panels for pretimed controllers shall be configured for operation of 36 circuit outputs from the controller unless otherwise specified on the plans. A flash transfer relay socket shall be provided for each pair of load switch positions. Flash circuit one shall be wired to positions one, 3, 5, 7, 9 and 11. Flash circuit 2 shall be wired to positions 2, 4, 6, 8, 10 and 12. All flash transfer relay sockets shall be fully wired for operation. All controller harness wiring shall be connected to labeled terminals on the front of the panel.

1092.4.1.6 Solid State Controllers. This section describes the general specifications for actuated solid state controllers. If requested by the engineer, the contractor shall provide a prototype controller for testing and evaluation.

(a) Each controller shall be solid state keyboard entry and the circuit design shall use microprocessor techniques.

(b) Timing shall be accomplished in a digital manner by counting the 60 hertz power supply frequency. Timing circuits, interval and phase switching functions shall be accomplished by solid state circuitry. Removing, changing wires or using any tools to make timing interval adjustments shall not be necessary. The controller shall indicate the right of way conditions of the phase timing interval in effect, detector or actuation on each phase and memory conditions or demand on each phase for vehicles and pedestrians by use of status lights or display panels. The controller shall be capable of flashing yellow arrow operation without any external devices or special software upgrades.

(c) Opening and closing of signal lamp circuits shall be performed by plug-in solid state load switches, rated at no less than 10 amperes and loaded at a maximum of 6.7 amperes, located external to the controller. All load switch jacks shall be completely wired to field output terminal strips. Actuated and pretimed controllers shall have a minimum of twelve load switch jacks. Each load switch shall provide three independent circuits with "on" indicator lamps and shall comply with the latest revision of NEMA Standards Publication TS.

(d) Each controller assembly shall contain a conflict monitor external to the controller circuitry conforming to NEMA Standards Publication TS and be capable of monitoring flashing yellow arrow operation on any channel. The monitor shall cause immediate transfer to flashing operation when conflicting or absent indications occur or when a voltage fault occurs. When the conflict monitor actuates flashing operation, the controller shall freeze or stop timing in the condition causing the actuation until manually reset. A single lamp failure in any signal head shall not cause the monitor to actuate.

(e) For double controller cabinets, two sets of switches shall be provided, one set for each controller installed in each compartment. Each controller cabinet shall be furnished with the following switches:

(1) Power Interrupt Switch - A switch located inside the main cabinet shall interrupt electrical power to the controller during maintenance on the controller. Operation of this switch shall not affect the flash operation. This switch shall not be accessible via the police panel.

(2) Flash Switch - A switch mounted in the police panel shall place the signal on flash. Operation of this switch shall not affect the electrical power supply to the controller. When the signals are returned to normal operation the external start shall be activated causing the controller to revert to the programmed initialization phase(s).

(3) Stop Time Switch - A three-position switch mounted inside the main cabinet shall provide the following functions:

(i) Stop Time - Causes the controller to stop time.

(ii) Normal - Allows the controller to cycle all phases, but during conflict monitor flash causes the controller to stop time.

(iii) Run - Allows the controller to cycle all phases and during any flashing operation allows the controller to continue cycling all phases without displaying them on the signal heads.

(f) During all direction flash condition, controller operation shall permit the cycling of all signal phases without an external load being connected to the field terminals.

(g) Solid state controllers shall have electronic filters to prevent interference caused by the opening and closing of circuits in electro-mechanical auxiliary equipment.

(h) The controller shall be of modular design constructed for individual removal and replacement in the controller by multiple prong jacks or outlets without modifying wiring. Hand operable positive locking devices shall be used to hold the modules securely in the controller.

(i) The functional operating circuits and associated components shall be grouped in plug-in printed circuit assemblies. Similar assemblies shall be interchangeable between controllers manufactured by the same company.

(j) The controller shall contain the necessary phase sequence, interval sequence timing, power supply and monitoring equipment required to supervise the operation for the phasing shown on the plans, including any future controller expansion. If future phases are specified, the controller shall be completely configured to accept the future phases.

(k) Controllers that are interconnected shall have a coordinated/free operation switch to allow the controller to operate in coordination with the system or run free.

(l) High energy transient surge protection shall be provided on all solid state controllers to minimize damage to the controller and auxiliary equipment. This device shall be located on the incoming 120 volts, 60 hertz power service between the controller and signal circuit breaker and the power inputs to the controller and auxiliary equipment. The surge protector will plug-in to a hardwired base. Two LEDs that indicate the status of the surge protector shall be incorporated on the surge protector. One LED will indicate the surge protector is still operable and the other will indicate it has failed. The surge protector and base shall be capable of operating in the temperature range of -40 C to +85 C. The arrestor shall meet the latest NEMA specifications for surge protection.

(m) Every all direction flash operation called from a source external to the controller shall occur through the flash transfer relay.

(n) Any multi-conductor cable shall be contained in an expandable braided sleeve.

(o) Switches or relays that completely interrupt power to the signal heads other than the protective circuit breaker shall not be installed in the cabinet.

(p) All controllers shall be capable of downloading all programming data to a printer via a front panel RS-232 connection. The controller shall be capable of printing directly to a printer or via an external computer. If an external computer is required, the required software shall be provided with the controller.

(q) All controllers shall be provided with internal pre-emption functions and circuitry.

1092.4.1.6.1 Solid State Actuated Controller. Each solid state actuated controller shall meet the latest revision of NEMA Standards Publication TS. Actuated controllers shall meet the following requirements:

(a) Recall by keyboard entry shall be provided for each phase to furnish continuous recall. With the recall function in the "OFF" position, the controller shall operate normally with the right of way being transferred only upon pedestrian or vehicle actuation or external force-off control.

(b) Controllers shall be furnished with provisions for external maximum control for each signal phase complete with wiring to permit installation of a coordination unit. All wiring to facilitate coordination shall be terminated on terminal strips and complete information stating the function of each terminal shall be shown on the controller-wiring diagram.

(c) All phases shall contain a non-locking memory feature that can be energized or de-energized by keyboard entry.

(d) All phases shall be capable of being activated or inactivated by keyboard entry.

(e) On the cabinet inside door test panel, an external push button switch for each vehicle and pedestrian phase shall be provided. Each switch shall provide call to the phase assigned and ability to extend the phase. This detector input shall be independent of the circuitry between the amplifier and back panel.

(f) A MoDOT D-plug shall be provided between the D-plug on the controller and the interconnect panel on the cabinet. In the absence of the sync signal, the coordination interface shall be configured to cause the controller to default to free operation. Configuration of the MoDOT D-plug shall be as follows:

Pin	Assignment	Pin	Assignment	Pin	Assignment
D1	Cycle 1	D10	Split 4	D19	Future (Pre-empt 4)
D2	Cycle 2	D11	Offset 1	D20	Flash
D3	Cycle 3	D12	Offset 2	D21	Hardware Interconnect[a]
D4	Cycle 4	D13	Offset 3	D22	Future
D5	Future (Cycle 5)	D14	Future (Offset 4)	D23	Future
D6	Future (Cycle 6)	D15	Future (Offset 5)	D24	Future
D7	Split 1	D16	Pre-empt 1	D25	Future
D8	Split 2	D17	Pre-empt 2		
D9	Split 3	D18	Pre-empt 3		

[a]Omit when activated through the cycle, split or offset inputs.

(g) The MoDOT D-Plug shall be a Cinch TRW Super D Connection as follows:

1 - Part #TB 25 P	Plug		1 - Part #SHD-25GL	Hood with Latch
1 - Part #TB 25SLB-1	Socket		1 - Part #SHD-25GFCS	Hood with Filler Ends

(h) Actuated controllers shall be fully configured for operation of a minimum of eight vehicle phases, four pedestrian phases and four overlaps, regardless of the number of phases shown on the plans.

1092.4.1.6.2 Timing Function. Timing intervals or periods shall be set by means of keyboard entry. Each timing interval shall be adjustable to any value within the following minimum ranges for each phase. Zero may be satisfied by a time increment of up to 100 milliseconds.

Interval	Range (seconds)
Minimal Initial	0 - 99
Unit Extension or Passage Time	0 - 9.9
Yellow Clearance	0 - 9.9
Red Clearance	0 - 9.9

Maximum I Green	0 - 99
Maximum II Green	0 - 99
Walk	0 - 99
Pedestrian Clearance	0 - 99
Seconds per Actuation	0 - 9.9
Maximum Initial	0 - 99
Time Before Reduction	0 - 99
Time to Reduce	0 - 99
Minimum Gap	0 - 9.9

1092.4.2 Type 170. Except as herein modified, the Microcomputer 170E controller, cabinet and equipment shall be in accordance with the Caltrans Transportation Electrical Equipment Specifications, Chapter 2, dated August 16, 2002, which shall form a part of these specifications. A copy of the Caltrans specifications is available upon request. In case of conflict, MoDOT specifications will govern. Certification that the equipment proposed is included on the most current Qualified Products List of Caltrans and MoDOT Approved Products List shall be provided. A list of pre-approved equipment and material is available through Traffic or MoDOT's web site. Department-specific equipment not defined in the Caltrans specification will be exempt from this Qualified Product List requirement.

1092.4.2.1 Type 170 Controllers.

(a) The controller shall be fully compatible with the software specified on the plans.

(b) The C2, C20, C30 and C40 connectors shall be amp standard.

(c) One spare set of internal printed circuit boards shall be furnished with each controller unit. This shall include, but is not limited to, the power supply, front panel, I/O, central processing unit and modem, if specified.

1092.4.2.1.1 Master Controller. If a master controller or master coordination unit is specified in the plans, the master controller shall be a Type 170 controller. This controller shall be in addition to the intersection controller and shall be installed in the same cabinet unless otherwise specified on the plans.

1092.4.2.1.2 Diagnostic Test Program. For each ten or fewer Model 170E controllers purchased, a Diagnostic Test Program Prom Chip shall be provided. The Diagnostic Test Program Prom Chip shall test the operation of the Model 170E controller units including, but not limited to, internal memory, the program module, the real-time clock, input-output circuitry, the modem, the display and keyboard. The program shall be capable of operating with an external monitor and controller keypad. Full documentation on the program shall be included. The software shall be configured to work on a 412C prom module.

1092.4.2.1.3 Prom Module. Each Model 170E controller unit shall be furnished with one prom module, Model 412C, including a back up lithium battery and real time clock adjuster circuit, one Dallas 1225 chip and two 6264 ram chips.

1092.4.2.2 Type 170 Controller Cabinets. Type 170 controller cabinets, including the auxiliary door, shall be cast aluminum or 0.125 inch reinforced sheet aluminum alloy and be of clean-cut design and appearance. An auxiliary door equipped with a raintight gasket, shall allow access to a police panel and shall be equipped with a lock whose key will not unlock the main door. The doors shall be louvered to direct the incoming air downward. The cabinet shall be supplied with a replaceable furnace-type fiberglass filter mounted behind the louvers and shall cover the vent openings. A filter shell shall be provided to fit over the filter to provide mechanical support. Each cabinet door shall have a No. 2 Corbin cabinet lock and provisions for locking with a padlock. Two keys shall be furnished for each type of lock used. The handles for each door shall swing outward. Components of the Type 170 controller cabinets shall meet the following requirements:

(a) The cabinet shall contain a pull out, hinged-top drawer, including sliding tracks, with lockout and a quick-disconnect feature, such as a Vent-Rak Retractable Writing Shelf, #D-4090-13, or equivalent. The pull out drawer shall extend a minimum of 14 inches to facilitate removal of the processor by providing an aluminum platform covered with a formica-type, chemical-proof plastic sheet while the rear connector is being removed. The interior of the drawer shall be accessible. Minimum interior dimensions of the drawer shall be one inch high, 13 inches deep and 16 inches wide. The drawer shall

be capable of supporting 40 pounds when fully extended and shall be mounted immediately below the controller assembly.

(b) All cabinet assemblies shall be supplied with a power distribution assembly Number 2, (PDA#2). If an auxiliary output file is specified, C5 connections shall be included.

(c) Each Type 336S cabinet shall include two fluorescent lighting fixtures mounted inside the front and back portion of the cabinet. The fixtures shall include a cool white lamp with protective cover and shall operate by a normal power UL listed ballast. The fixtures shall be installed to automatically power on when the cabinet door is opened and automatically power off when the cabinet door is closed. A manual on/off switch shall be provided for each fixture. Each switch should work each individual light. The Type 332 cabinet will require only one lighting fixture meeting the above requirements.

(d) Each controller cabinet shall be furnished with a clearly labeled switch, mounted in the access or police panel to place the signals on flash. Operation of this switch shall not affect the electrical power supply to the controller. The switch shall be labeled FLASH/AUTOMATIC. This shall be the only control switch accessible from the police panel.

(e) All output field conductors shall be terminated in the cabinet on a one-piece copper 600-volt heavy duty mechanical screw connector offset tang assembly. Each mechanical screw connector shall accommodate up to four No. 12 AWG conductors. Each clamp shall be captive to the contact screw and the screw captive to the contact. Field wiring shall not be spade lugged. The alternating current neutral bus and chassis ground bus shall be a 17-position solid copper neutral bar with set screws that allow the wires to be attached without tang or spade assemblies.

(f) The output file shall be hand wired and printed circuit boards will not be allowed, except for red fail monitoring. The back of the load switch bay and the conflict monitor bay shall be enclosed to prevent wires interfering with plugging in of components.

(g) A 420 auxiliary output file will be required when specified on the plans or if more than 12 load switches are required.

(h) I and J input files shall be provided unless otherwise specified.

(i) All cables shall be located and secured such that the cables do not interfere with removal of the controller or the opening of the controller front panel.

(j) A diagnostic cabinet test program, including documentation, shall be provided with each ten or fewer cabinets.

1092.4.2.3 Surge Protection. Each cabinet shall be provided with devices to protect the control equipment from surges and over voltages. This shall include incoming power lines, the input and output files and communication lines.

1092.4.2.3.1 All input file inputs shall be protected with a 30-volt MOV with a 30-j rating. All load switch outputs shall be protected with a 150-volt MOV with an 80-j rating. Each MOV shall be connected from the alternating current positive field terminal to the chassis ground. Each output MOV shall be mounted on the field terminal side of the output assembly.

1092.4.2.3.2 For the 332A cabinet, appropriate input surge protection shall be mounted on the lower input termination panel (LIP). The PDA#2 of each controller cabinet shall include a surge protection unit on the alternating current service input. The protector shall be installed between the applied line voltage and earth ground. The surge protector shall be capable of reducing the effect of lightning transient voltages applied to the alternating current line. The protection device shall be a two-stage series parallel device. The device shall include the following features and functions:

(a) Maximum alternating current line voltage shall be 140 volts during 20 pulses of peak current, each of which shall rise in 8 microseconds and fall in 20 microseconds to one half of the peak of 20,000 amps.

(b) The protector shall be provided with the following terminals:

(1) Main line (alternating current line first stage terminal).

(2) Main neutral (alternating current neutral input terminal).

(3) Equipment line out (alternating current line second stage output terminal, 10 amps.).

(4) Equipment neutral out (neutral terminal to protected equipment).

(5) GND (earth connection).

(c) The main alternating current line in and the equipment line out terminals shall be separated by a minimum 200 microhenry inductor rated to handle 10-amp alternating current service. The first stage clamp shall be between the main line and ground terminals.

(d) The second stage clamp shall be between the equipment line out and equipment neutral.

(e) The protector for the first and second stage clamp shall have an MOV or similar solid state device rated at 20 kiloamps and shall be of a completely solid stage design. Gas discharge tubes will not be allowed.

(f) The main neutral and equipment neutral out shall be connected internally and shall have an MOV similar solid state device or gas discharge tubes rated at 20 kiloamps between the main neutral and ground terminals.

(g) Peak clamp voltage shall be 350 volts at 20 kiloamps measured between the equipment line out and equipment neutral out terminals. Current shall be applied between the main line and ground terminals. Ground and main neutral terminals shall be externally tied together. The voltage shall not exceed 350 volts.

(h) The protector shall be epoxy-encapsulated in a flame retardant material.

(i) Continuous service current shall be 10 amps at 120 volts alternating current root means squared (RMS).

(j) The equipment line out shall provide power to the Type 170 controller and to the 24 volt power supply.

(k) Communications line protector for incoming and outgoing communication lines shall be EDCO part #PC642C-008 or equivalent with mounting connector #PCB1B or equivalent. If fiber or radio communications are specified, these communications line protectors will not be required.

1092.4.2.4 Cabinet Accessories. Each cabinet shall be equipped with the following, unless specified otherwise:

(a) A minimum of one direct current isolator.

(b) Load switches, quantity as specified in the contract documents.

(c) Two flashers.

(d) Alternating current isolators, quantity as specified in the contract documents.

(e) Four flash transfer relays. Two additional flash transfer relays shall be provided when a 420 auxiliary is shown on the plans.

(f) Modem, quantity as specified in the contract documents.

(g) SM modem, quantity as specified in the contract documents.

(h) Fiber optic modem, quantity as specified in the contract documents.

(i) Computer cable. The computer cable shall consist of both male and female amp connectors. The female connector shall be located in the front of the cabinet and shall extend past the front edge of the rack a minimum of 0.5 inches and a maximum of 1 inch. The male connector shall be located in the back of the cabinet. The cable shall extend 14 inches along the side of the rack with a minimum of 12 inches free that can be used to plug into any of the controller's four ports. The cable shall consist of one wire connecting the like pin in the other connector starting with A and ending with R. The wire shall be 20 AWG. One cable shall be supplied for each cabinet. The mounting of this cable shall not interfere in any way with the installation or removal of the controller. If the cable is mounted within the pull out drawer, any hole that is drilled in the drawer shall be equipped with a rubber grommet to protect the cable and the cable shall have enough slack to prevent binding.

(j) Conflict monitor.

(1) The conflict monitor shall be external to the controller circuitry in accordance with the Caltrans specifications. The monitor shall cause immediate transfer to flashing operation when conflicting or absent indications occur or when a voltage fault occurs. When the conflict monitor actuates flashing operation, the controller shall freeze or stop timing in the condition causing the actuation until manually reset. A single lamp failure in any signal head shall not cause the monitor to actuate.

(2) A connector and terminal assembly designated as P20 ,Magnum P/N 722120 or equivalent, for monitoring the absence of red shall be an integral part of the output file. The connector shall terminate and shall be compatible with the cable and connector of the conflict monitor unit. The pin assignments of the P20 connector and terminal assembly shall be provided with the cabinet plans. The P20 connector shall be designed such that the cable may only be inserted into the P20 connector in one direction. Unused red channels shall be programmed through jumpers. These jumpers shall cause 115 volts alternating current to be applied to any and all unused red monitoring channels. These jumpers and the respective attachment points shall be part of the output file.

1092.4.2.5 Software. Software shall be provided with each Type 170 controller unless otherwise specified. Requirements for software will be as follows.

1092.4.2.5.1 District 4 - Kansas City Area. The 412C prom module shall be configured for Wapiti software. For intersection controllers, the most recent revision of Wapiti W4IKS shall be mounted on the prom module. For master controllers, the most recent revision of Wapiti W70SM shall be mounted on the prom module.

1092.4.2.5.2 District 8 - Springfield Area. The 412C prom module shall be configured for Bi-Trans software that will be provided by District 8.

1092.4.2.6 Testing Requirements. All equipment shall be tested for conformance to these specifications. Testing may be done by an independent laboratory if the manufacturer does not have sufficient facilities to conduct the testing. A copy of the test results for all equipment shall be supplied by the manufacturer to the engineer.

1092.4.2.6.1 Conflict Monitor Test Cable. To facilitate testing of the conflict monitor, one additional 4-foot connector cable shall be furnished by the manufacturer and installed in each cabinet. The cable shall utilize an 18 AWG wire to connect a 36-pin plug to the back panel terminals as specified below. The connector cable shall utilize a 36-circuit polarized nylon Waldon Molex type receptacle, P/N 03-06-1361, using a 0.062-inch female terminals made of 70/30 spring tempered 0.010 inch thick tin-plated brass with contact of resistance 0.0025 ohm millivolts, drop of 2.5 millivolts at one amp with 250 volts, 4 amps maximum per circuit. This connector cable shall "free float" in the bottom front 6 inches of the cabinet and shall not be used in the normal operation of the controller. A moisture-proof cap shall be provided to prevent the accumulation of moisture on the plug terminals. The cap shall remain attached to the connector when the cable is in use.

Receptacle Circuit	Terminal Phase		Receptacle Circuit	Terminal Phase
1	1 G		19	4 WALK

2	1 Y		20	8 WALK
3	2 G		21	1 AUX G[a]
4	2 Y		22	1 AUX Y[a]
5	3 G		23	3 AUX G[a]
6	3 Y		24	3 AUX Y[a]
7	4 G		25	5 AUX G[a]
8	4 Y		26	5 AUX Y[a]
9	5 G		27	6 AUX G[a]
10	5 Y		28	6 AUX Y[a]
11	6 G		29	I14-W STOP TIME
12	6 Y		30	DC GROUND
13	7 G		31	MONITOR RESET
14	7 Y		32	DC GROUND
15	8 G		33	2 AUX G[a]
16	8 Y		34	2 AUX Y[a]
17	2 WALK		35	4 AUX G[a]
18	6 WALK		36	4 AUX Y[a]

[a]Circuits used only in a 332A cabinet with an auxiliary output file

1092.4.2.6.2 Controllers. Each Model 170E controller unit shall be tested over a temperature range of -29 to 165 F. Proper operation of the unit shall be verified at both temperature extremes and at ambient temperature. Testing shall be conducted prior to final inspection, and will not constitute a substitute for any quality control testing or final inspection testing normally performed.

1092.4.2.6.2.1 The environmental chamber(s) shall have provisions for remotely operating the Model 170E controller under test. Front panel displays shall be visible from a window in the environmental chamber. Signal outputs shall be brought out of the chamber to display board if controllers cannot be directly observed. Cold and hot soak times shall be sufficient to allow all components in the device to reach the specified temperatures. A minimum soak time of three hours shall be used for all testing.

1092.4.2.6.2.2 The manufacturer shall submit to the engineer a proposed testing procedure and schedule 30 days prior to testing for evaluation. Test procedures, environmental chambers, automatic test equipment, display boards, power supplies and controls shall be described in detail.

1092.4.2.6.2.3 The controller shall pass the following test at least five times at each temperature extreme and ambient:

(a) Recovery from a short power interruption of approximately 500 milliseconds.

(b) Recovery from a long power interruption of approximately 5 seconds.

1092.4.2.6.2.4 The vendor shall provide a method of testing controller inputs and outputs. Diagnostic software and wraparound connector for controller harnesses may be used. If diagnostic software is not used, outputs shall be brought out to a display board. Inputs may be paralleled to each controller.

1092.4.2.6.3 Cabinet Testing. Cabinets shall be tested at ambient conditions only. An automatic or semi-automatic method of checking cabinet wiring between equipment harnesses and field connections will be required.

1092.4.2.6.4 Card Rack Assemblies. Card rack assemblies shall be in accordance with Caltrans.

1092.4.3 Auxiliary Equipment and Interfaces for Controllers. Interface panels shall be aluminum panels installed in the controller cabinet containing the required terminals and equipment. Interface panels shall be neatly laid out, neatly wired and easily accessible. Each auxiliary unit shall be enclosed in a suitably finished metal case and shall be mounted in the controller cabinet unless otherwise specified. The function of each auxiliary unit shall be indicated by an identification plate on the case. Auxiliary equipment cases shall be

ventilated. Temperature, voltage and frequency shall be in accordance with Sec 1092.4.

1092.4.3.1 Pre-Emption Interface. The pre-emption interface shall consist of internal pre-emption functions in the controller, any field wire termination panels, relays, wiring and connectors required for proper operation. The pre-emption interface shall be wired to transfer control of the signals to the pre-emption sequence when actuated and shall provide the color sequence specified. After release of pre-emption, normal controller operation shall be automatically resumed except that actuated controllers shall be on recall for one complete cycle.

1092.4.3.2 Master and Local Coordination Interface. The coordination interface shall consist of internal coordination functions in the controller, and of any field wire termination panels, wiring and connectors required for proper operation. The master coordination interface shall supervise the actuated controller operating the signals in the intersection at which the actuated controller is located. Local coordination interfaces shall be supervised by the master coordination interface and shall in turn supervise the actuated controllers operating the signals at the intersections where the controllers are located. Coordination interfaces shall be connected to one another or to a telephone interconnection unit by a multi-conductor cable. The master coordination interface shall be furnished with internal time-based functions in the controller. The coordination interface shall provide the following:

(a) Fully actuated operation.

(1) Cycle length of the actuated controller may vary with traffic demand, but shall not exceed the cycle length set on the coordination interface.

(2) Vehicle and pedestrian detectors shall remain energized.

(3) During periods of light traffic, the actuated controller shall respond to detector demand on any signal phase.

(4) When there is continuous demand for all signal phases, the coordination interface shall cause termination of each signal phase in accordance with the time intervals set on the coordination interface for each signal phase.

(5) The actuated controller shall not be forced to transfer right of way to a signal phase if there is no demand.

(b) Semi-actuated operation.

(1) Signal phases, controlling the street on which signal progression is desired, shall be placed on maximum recall.

(2) Vehicle and pedestrian detectors shall remain energized.

(3) Transfer of right of way from the coordinated signal phase(s) shall not occur until there is detector actuation for a non-coordinated signal phase and only after the coordination interface has terminated the coordinated signal phase(s).

(4) The right of way interval awarded the coordinated signal phase(s) shall be governed by the time interval set on the coordination interface.

(5) If detector actuations for a non-coordinated signal phase(s) causes the phase(s) to time to maximum, the phase(s) shall be forced off and the coordinated phase(s) awarded right of way.

(6) If demand for the non-coordinated signal phase(s) is not sufficient to extend the phase(s) to maximum, right of way shall transfer to the coordinated phase(s) and remain there until demand for the non-coordinated phase(s) occurs and the coordination interface times the coordinated phase(s) to maximum.

(7) Detector actuation on a non-coordinated signal phase(s) occurring during the coordinated phase(s) right of way interval shall cause a call to be placed and retained for the non-

coordinated signal phase(s).

(c) Fixed cycle length operation.

(1) All signal phases shall be placed on maximum recall.

(2) Vehicle and pedestrian detectors shall remain energized.

(3) The coordination interface shall control the time interval that each signal phase is awarded right of way.

(d) Free operation.

(1) When permitted by internal time-based functions, the coordination interface shall provide free operation of associated actuated controllers. During this operation the actuated controller shall operate without supervision by the coordination interface.

(2) Pretimed controllers, in a signal system supervised by a master coordination interface, shall revert to dial 1, reset 1 or internal time based coordination during free operation at the user's option.

1092.4.3.2.1 Each coordination interface shall have the following minimum operational characteristics:

(a) Three cycles.

(b) Eight splits.

(c) Eight force off periods per split.

(d) Three offsets per cycle.

(e) Selectable recall by signal plan.

1092.4.3.2.2 Each coordination interface shall have all of the following methods of synchronizing to the master sync pulse:

(a) Dwell. The coordinator shall establish a new offset by stopping the cycle timer in the coordinated phase(s) green, until the new offset value is reached.

(b) Dwell with Interrupt. The coordinator shall establish a new offset by stopping the cycle timer in the coordinated phase(s) green. The maximum time the coordinator can dwell shall be adjustable from 1 to 99 seconds.

(c) Shortway. The coordinator shall establish a new offset by the shortest route possible.

1092.4.3.2.3 Each master coordination interface shall be furnished with necessary relays and internal functions in the controller to provide the following supervisory functions:

(a) Semi-actuated operation.

(b) Fixed cycle length operation.

(c) Free operation.

(d) Cycle Transfer (cycle 1 to cycle 2, cycle 3 or cycle 4 and vice versa; cycle 2 to cycle 3 or cycle 4 and vice versa; cycle 3 to cycle 4 and vice versa).

1092.4.3.2.4 Each controller shall be capable of permitting the manual selection of the following:

(a) Cycle Length 1, 2, 3, 4 or System.

(b) Offset 1, 2, 3, 4 or System.

(c) Semi-actuated operation, fixed cycle length operation or free operation.

1092.4.4 Remote "ON - OFF" Switch (Pedestrian Interval Sequence). The following type of "On - Off" switches shall be furnished as specified:

(a) Type I. Type I switches shall consist of one manually operated heavy-duty switch in a circuit not exceeding 18 volts. Necessary relays shall be located in the controller cabinet for including or excluding the pedestrian phase in the phasing sequence or switching signals between flashing and sequence operation. This shall be accomplished by energizing or de-energizing the pedestrian signal indications and push-button detectors. The switch shall be enclosed in a weatherproof, cast aluminum housing equipped for post mounting. The housing shall have a suitable lock, the key of which shall not unlock the controller cabinet. The housing shall be tapped for conduit.

(b) Type II. The Type II switch shall be operationally identical to the Type I, except the switch may be 120 volts and shall be located inside the police panel of the controller cabinet.

1092.4.5 Interconnect Types.

1092.4.5.1 Time Base Coordination Interface. The time base coordination interface shall consist of internal time base coordination functions in the controller.

(a) Timing base shall be the 60-hertz power line frequency. Timing error due to power failure or low voltage shall not exceed ± 0.005 percent during these conditions. Changes to and from standard time and daylight time shall be programmed to automatically occur at the specified times. Memory and timing shall be maintained for at least 48 hours during an alternating current power failure. A power failure indicator shall be provided.

(b) The interface shall have a multi-digit security access code or key and lock security access.

(c) The interface shall be zero time based, settable to the second, programmable for 52 weeks, accommodate at least three weekly programs, twelve day programs and no less than twelve exception day programs. Total event changes shall be a minimum of 160. Interrogation of the interface to determine the year, month, day, hour, minute, second, a.m. and p.m., as well as program information programmed in the unit, shall be possible. Indicators shall show the condition of all outputs.

(d) The interface shall permit the controller to operate free or in coordination. When in coordination, all maximum green limits shall be inhibited. The interface shall be capable of continuously generating no less than four cycle lengths from 40 to 255 seconds.

(e) The interface shall be capable of continuously generating eight individual force-off commands in each cycle length even though the use all of the force-off commands may not be necessary. The interface shall also place a continuous call to the detector inputs of the coordinated phases. Position of the force-off and continuous call functions shall be settable at any percentage point or seconds in any selected cycle length.

(f) The first program of the day shall be implemented at the beginning of the minute selected. When changing from one cycle length to another while in the coordination mode, the change to the new cycle length shall not occur until the present cycle length has terminated. If the controller is operated in the free mode between cycle lengths, the next cycle length programmed shall begin at the beginning of the minute selected.

(g) The interface shall be furnished with the capability of generating a daily reference point at which time all cycles are resynchronized. This daily reference point shall be either 12:00 midnight or a selectable time of which 12:00 midnight could be selected. The resynchronization reference time is an arbitrary point in time that marks the beginning of all cycles on a daily basis.

(h) When designated, the interface shall be capable of generating an absolute reference point at which time all cycles are resynchronized. This absolute reference point shall be a selectable time by date and hour and minute that marks the beginning of all cycles.

(i) While under coordination, the designated coordinated phase(s) shall be capable of releasing from a hold status and operating in the actuated mode. The controller unit shall operate in actuated mode from a designated hold release point to the corresponding force-off point(s) of the coordinated phase(s).

(j) Three instruction manuals covering operational information shall be furnished with each interface.

1092.4.5.2 Closed Loop Systems.

1092.4.5.2.1 Equipment. New systems shall be compatible with any existing components in the system.

1092.4.5.2.1.1 System Software. The system software shall be designed to operate a traffic-responsive signal system with two-way communications between all local controllers and the system master. The software shall be capable of time-of-day system operation and a mix of time-of-day and traffic responsive operation. The software shall also provide for two-way communication between the system master and a remote personal computer, via a dial-up modem and a direct connect to the system master. The system software shall be fully compatible with all equipment supplied in the system and shall be compatible with the latest Windows operating system. The software shall be new and in the original packaging provided by the manufacturer. The system manufacturer shall provide software updates at no cost to the Commission for a period of at least two years from the date of final acceptance of the project. All licensing issues shall be addressed by the contractor.

1092.4.5.2.1.2 Closed Loop System Components. The principal components of the closed loop system shall consist of the system master, local intersection controller(s) and a modem.

1092.4.5.2.1.2.1 System Master. The system master controller shall consist of a NEMA or Type 170 microcomputer signal controller as specified in the plans, prom module and all necessary connectors and cables. The system master controller shall be installed in the local controller cabinet designated on the plans. A separate cabinet will not be required.

1092.4.5.2.1.2.2 Local Intersection Controller. The local controller assembly shall consist of a NEMA or Type 170 complete actuated traffic controller assembly, as specified in the plans and in accordance with these specifications.

1092.4.5.2.1.3 Cabinet Accessories.

1092.4.5.2.1.3.1 Telephone Interface Panel. The panel shall provide for interfacing of a leased, unconditioned telephone drop to a Hayes compatible modem that connects to the on-street system master. The panel shall be fabricated from 0.125-inch sheet aluminum with deburred edges and rounded corners. The panel shall be mounted on the inside of the cabinet as directed by the engineer. A telephone network interface, such as a Siecor CAL3000 or other approved interface acceptable to the local telephone company, shall be attached to the aluminum panel. The telephone interface shall include the installation of all necessary equipment to connect the interface to the telephone drop. The contractor shall be responsible for the installation of the telephone line. The system acceptance test shall not begin until the telephone line is in operation.

1092.4.5.2.1.3.2 Extra Service Outlet. One extra duplex service outlet shall be provided in the controller cabinet housing of the system master. The extra duplex service outlet shall not be located on the door of the cabinet. The receptacle shall be connected to the 120 volts alternating current auxiliary circuit in the cabinet.

1092.4.5.2.1.3.3 Interconnect Panel. The interconnect panel shall provide for system communication between the system master and local intersection controller units. An interconnect panel shall be provided in each controller cabinet. The panel may include terminations for system detector inputs and other auxiliary input/output functions. All controller assemblies shall be configured with inputs for system detectors. The panel shall be fabricated from 0.125-inch sheet aluminum with deburred edges and rounded corners. The panel shall be mounted on the inside of the cabinet on the left side. Over-voltage protectors shall be provided and shall be an encapsulated, three-element gas tube type equipped to mate with a ten-circuit Buchannan Connector PnPcB1B. As a minimum, the over-voltage protection ratings shall be:

(a) Primary surge current – 10 kiloamps (80 x 20 us, waveshape).

(b) Secondary protector: Solid state clamps 1.5 kilowatts.

(c) Response time < 5 nanoseconds.

(d) Clamp voltage – 8 volts.

1092.4.5.2.1.3.4 Door Alarm. A limiting switch shall be installed and wired to activate an alarm when the cabinet door is opened.

1092.4.5.2.1.3.5 Dial-Up Modem. The modem shall be in accordance with Sec 1092.4.6 and shall be installed in the controller cabinet housing of the on-site system master.

1092.4.5.3 Twisted Pair Interconnect. If 3-pair cable is specified, the interconnect cable for system communication between the on-street master and local controllers shall be 16 AWG, stranded copper conductor, twisted pairs individually shielded. The cable shall be PVC insulated, aluminum shielded, in accordance with specifications of Belden No. 1037A. Each interconnect cable shall have three pairs. Each pair shall be wired to a terminal strip on the interconnect panel. Each shield shall be grounded on at least one end.

1092.4.5.4 Wireless Interconnect.

1092.4.5.4.1 Wireless Closed Loop System Components. The wireless system shall consist of a fully operational wireless interconnect system between the system master and all local controllers. Components shall include telemetry radios, interface cables between the radios and signal controllers, radio power supply and handheld diagnostic/programming keypads.

1092.4.5.4.1.1 Telemetry Radios. The telemetry radio shall be an unlicensed frequency hopping spread spectrum and shall be a Microwave Data Systems, Model 9810 or equivalent, in accordance with the following:

Item	Requirement
Frequency Band	902-928 Megahertz FCC Part 15 Spread Spectrum Band or1.2 Gigahertz FCC Part 15 Spread Spectrum Band
Frequency Hopping Range	8 Selectable Zones @ 128 frequencies – 1019 total frequencies
Frequency Stability	± 1.5 ppm @ -20 to 140 F
Data Interface	RS232 (or as required by the system)
Data Interface Rate	Std. Baud Rates up to 19200 bytes/second, minimum
Latency	<10 milliseconds typical (buffer off mode)
Transmitting Power Output	1 watt minimum, adjustable
Transmitting Duty Cycle	Continuous
Transmitting Max Voltage Standing Wave Ratio (VWSR) (No Damage)	Infinite, all phase angles
Receiving Bit Error Rate	Less than 10^{-6} at -110 decibels
Receiving Intermodulation	75 decibels, minimum
Receiving Desensitization	65 decibels, minimum
Receiving Spurious	70 decibels, minimum
Operating Humidity	95% Relative Humidity at 104 F
Operating Temperature	-20 to 140 F with full performance

1092.4.5.4.1.1.1 Telemetry radios shall provide transparent communications between signal controllers. All radio equipment shall be installed in the signal controller cabinets. Radio power supplies shall meet all requirements of the radio manufacturer, including power, temperature and humidity. All required interface cables and connectors shall be provided with the radios.

1092.4.5.4.1.1.2 The radio shall have the capability to monitor receiver signal strength and be programmed through a diagnostic/programming keypad. Two handheld diagnostic/ programming keypads for the radios shall be provided with the system.

1092.4.5.4.1.2 Antenna System. The antenna system shall consist of the omnidirectional antenna or yagi

directional antenna, as specified, antenna mounts, coaxial cable and surge and lightning protection. Antennas shall be products manufactured by Decibel Products, Celwave, Scala or Antenna Specialists, and shall meet the following requirements.

1092.4.5.4.1.2.1 Omnidirectional Antenna. All omnidirectional antennas shall be in accordance with the following:

Item	Requirement
General Frequency Range	896-960 Megahertz
Bandwidth at Rated VSWR	70 Megahertz, min.
VSWR	1.5:1, min.
Polarization	Vertical
Maximum Power Input	250 watts, min.
Connector	N Female
Antenna Housing	Fiberglass Radome
Radiating Elements	Brass or Copper
Support Pipe	6061-T6 Aluminum
Lightning Protection	Direct Ground
Rated Wind Velocity	100 mph, min.

1092.4.5.4.1.2.2 Yagi Directional Antenna. All yagi directional antennas shall be in accordance with the following:

Item	Requirement
General Frequency Range	896-960 Megahertz
Gain	10 decibels, min.
Bandwidth at Rated VSWR	60 Megahertz, min.
VSWR	1.5:1, min.
Horizontal Beamwidth	45 degrees, min.
Vertical Beamwidth	30 degrees, min.
Polarization	Vertical or Horizontal
Maximum Power Input	100 watts Min.
Connector	N Female
Radiating Elements	Gold Anodized Welded Aluminum Alloy
Lightning Protection	Direct Ground
Rated Wind Velocity	100 mph Min.

1092.4.5.4.1.2.2.1 Directional antennas shall be in accordance with the level of gain shown on the plans and with the following:

Antenna	Gain	Vertical Beam Width
3 decibel	3 decibels, min.	30 degrees, min.
6 decibel	6 decibels, min.	16 degrees, min.
9 decibel	9 decibels, min.	7 degrees, min.

1092.4.5.4.1.2.3 Antenna Mounts. Mounts shall provide a rigid mounting of the specified antenna that will withstand winds of up to 100 mph minimum. Mounts and associated hardware shall be constructed of galvanized steel, aluminum or stainless steel.

1092.4.5.4.1.2.4 RG-8/U Coaxial Cable. All antenna cable shall be a low loss, RG-8/U, Belden 9913 or equivalent, coaxial cable in accordance with the requirements listed below. Connectors for antenna cable shall be Type N male connectors constructed of silver-plated brass with a gold plated pin and soldered center connection.

Item	Requirement
Impedence	50 ohms, nominal
Attenuation at 900 Megahertz	5.7 decibels/100 ft., max.
Overall Diameter	0.405 in., nominal
Outer Conductor	Tinned Copper Braid with 95% min. coverage
Inner Conductor	0.108 in. Copper

Dielectric	Foam-Polyethylene
Outer Jacket	Black Polyvinyl Chloride

1092.4.5.4.1.2.5 Antenna Surge and Lightning Protection. A lightning and surge arrestor shall be provided for the coaxial cable in the controller cabinet. The arrestor shall be bulkhead-mounted or flange-mounted and shall be securely fastened to a grounded metal surface inside the cabinet. The arrestor shall be manufactured by Polyphaser and shall be in accordance with the following:

Item	Requirement
Throughput Energy	220 µj
Maximum Surge Current	50 kiloamps
Turn On Voltage	600 volts
Turn On Response	2.5 nanoseconds
Connectors (both ends)	N Female
Housing	Aluminum
Hardware	Stainless Steel

1092.4.5.5 Fiber Optic Interconnect. The fiber optic system shall consist of a fully operational fiber optic interconnect system between the system master and all local controllers. Components shall include fiber optic cable, splice cabinet, closed loop system components, modem and a fiber distribution unit.

1092.4.5.5.1 Splice Cabinet. The Type 336 cabinet and EIA 19-inch rack cage shall be in accordance with the *Traffic Signal Control Specifications* published by the California Business, Transportation & Housing Agency, Department of Transportation (Caltrans), dated January 1989, including all current addenda and revisions. Housing shall include, but will not be limited to, the enclosure, doors, latches/locks, hinges and door catches, ventilation, gaskets, cage supports and mounting, the rack cage, and anchor bolts.

1092.4.5.5.1.1 Each splice cabinet shall include a fiber distribution unit to provide a termination and service access point for the fiber optic cables. The fiber distribution unit shall be mounted on the 19-inch rack cage and shall be a modular design to support both fusion and mechanical splices of multimode and single mode fiber. The single cabinet construction shall have a minimum termination/connection capacity of 48 fibers and four splice trays. The connector panel, to be located at the top of the unit, shall be designed to accommodate stick and turn (ST) and other standard connectors. Six ST couplings with ceramic inserts, designed to accommodate both single mode and multi-mode fiber, shall be provided and installed for future use. One single mode splice tray and one multi-mode splice tray, each with a closure for 12 fusion splices, as a minimum, shall be provided in each cabinet. Additional trays shall be provided as necessary to splice or terminate fibers in accordance with the system design and this specification.

1092.4.5.5.1.2 The design of the unit shall allow stacking of splice trays in a manner that permits access to individual trays without disturbing other trays and splicing to be conducted at a distance from the unit. The lower portion of the unit shall provide for the neat storage of continuous tubes. Excess cable may be stored either in the fiber distribution unit or within the splice cabinet. The unit shall provide both front and rear access with hinged door access and cable strain relief accommodations. The unit and splice tray shall be constructed of durable aluminum designed for outdoor applications. Plastic doors may be considered for approval by the engineer.

1092.4.5.5.2 Fiber Optic Data Link for Closed Loop System. The data link between the fiber optic cable and the master or local intersection NEMA or Type 170 controller arranged in a closed loop system shall be accomplished using a data link, referred to as a modem on the plans, compatible with daisy chain operation to transmit RS-232 data using fiber optics. This data link shall be compatible with and installed in the NEMA or Type 170 controller unit in accordance with the manufacturer’s recommendations.

1092.4.5.5.2.1 The fiber optic data link shall be capable of operating in a full duplex mode of operation, employing asynchronous RS-232 data link protocols. RS-232 signals shall be converted to light and transmitted from data link to data link until the light is reconverted to RS-232 electrical signals sent to a particular controller. The fiber optic data link shall operate in a daisy chain communication mode.

1092.4.5.5.2.2 On the data link assembly, there shall be two pairs of clearly labeled optical emitters and optical detectors, designed to attach to standard ST connectors. There shall be two clearly labeled LED's, one for transmit and one for receive. These LED's shall illuminate when the fiber optic data link is either receiving or

transmitting at the local controller. There shall be a slide switch labeled "M" for master operation and "L" for local operation.

1092.4.5.5.2.3 In the master mode of operation, the electrical data entering the fiber optic data link from the controller unit shall be transmitted as optical signals in a parallel mode from each of the two emitters. The optical signals received by the two detectors shall be converted to electrical signals and sent in parallel to the controller.

1092.4.5.5.2.4 In the local mode of operation, optical signals received by Detector 1 shall be converted to electrical signals and sent to the controller unit. These same signals shall be regenerated and transmitted by Emitter 2 to the next adjacent fiber optic data link downstream in the daisy chain. Optical signals received by Detector 2 shall be regenerated and transmitted by Emitter 1 to the next adjacent fiber link upstream. Electrical signals received by Emitter 1 from the controller shall be transmitted to the next adjacent fiber link upstream. Regeneration shall maintain pulse fidelity within ± 0.1 percent for each data link.

1092.4.5.5.2.5 The fiber optic data link shall have an emergency backup power source that allows continued daisy chain operation when the NEMA or Type 170 controller unit is removed or if the power to the controller has been turned off. The backup power source shall provide uninterrupted operation of the daisy chain interconnect system, both upstream and downstream from the affected data link, for a period of 12 hours. An RJ11/4 jack shall be available on the assembly to interface an external data link, allowing fiber optic communications in four directions.

1092.4.5.5.2.6 The fiber optic data link shall operate with all fiber ranging from 50/125 glass to 1 mm plastic fiber and shall meet the following electrical requirements:

Item	Requirements
Voltage	12-volt direct current
Current	26 milliamps continuous
Wavelength	850 nanometers
Data Link Sensitivity	Maximum 0 decibels, Minimum –40 decibels
Data Rate	100 to 19.2 k baud
Operating Range	1.9 miles from data link to data link
Temperature Range	-30 to 165 F

1092.4.5.5.2.7 Fiber Distribution Unit. Each controller cabinet shall be equipped with a fiber distribution unit to provide a termination, storage and service access point for fiber optic cables. The fibers in the interconnect cable(s) shall be terminated on one side and duplex jumpers shall extend on the other side to the data links. The fiber distribution unit shall be a modular design to support a minimum termination/connection capacity of 12 fibers, one splice tray and strain relief for up to four cables. No splice tray will be required. The connector panel shall be designed to accommodate ST connectors for both multi-mode and single mode fibers, as appropriate. ST couplings with ceramic inserts shall be provided to accommodate all fibers brought into the controller cabinet from the splice cabinet. The unit shall provide both front and rear access with hinged door access. The unit shall be constructed of durable aluminum constructed for outdoor applications. Plastic doors may be considered for approval. The unit shall be sized to fit in the controller cabinet and shall be positioned to allow fiber cables to be routed with bending radii exceeding manufacturer's recommendation. The unit shall not conflict with other cabinet components or panels. Fiber cables shall not conflict with other cabinet wiring.

1092.4.5.5.3 Training for Fiber Optic Installation. When specified in the contract documents, training on system software and system operation shall be provided. Training shall be conducted by qualified instructors and shall be provided to personnel designated by the engineer on all facets of the system. Personnel shall be trained to operate the system, analyze system performance and revise critical operating parameters based on the analysis. The training shall be in a classroom atmosphere and shall be for a minimum of 16 hours over two days. The first eight-hour training session shall be conducted prior to the system acceptance test. The second eight-hour session shall be conducted at the conclusion of the system acceptance test. Maintenance personnel shall be trained on maintenance and repair of all serviceable equipment. Training shall include field level troubleshooting and bench repair. The training shall be for a minimum of eight hours in one day.

1092.4.6 Dial Up Modems. The dial-up modem shall be an auto-dial, auto-answer modem and shall be installed in the controller cabinet as specified on the plans. If specified, an identical modem shall be installed at the central office computer facility in the MoDOT district office. The modem shall be Hayes compatible capable of

responding to the standard "Hayes command set" and shall be self-contained. The unit shall be powered by a nominal 120-volt alternating current from the duplex service outlet provided in the cabinet. The modem shall be capable of operating at all standard baud rates from 300 to 56k baud over a standard dial-up, unconditioned telephone line and shall be capable of reliable operation from -35 to 165 F. Installation shall include the appropriate interface cable to connect to an RJ-11 telephone jack on the telephone interface panel, the RS-232 cable from the modem to the system master and all other cabling, connectors and incidental items necessary for operation.

1092.4.7 Detectors.

1092.4.7.1 Induction Detector Probes. The encapsulated induction detector probe shall detect the passage or presence of all vehicles with a standard induction loop detector amplifier. The induction detector probe shall operate in a temperature range from -35 to 165 F with 0 to 100 percent humidity. The operating field intensity range shall be 0.2 to 1.0 oersted with a nominal inductance of 20 microhenries plus 20 microhenries per 100 feet of cable. The nominal direct current resistance shall be 0.5 ohm plus 3.2 ohms per 100 feet of probe cable. Induction detector probes shall be as specified on the plans and shall meet the following:

(a) The sensing probes shall be cylindrical having maximum dimensions of 7/8-inch diameter by 4 inches long. The sensing probes shall be suitable for installation in a one-inch diameter bored hole. The interconnecting four-conductor cable and lead-in cable shall be suitable for installation in a 1/4-inch wide pavement sawed slot.

(b) The jacket on the interconnecting cable and the casing on the sensing probe shall be an abrasion resistant polyurethane elastomer. The device shall be impervious to moisture and chemically resistant to all normal motor vehicle petroleum products. Lead-in cables shall be shielded, chemical resistant and completely waterproof.

(c) The combined probe sets, manufacturer specified lead-in cable and detector probe shall detect all vehicles up to a lead-in cable length of 750 feet with up to six probes per set.

(d) The conductor cable from the probes to the detector panel in the controller assembly shall be as specified by the detector manufacturer, shall be continuous and unspliced and shall be a minimum of 50 feet in length. Probes shall be assembled in a set to form a vehicle detector as shown on the plans. No more than six probes shall be assembled as a set. The cables between probes shall be long enough to provide the spacing shown on the plans plus 5 feet. If spacing is not shown on the plans, 15 feet of cable shall be provided between probes. Each set of probes shall have one lead-in cable.

1092.4.7.2 Pedestrian Push Button. Pedestrian push-button detectors shall be of the pressure-activated type with essentially no moving parts. The housing shall be black, round in shape and shaped to fit the curvature of the post to which it is attached and shall provide a rigid installation. Contacts shall be normally open, entirely insulated from the housing and actuator, and have connecting terminals. The housing shall have one outlet tapped for ½ inch pipe. The actuator shall be a minimum of 2 inches in diameter, raised, contrast visually with the housing and be made of brass or corrosion-resistant metal alloy or non-metallic material. A maximum force of 5 pounds shall be required to activate the switch. Switch shall be of the solid-state electronic, piezo type, The operating voltage shall not exceed 24 volts. The entire assembly shall be weatherproof, secure against electrical shock to the user and vandal resistant. Entire assembly shall be rated to operate between –30 degrees F to 165 degrees F and shall not allow ice to form such to impede the operation of the button.

1092.4.7.3 Induction Loop Detectors. Induction loop vehicle detectors shall detect a vehicle stopped within the field of the loop or passing over the loop at speeds up to 80 mph. Induction loop detectors shall be card rack mounted. For double controller cabinets, card rack assemblies and detectors shall be installed in the same compartment as each respective associated controller.

1092.4.7.4 NEMA Card Rack Assemblies. The supporting and connecting rack shall contain space for a minimum of two power supplies and shall have a minimum of eight card positions for two-channel detector units. Upper and lower slide guides shall be provided for the power supply and each detector card. Where detectors are specified, the rack and power supplies shall be included with the detectors, and no direct payment will be made.

(a) The card mounting rack shall be attached to the controller cabinet by a hinge or pivot assembly,

which allows the rack to rotate horizontally so as to expose the rack wiring to facilitate maintenance operations. The rack shall be positioned to rotate out freely 90 degrees without conflicting with other wiring, equipment or the controller cabinet. Sufficient wire lengths shall be provided for rotation. The rack shall not block the back panel or other termination panels.

(b) The power supply shall be capable of supplying a minimum of 200 milliamps to each detection channel position. The power supply shall be capable of operating a full rack of time delay detectors regardless of the amount and type of detectors required. Each power supply channel shall power no more than one detector card. Each channel shall be individually fused.

(c) Each card rack detector shall have a regulator for the power input. The regulator shall have the appropriate power and voltage rating for operation of the detector.

(d) Card racks shall mate with a 44-terminal, double row, 0.156-inch contact spacing, Cinch Jones card edge connection 50-44A-30M or equivalent. Input/output connector pin terminations shall be in accordance with NEMA Specification TS. All useable functions shall be fully wired for use.

(e) All circuitry shall be of solid state, temperature compensating components.

(f) Unless shown otherwise on the plans, each detector in the card rack shall be associated with the appropriate phase as follows:

Channel	**Card Position**							
	1	2	3	4	5	6	7	8
1	ø 1	ø 1 or 6	ø 6	ø 6	ø 3	ø 3 or 8	ø 8	ø 8
2	ø 5	ø 5 or 2	ø 2	ø 2	ø 7	ø 7 or 4	ø 4	ø 4

(g) Each detector channel shall be clearly labeled with phase and direction.

1092.4.7.4.1 Card Rack Detectors. Card rack detectors shall meet the following requirements:

(a) Card rack-mounted detectors shall incorporate two detection channels.

(b) Each detector channel shall have at least a two-frequency selection capability, at least two levels of operational sensitivity and shall be capable of tuning to a minimum inductance range of 70 to 1000 microhenries.

(c) All controls and indications shall be mounted on the front panel of the sensing unit, with the exception of extension and delay timing controls on card rack mounted detectors.

(d) A manual control shall be provided for each channel to select pulse or full presence operation.

(e) Each detector channel, after installation and initial adjustment, shall automatically tune to various loop configurations ranging in size from 6 x 6 feet minimum to 6 x 100 feet maximum. The maximum lead-in length shall be 750 feet.

(f) Each detector channel shall time out and retune automatically if a continuous vehicle occupation of the loop field for a nominal time of 10 to 30 minutes is sensed.

(g) In the event of power loss to the detector or channel, a continuous call shall be made to the controller.

(h) All circuitry shall be of solid state, digital design and incorporate temperature-compensating components, with the exception of the output relay.

(i) If specified, each channel shall have extension and delay timing features, as follows:

(1) Delay timing range from 0 to 30 seconds in 1.0-second increments.

(2) Extension timing range from 0 to 7.5 seconds in a maximum of 0.5-second increments.

(j) The sensing unit shall have a light that will illuminate when a vehicle is within the loop field. Other visual indications of relay closure may be used if approved by the engineer.

(k) Each detector and channel shall be in accordance with NEMA Standard Publication TS.

1092.4.7.4.2 Dual Output Card Rack Detectors. Dual output card rack detectors shall be in accordance with NEMA and shall provide two relay outputs per induction loop detector. One output shall be capable of pulse detection for the purpose of traffic counting, speed and occupancy measurements. The other output shall be capable of presence detection. Each detector output shall be assigned to a separate detector input into the controller.

1092.4.7.5 Calling Detector Relay. A calling detector relay shall operate with any detector and allow the detector to place only one actuation when the red indication is being displayed to the associated phase. The relay shall be self-contained.

1092.4.7.6 Microwave Vehicle Detectors. The unit shall detect all vehicles moving within the field of detection at speeds from 2 to 80 mph. The unit shall have a minimum detection range from 3 to 200 feet for all vehicles. The pattern spread of the detection field shall be no more than 16 degrees. The unit shall be self-tuning and capable of continuous operation over a temperature range of -35 to 165 F. The unit shall be microprocessor based using Doppler microwave at an operating frequency of 10.525 GHz. The unit shall have FCC certification and shall be tested to the applicable FCC specifications. The unit shall be capable of side-fire mount or overhead mount. The enclosure shall be constructed of aluminum or stainless steel and shall be water resistant. The unit shall be capable of detecting directional traffic and the direction shall be user selectable. All user operated controls and adjustments shall be clearly marked and easily accessible. The unit shall have a relay detection output to the controller with a minimum 5-amp rating and shall be designed to place a constant call to the controller in the event of any failure. The unit shall have an easily accessible indicator showing activation of detection relay. Required wiring shall be as specified by the manufacturer. Mounting hardware for the type of mounting shown on the plans and power supply equipment shall be as specified by the manufacturer and shall be provided with the unit.

1092.4.7.7 Video Detection System.

1092.4.7.7.1 System Requirements. The video detection system shall provide flexible detection zone placement at any location and at any orientation within the combined field of view of the image processors. Preferred presence detector zone configurations shall be a box or lines placed across lanes of traffic or lines placed parallel with lanes of traffic. Detection zones shall be capable of overlapping.

1092.4.7.7.1.1 The detection zones shall be created by using a track ball to draw the detection zones on the video image. A graphical user interface shall be built into the automatic control unit (ACU) and displayed on a video monitor or computer. Editing of previously defined detector configurations to fine-tune detection zone placement shall be possible.

1092.4.7.7.1.2 When a vehicle is detected by crossing a detection zone, there shall be a visual change on the video display, such as a flashing symbol or a change in color or intensity to verify proper operation of the detection system.

1092.4.7.7.1.3 Overall performance of the video detection system shall be comparable to inductive loops. Using camera optics and in the absence of occlusion, the system shall be able to detect vehicle presence with 95 percent accuracy under normal day and night conditions with only slight deterioration in performance under adverse weather conditions, including fog, snow and rain. When visibility exceeds the capabilities of the camera, the system shall default to placing a call on all detectors.

1092.4.7.7.1.4 The video detection system shall be programmable via one dial up modem connection at a minimum of 19,200 bytes per second to the camera(s). Still image and real time detection displays to a remote computer using supplied system software through the modem shall be provided.

1092.4.7.7.2 System Components. The video detection system will be defined as the complete assembly of all required equipment and components for detection of vehicles. Each system shall consist of the video camera(s), lightning arrester for video cabling, an ACU, a track ball, software and license, if applicable, for system control

via a computer, one dial-up modem, 56.6 kilobytes per second maximum connection and V.90 compliant and a monitor. All camera views shall be obtainable without requiring the disconnection and reconnection of cables within the system.

1092.4.7.7.2.1 System Software. The system shall include software that detects vehicles in multiple lanes using only the video image. Detection zones shall be defined using a video monitor and a pointing device to place the zones on a video image, which may include a laptop computer. A minimum of 12 detection zones per camera shall be available.

1092.4.7.7.2.2 Automatic Control Unit. The bus connections used to interconnect modules of the ACU shall be gold-plated DIN connectors. Serial communications to a computer shall be through an RS-232/RS-422 serial port. The port shall have the capability to access detection system data as well as the real-time imagery needed to show detector actuations. A subminiature "D" connector on the front of the ACU shall be used for serial communications with a computer running supplied system software.

1092.4.7.7.2.2.1 The equipment shall be provided with either a NEMA TS1 or NEMA TS2 interface as shown on the plans.

1092.4.7.7.2.2.1.1 For TS1 systems, the ACU process unit shall be equipped with a TS1 detector interface for a minimum of 16 detector outputs or 32 detector outputs, if required by specifications. NEMA red/green inputs for each phase shall be available to provide delay/extend functions, either through the detector or the controller. Logic output levels shall be compatible with the TS1. A subminiature "D" connector on the front of the ACU shall be used for interfacing to these outputs.

1092.4.7.7.2.2.1.2 For TS2 systems, the ACU processor unit shall be equipped with a TS2 Type 1 detector interface, where detector information is transmitted serially via an RS-485 data path. NEMA red/green inputs for each phase shall be available to provide delay/extend functions, either through the detector or the controller. A 15-pin subminiature "D" connector, meeting the requirements of the TS2 standard, shall be used for the serial detector output. A minimum of 32 detector outputs will be required.

1092.4.7.7.2.2.2 The video detection system shall be provided for either single camera or multiple camera installations as shown on the plans.

1092.4.7.7.2.2.2.1 For single camera installations, the ACU shall have an RS-170 (NTSC) video input to process the camera or any other synchronous video source in real-time. The ACU shall have an RS-170 (NTSC) video output.

1092.4.7.7.2.2.2.2 For multiple camera installations, the ACU shall have a minimum of four RS-170 (NTSC) composite video inputs to process the synchronous video cameras or any other synchronous video source in real-time. A fifth video input shall be provided to allow connection of a local surveillance camera or other non-detection video source. The video from the auxiliary input shall not be processed for video detection. The ACU shall have an RS-170 (NTSC) composite video output, which may correspond to any of the video inputs, as selected remotely via RS-232 or locally by front panel switch. Multiple video inputs requiring external cable connections will not be permitted.

1092.4.7.7.2.2.3 The ACU or computer shall store a minimum of two separate detection zone configurations. The ACU shall be capable of switching to any of the different detector patterns at the request of the user and shall be a menu selection with a track ball.

1092.4.7.7.2.3 Monitor. The monitor shall have a 9-inch screen, an NTSC-M system and BNC video in-out connections.

1092.4.7.7.2.4 Video Camera and Housing. The ACU supplier shall furnish the video camera for traffic detection. The camera shall produce a video image of vehicles under normal roadway lighting conditions regardless of time of day. The video shall produce a clear image for scenes with a luminance from 0.009 to 929 footcandles.

1092.4.7.7.2.4.1 The camera shall provide a minimum resolution of 500 lines horizontal and 350 lines vertical.

1092.4.7.7.2.4.2 The camera shall include an electronic shutter or auto iris control based on average scene

luminance and shall be equipped with an auto iris lens.

1092.4.7.7.2.4.3 The camera shall have a variable focal length. The maximum aperture of the lens shall not be smaller than f1.8 and the minimum aperture shall not be larger than f300. The camera shall have a horizontal field of view ranging from a minimum angle of view between 5 degrees and 10 degrees wide to a maximum angle of view 45 degrees or more. The adjustments for focus and focal length shall be made without opening up the camera housing.

1092.4.7.7.2.4.4 The camera shall be contained in an enclosure that is waterproof and dust-tight to NEMA-4 specifications. A heater shall be incorporated in the camera to prevent the formation of condensation and to assure proper operation of the lens' iris mechanism. The heater shall not interfere with the operation of the image sensor electronics and shall not cause interference with the video signal. The enclosure shall allow the camera to be rotated in the field during installation.

1092.4.7.7.2.4.5 The housing shall be equipped with a sun shield that prevents sunlight from directly entering the lens. The sun shield shall include a provision for water diversion to prevent water from flowing in the camera field of view.

1092.4.7.7.2.4.6 The total weight of the enclosure, camera, lens, housing, sun shield and mounting bracket shall be less than 10 pounds.

1092.4.7.7.2.5 Cable. Coaxial cable shall be a 75 ohm, precision video cable with 20 AWG solid or stranded bare copper conductor, maximum of 10.1 ohms/m Nom. direct current resistance, solid polyethylene insulating dielectric, 96 percent minimum tinned copper double-braided shield with a black polyethylene outer covering. The signal attenuation shall not exceed 0.8 decibels per 100 feet at 10 megahertz. Nominal outside diameter shall be
0.305 inches. The cable shall be in accordance with Belden Type 8281, West Penn P806 or approved equal.

1092.4.7.7.2.5.1 Seventy-five ohm BNC plug connectors shall be used with coaxial cable. The supplier of the video detection system shall approve the coaxial cable, BNC connectors and crimping tool. The manufacturer's instructions shall be followed.

1092.4.7.7.2.5.2 Multi-conductor cable shall be per the manufacturer's recommendations and in accordance with Sec 1061.

1092.4.7.7.2.6 Maintenance and Support. The supplier shall maintain an ongoing program of technical support and software updates for the video detection system following expiration of the warranty period. The supplier shall maintain an adequate inventory of parts to support maintenance and repair of the video detection system.

1092.4.7.7.2.7 Warranty of Video Detection System. The video detection system shall be warranted to be free of defects in material and workmanship for a minimum of two years. During the warranty period, technical support from factory certified personnel or factory certified installers shall be available from the supplier. Ongoing software support by the supplier shall include updates for the ACU and computer software and shall be provided at no cost to the Commission during the warranty period. The update of the ACU software to be National Transportation Communications for ITS Protocol (NTCIP) compliant shall be included.

1092.4.7.7.2.8 Training of Video Detection System. A minimum of one day of training shall be provided in the operation, setup and maintenance of the video detection system.

1092.5 Detector Loop Sealant. Loop sealant shall have the following minimum characteristics:

(a) The loop sealant used to fill the saw cuts and other gaps shall be of a type intended for and designed to be used as traffic loop embedding. The sealant shall be designed for installation when the surface temperature of the roadway is between 40 and 120 F and exhibit minimal shrinkage and stringing during and after installation. The curing time of the sealant shall be a maximum of 72 hours. Cured sealant shall retain permanent flexibility to 0 F, be temperature stable and ensure the integrity of the loop detector installation from -40 to 200 F. The loop sealant shall adhere to the roadway pavement and resist the effects of weather, including freeze-thaw cycles, de-icing chemicals, salts, gasoline and motor oils, such that the operation of the detector is not affected.

(b) The three types of allowable loop sealant will be two-part polyester resin, one-part moisture curing polyurethane and hot-melt bituminous.

(c) The loop sealant shall provide a minimum shelf life of nine months. Prior to the installation of any detector loop sealant, the MSDS or an OSHA Form 20 along with the manufacturer's technical data sheet, shall be submitted to the engineer. Any sealant used on loop detectors shall meet the approval of the engineer.

1092.6 Warranty. All traffic controller assemblies, excluding video detection systems, shall be warranted by the manufacturer to be free from defects in workmanship and material for at least one year from the date of project acceptance. Any components found to be defective during the warranty period shall be replaced free of charge. All warranties provided shall be transferred to the Commission upon project acceptance. Video detection systems shall be warranted in accordance with Sec 1092.4.7.7.

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