ENGINEERING POLICY BALLOT

Effective: January 1, 2023

Level 2

Level two revisions require the approval of the **Assistant Chief Engineer** and the **Federal Highway Administration** only. The **Senior Management Team** is encouraged to review the content and provide comment to the appropriate director. For all other parties, these revisions are posted for information only.

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Issue 1: Provide a formal process to address preliminary maintenance prior to the start of work.

Approval: **Level 2 – Assistant Chief Engineer**

Sponsor: Dennis Brucks – CM

Summary: At times, MoDOT will stop certain maintenance operations on roadways once a construction contract is awarded. This can lead to significant maintenance work for the contractor before the actual contract work begins. An example of this would be approach pavement for bridge rehabilitation work. This specification makes the process of maintenance work agreements with a contractor contractual and easier to document.

Fiscal Impact: There is no anticipated fiscal impact associated with this revision.

Publication: Std. Specification Sec. 104.7.3.1

Issue 2: Adding a Max Temperature to Concrete in Sec. 703

Approval: **Level 2 – Assistant Chief Engineer**

Sponsor: John Donahue – CM

Summary: There has never been a specified high temperature for masonry concrete mixes. This specification revision establishes an upper limit mix temperature for constructing culverts, bridges, and other concrete structures.

Fiscal Impact: There is no anticipated fiscal impact associated with this revision.

Publication: Std. Specification Sec. 703.3.3

Issue 3: Revised EPG 403.17

Approval: **Level 2 – Assistant Chief Engineer**

Sponsor: Dennis Brucks – CM

Summary: This revision is to bring the EPG article up to current internal QC/QA field practices for asphaltic concrete pavement (Superpave). The revised article explains sampling, testing, and acceptance procedures for projects with Superpave mixes. Additional revisions were made to update in accordance with current construction and materials specifications.

Fiscal Impact: There is no anticipated fiscal impact associated with this revision.

Publication: EPG 403.17

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.

104.7.3.1 Preliminary Maintenance. Prior to the start of construction operations, the contractor shall notify the engineer of any preliminary pavement surface maintenance work that, in the opinion of the contractor, should be completed prior to the contractor assuming maintenance responsibility. The engineer will review such notice and respond with either concurrence or rejection of the request for preliminary maintenance work. If preliminary maintenance work is deemed necessary, the engineer will either arrange for the work to be done by others prior to the start of construction operations or will direct the contractor to perform the work prior to the start of construction operations. If the contractor is directed to perform the work, payment will be made per Sec 109.4.

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.

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. The concrete temperature shall not exceed 90°F at the time of placement. 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.

403.1 Construction Inspection for Sec 403

403.1.1 Description (Sec 403.1)

There will be no commentary for sections in which the intent of the specifications, as written, is clear.

Design Levels (Sec 403.1.2)

At the contractor's expense, a mix with the same size aggregate and one design level higher can be substituted for the mix required by the contract~~. Substitutions typically require a change order to pay for the higher quality mix~~ at the price of the lower mix. Care should be taken to assure that the material product codes reflect the mix actually placed on the roadway. The substitutions must be done uniformly and various design levels in the same lift will not be allowed.

403.1.2 Material (Sec 403.2)

See also Aggregate for Asphaltic Concrete, Bituminous Material and Asphalt Release Agents, Fiber Additives and Liquid Anti-Strip Additives for Materials information.

Fine Aggregate Angularity (FAA) (Sec 403.2.1)

Fine Aggregate Angularity (FAA) ensures a high degree of fine aggregate internal friction and rutting resistance. FAA provides an indication of the particle shape and is defined as the percent voids in loose, uncompacted fine aggregates. More fractured faces results in a higher void content in the aggregate. FAA is determined on the fine portion of the blended aggregate (passing the #8 sieve) in accordance with AASHTO T304 (Level 2 Aggregate Training). The minimum requirements, based on the design level of the mix, are given in Standard Specification Section 403.2.1.

Coarse Aggregate Angularity (CAA) (Sec 403.2.2)

Coarse Aggregate Angularity (CAA) ensures a high degree of coarse aggregate internal friction and rutting resistance. CAA is defined as the percent of coarse aggregates with one or more fractured faces. CAA is determined on the coarse portion of the blended aggregate (retained on the #4 sieve) in accordance with ASTM D5821 (Level 2 Aggregate Training). The minimum requirements, based on the design level of the mix, are given in Standard Specification Section 403.2.2.

Clay Content (Sec 403.2.3)

Clay content, or sand equivalency, is the percentage of clay-like material present in the aggregate. The higher the sand equivalent value, the less clay-like material present in the aggregate. Clay-like material can coat the aggregate surfaces and prevent the binder from adhering to the aggregate particles. Sand equivalency is determined on the fine portion of the blended aggregate (passing the #4 sieve) in accordance with AASHTO T176 (Level 2 Aggregate Training). The minimum requirements, based on the design level of the mix, are given in Standard Specification Section 403.2.3.

Thin, Elongated Particles (Sec 403.2.4)

This property, also known as flat and elongated, is the percentage of coarse aggregates that have a maximum to minimum dimension ratio of 5:1 or greater. Flat and elongated particles are undesirable because they have a tendency to break more easily than other aggregate particles. When an aggregate particle breaks, it creates a face that is not coated with binder, increasing the potential of the mix to strip or ravel. Also, the gradation of the mix becomes finer, which may be detrimental to the mix properties. Finally, a mix that contains flat and elongated particles may be difficult to place and compact. The percentage of flat and elongated particles is determined on the coarse portion of the blended aggregate (retained on the #4 sieve) in accordance with ASTM D4791 (Level 2 Aggregate Training). The maximum allowable percentage of flat and elongated particles for all mixes other than SP125xSM is given in Standard Specification Section 403.2.4.

SP125xSM Requirements (Sec 403.2.5)

In a Stone Matrix Asphalt (SMA) mix, the coarse aggregate will consist of crushed limestone and a hard durable aggregate, i.e. low Los Angeles Abrasion and absorption. Durable aggregate is generally either porphyry or steel slag but may be aggregates such as crushed gravel or quartzite. Mixtures designated as SMR, for rural interstates, may use 100% dolomite aggregates. SMA mixes have flat and elongated requirements for ratios of 5:1 and 3:1. The maximum allowable percentages of flat and elongated particles based on these ratios are given in Standard Specification Section 403.2.5.

Filler Restriction (Sec 403.2.5.1)

See Mineral Filler, Hydrated Lime, and Baghouse Fines in Plant Inspection.

Fibers (403.2.5.2)

Cellulose or mineral fibers, in accordance with Standard Specification Section 1071.4, must be used as a stabilizer in SMA mixes. Because the aggregate gradation of an SMA mix is gap-graded, fibers are used to increase the surface area of the mix and hold the binder in the mix. The fibers do not absorb the binder. The manufacturer, brand name, and dosage rate will be shown on the JMF. Fibers are proportioned by weight in both batch and drum plants. If an SMA mix is produced in a batch plant, the fibers can be added to the aggregate in the weigh hopper or in the pugmill. This can be done manually or mechanically with a metering device. If the fibers are added in the weigh hopper, aggregate from at least one hot bin must be discharged into the hopper before the fibers are added. If the fibers are added in the pugmill, the fibers must be added after the aggregate and before the binder. In either case, the dry mixing time shall be a minimum of 20 seconds and the wet mixing time shall be a minimum of 35 seconds. The mixing times and/or temperatures should be adjusted if a uniform mix is not produced. If an SMA mix is produced in a drum plant, the fibers can be added to the drum in loose or pelletized form. The fibers shall be uniformly and continuously metered into the mix. The metering system must be interlocked with the blending system. Pelletized fibers are added to the drum through the RAP inlet. Record all fiber shipments in the corresponding APIW. The inspector should verify that the manufacturer and brand name are included on the Pre-Acceptance List (PAL) and that the dosagerate meets the minimum requirements of Standard Specification Section 403.2.5.2. Fibers will be sampled in accordance with the PAL requirements and shipped to the Central Laboratory for testing. More information on the PAL requirements can be found in Standard Specification Section 106.12 and Control of Material.

Reclaimed Asphalt (Sec 403.2.6)

Both reclaimed asphalt pavement (RAP) and reclaimed asphalt shingles (RAS) are allowed in some mix types by specification but not all mix types. When RAP or RAS are allowed, the contractor chooses when and how much recycled material to utilize within the specification limits. Depending on how much RAP or RAS the contractor chooses to use, there may be additional requirements placed on the virgin binder by the specifications. Effective virgin binder is used to account for binder absorbed by the aggregates and is not available for blending with the reclaimed binder.

Reclaimed binder contribution is calculated using a spreadsheet provided on MoDOT's website. When a mix design approval is based off of a blend chart binder grade or extracted binder grade, substitution of a different virgin binder may require additional testing to prove the specification requirements are met.

403.1.3 Composition of Mixtures (Sec 403.3)

Gradation (Sec 403.3.1)

The master range for the combined aggregate gradation of each mix type is given in Standard Specification Section 403.3.1. These master ranges apply to the final gradation of the aggregate, including filler materials, before the binder is added. During production, the combined aggregate gradation may be outside of the master range when the tolerances of Standard Specification Section 403.5.1 are applied.

Anti-Strip Agent (403.3.2)

See Liquid Anti-Strip Additives in Plant Inspection.

403.1.4 Job Mix Formula

The mix design procedure will be in accordance with Materials Inspection.

Approval (Sec 403.4.3)

No mix shall be produced or placed by the contractor or accepted for use by an inspector without an approved JMF. This includes mix transfers. The Materials Field Office (MFO) will give written approval. In some extreme cases, approval may be verbal with written approval to follow. Occasionally, contractors may elect to place mix while the request is still pending. In this situation, contractors are proceeding at their own risk and should be so advised by an order record.

Job Mix Formula Modifications (Sec 403.4.4)

A new JMF will be required if a material source is changed or if unsatisfactory results are obtained. The exception for the new JMF requirement will be when a binder source change has been made to a supplier, previously provided by the contractor in the original JMF, for which an alternate JMF number has already been created. Unsatisfactory results may include a mix that fails to meet specifications (binder content, volumetrics, and/or density) or if the visual appearance of the mix is unacceptable. If a new JMF is required, the procedures outlined in Standard Specification Section 403.11 should be followed.

403.1.5 Mixture Production Specification Limits (Sec 403.5)

Intentional deviations from the JMF will not be permitted, except under the conditions set forth in Sec 403.11. The plant shall be operated in such a manner that the mix is produced as shown on the JMF. The specification tolerances are developed in an attempt to keep the mix as consistent as possible and to allow for some variation during production. However, these tolerances are not production limits. For example, if the target binder content is 5.0%, the binder content of the mix can range from 4.7% to 5.3% when the tolerances are applied. The contractor will not be allowed to produce the mix at 4.7% to save money.

Operating out of the specifications may reduce the contractor's pay and/or the pavement service life. When QC tests, either random or informational, are out of specification tolerances, the contractor should adjust the production to bring the mix back in. When QA tests are out of specification tolerances, the contractor should be notified immediately. The contractor is responsible for deciding when adjustments are made to control the mix. Some test properties may be allowed to deviate beyond specification limits occasionally, provided that adjustments are made and the following tests show that production is back within limits.

Production may be required to cease if the random QC or QA test results are either out of specifications far enough to indicate that the mix may be subject to failure or beyond the specification removal limits. Production should cease until the problem is corrected. An order record should be written describing the deficiency and the location and amount of mix affected. The contractor may elect to continue production in order to run more tests. If so, the order record should state that any mix produced after the order record was issued is at the contractor’s risk. Final disposition of the mix can then be made based on all tests and observations and may consist of acceptance at a reduced price or removal and replacement.

Both QC and QA will use the following procedures to determine volumetrics of the mix and compliance with Standard Specification Sections 403.5.3 through 403.5.5. These procedures are discussed in greater detail in the Levels 1 and 2 Bituminous Training.

~~A loose mix sample consisting of roughly 100 lbs. will be taken from the roadway behind the paver, in accordance with AASHTO T168, at the required frequency. The sample will be thoroughly mixed and quartered in accordance with AASHTO R47, or with an approved splitting/quartering device. Two opposite quarters will be retained for testing during the dispute resolution process, if necessary. The remaining two quarters will be mixed together and quartered again.~~

~~The required weight of mix, as listed on the JMF, will be taken from one quarter and used to compact a specimen in accordance with AASHTO T312. The mix will be compacted to N_{des} gyrations while the mix temperature is within the molding range listed on the JMF. Using the opposite quarter, follow the same procedure for the second specimen. The G_{mb} of each specimen will be determined and the average will be used to calculate the air voids V_a and the voids in the mineral aggregate (VMA). By specification, a minimum of two compacted specimens must be used to calculate these properties.~~

~~A third quarter will be used to determine the G_{mm} of the mix in accordance with AASHTO T209. The minimum sample size for each type of mix can be found in the training manual. This property is used to calculate the V_a and density. The volume of the sample, which is needed in the calculation, can be determined by either the weigh-in-air method or the weigh-in-water method. The weigh-in-air method consists of weighing the sample and container (with the lid) completely filled with water in air. The weigh-in-water method consists of weighing the sample and container (without the lid) completely submerged in water.~~

~~The remaining mix should be mixed together and quartered again. To determine the binder content using the nuclear gauge, enough mix should be taken from opposite quarters. The required weight of mix is listed on the JMF. A moisture content sample should be taken from the same quarters. To determine the binder content using the binder ignition oven, enough mix should be taken from one quarter. The minimum sample size for each type of mix can be found in the training manual. A moisture content sample should be taken from the same quarter. Sometimes the ignition oven may not shut itself off. The oven may be shut off manually as long as 3 consecutive readings show less than 0.01% loss. The sample should be examined to assure that a complete burn has been achieved. This will be considered a valid test.~~

In situations where a retained sample must be tested, the following procedure should be used to reheat the sample. Heat the sample in an oven until the mix is workable. Take the mix out of the sample container (box, bucket, etc.) and spread it in a large pan or several smaller pans. Using this procedure, the mix will reach the molding temperature much quicker than it would if it were left in a mass in the sample container. Also, less aging of the mix occurs since the mix is in the oven for a shorter period of time. Once the mix has reached an acceptable temperature, quarter split the mix. The split portions to be used for making gyratory specimens shall then be heated to the compaction temperature~~the sample must be quartered using the procedures discussed above~~. The entire suite of tests must be performed on a retained sample.

Gradation (Sec 403.5.1)

See Sieve Analysis in Plant Inspection. The gradation of the mix is not a pay factor item. However, it does have a significant influence on the volumetrics of the mix. Samples may be taken from the hot bins at a batch plant or from the combined cold feed at a drum plant. It is acceptable to determine gradation from the binder ignition sample according to AASHTO Standard Test Method T 308. Contractors should be allowed the option provided that the chosen method is spelled out in the Quality Control Plan. Gradations of extracted samples would be satisfactory as well. QC is required to sample the aggregate and perform a sieve analysis twice per lot. QA is required to independently sample the aggregate and perform a sieve analysis once per lot. These testing requirements are minimums and should be increased as necessary. Minor deviations outside the tolerances given in Standard Specification Sections 403.5.1.1 or 403.5.1.2, whichever is applicable, may be allowed if the test results indicate that the binder content, volumetrics, and density of the mix are satisfactory. If the test results are unsatisfactory, adjustments of the JMF, in accordance with Standard Specification Section 403.11, are necessary.

Stone Matrix Asphalt Tolerances (Sec 403.5.1.1)

The tolerances from the JMF for SMA mixes are given in Standard Specification Section 403.5.1.1.

Mixture Tolerance (Sec 403.5.1.2)

During production, the combined aggregate gradation must be within the following limits:

Percent Passing by Weight			
Sieve Size	**SP250**	**SP190**	**SP125**
1 ½ in.	100	--	--
1 in.	90-100	100	--
¾ in.	92 Max.	90-100	100
½ in.	--	92 Max.	90-100
3/8 in.	--	--	92 Max.
#4	--	--	--
#8	17-47	21-51	26-60
#16	--	--	--
#30	--	--	--
#50	--	--	--
#100	--	--	--
#200	1-7	2-8	2-10

Density (Sec 403.5.2)

See also Density in Plant Inspection Density Samples in Paving Operations. One sample per sublot will be taken for QC testing. QA will randomly test one of the samples from each lot to verify that a favorable comparison is obtained. These testing requirements are minimums and should be increased as necessary. SMA mixes shall have a minimum density of 94.0% with no upper limit. All other mixes shall have a density of 94.0 ±2.0%.

Shoulder Density (Sec 403.5.2.1) and **Integral Shoulder** (Sec 403.5.2.2)

If the shoulders and the traveled way are placed in the same pass (integrally), the cores will be taken on the traveled way. No cores will be taken on the shoulder. For example, if the paving width is 16’ with a 12’ travel lane and a 4’ shoulder, the shoulder will not be subject to density testing.

Asphalt Content (Sec 403.5.3)

QC is required to sample and test the mix for the binder content once per sublot and QA is required to independently sample and test the mix once per lot. These testing requirements are minimums and should be increased as necessary. During production, the binder content of the mix, as determined by sampling and testing, shall be within ±0.3% of the target listed on the JMF.

Voids in the Mineral Aggregate (VMA) (Sec 403.5.4)

QC is required to sample and test the mix for the VMA once per sublot and QA is required to independently sample and test the mix once per lot. These testing requirements are minimums and should be increased as necessary. The VMA of the mix shall be within –0.5% and +2.0% of the minimum required for the corresponding mix type (see Standard Specification Section 403.4.6.2).

The following table gives the ranges for each mix type:

Mix Type	VMA Limits (percent)
SP250	11.5-14.0
SP190	12.5-15.0
SP125	13.5-16.0
SP095	14.5-17.0
SP048	15.5-18.0
SMA	16.5-19.0

Air Voids (V_a) (Sec 403.5.5)

QC is required to sample and test the mix for the air voids once per sublot and QA is required to independently sample and test the mix once per lot. These testing requirements are minimums and should be increased as necessary. The V_a for all mixes shall be 4.0 ±1.0%.

Tensile Strength Ratio (TSR) (Sec 403.5.6)

The TSR is used to evaluate the impact that water saturation and freeze-thaw cycles have on the strength of an asphalt mix. It can also be used to predict the susceptibility of the mix to stripping.

During production, loose mix samples will be taken and quartered as described in Mixture Production Specification Limits. TSR samples do not need to be located by random numbers. However, they should be taken whenever it is convenient to production, such as during a big gap between QC volumetric tests. QC has the option of taking the loose mix samples from any point in the production process. The recommended locations are from the roadway behind the paver or

from the plant. The QA sample(s) should be taken from the same point as the QC sample(s). If QC takes their sample from the plant, QA should take their sample from the plant also. This does not mean that QA should be taking their samples at the same time as QC. Two opposite quarters will be retained and the remaining two quarters will be mixed together and tested in accordance with AASHTO T283.

QC should obtain enough mix to retain a sample. QC will sample and test each mix at a minimum of once every 10,000 tons, or fraction thereof. QA will independently sample and test each mix at a minimum of once every 50,000 tons. The TSR sampling requirements are best described with an example. Suppose that 112,960 tons of SP190 are to be placed on a project. By specification, QC is required to take twelve samples and QA is required to take three samples. There are two possible scenarios for sampling this mix. QC may take eleven samples representing 10,000 tons each and a twelfth sample that represents the remaining 2,960 tons. Or QC may take ten samples that represent 10,000 tons each and two samples that represent the remaining 12,960 tons (6,480 tons each). Either scenario is acceptable. Likewise, QA may take two samples representing 50,000 tons each and a third sample that represents the remaining 12,960 tons. Or QA may take one sample that represents 50,000 tons and two samples that represent the remaining 62,960 tons (31,480 tons each). The contract quantity may be used to approximate sample 1 locations.

MoDOT should collect at least 250 pounds of asphalt mix for the QA sample. 125 pounds is retained by the RE and the other 125 pounds is sent to the Central Laboratory (typically) in 4 – 13" x 13" x 4.5" boxes for QA testing. ~~QA will send approximately 125 lbs. of loose mix (approximately 4 – 13" x 13" x 4.5" boxes) to the Central Laboratory for testing.~~ Each box must be labeled on one side with the AASHTOWARE Project (AWP) ID, Mix Type, VMA Limits (percent) number and the mix number. An AWP record must be created for each sample, which must include all required information, the mix number, lot, sublot, and the represented tonnage. The represented tonnage is explained in the example in the preceding paragraph.

Additional information that may be included in the AWP record is the G_{mm} from the sublot that the sample was taken in (QC or QA) and the specimen weight that QC has been using. The specimen weight may be different from that shown on the JMF because of bin percent changes, etc. This information is helpful because it results in less trial-and-error for the Central Laboratory.

In the laboratory, a minimum of six specimens are compacted to a height of approximately 95 mm. The air voids of the specimens are calculated. For all mixes other than SMA, the air voids must be within 7.0 ±0.5%. For SMA mixes, the air voids must be within 6.0 ±0.5%. Half of these specimens are saturated, frozen, and thawed. These are the conditioned specimens. The degree of saturation of the conditioned specimens is also calculated. The remaining specimens are unconditioned. Then, the indirect-tensile strength of all of the specimens is determined. Therefore, the TSR is the ratio of the average tensile strength of the conditioned specimens to the average tensile strength of the unconditioned specimens.

A favorable comparison will be obtained if the QC and QA test results are within 10% of each other. The contractor's pay will be adjusted in accordance with Standard Specification Section 403.23.5 based on the QC test results. For example, if the QC TSR is 95% and the QA TSR is 93%, a favorable comparison has been obtained and the contractor will receive a 3% bonus. However, if the difference is greater than 10%, the field office should be consulted. The field office will evaluate the air voids and saturation levels. The raw data should be collected from QC and forwarded to the field office for comparison in order to determine whether it will be necessary to proceed with 3rd party testing. QC and QA retained samples should be kept for an extended period of time so that they may be used during dispute resolution, if necessary.

The QC data should be reported in AWP (Test - SAA402AB). Contractors may report their own test results using the TSR Contractor Reporting Excel to Oracle Spreadsheet available on the MoDOT Quality Management website. Furthermore, this information is quarried regularly and, provided that a favorable comparison is reached, used to signal the appropriate time for disposal of the remaining TSR sample at the Central Lab.

Aggregate Properties (Sec 403.5.7)

The aggregate consensus tests (Fine and Coarse Aggregate Angularity, Clay Content, and Thin, Elongated Particles) are performed on the blended aggregate. The aggregate will be sampled from the combined cold feed whether dealing with a drum-mix plant or a batch plant.

For each mix that is produced, QC shall sample the aggregate and perform the consensus tests once every 10,000 tons with a minimum of one per mix per project. QA will independently sample the aggregate and perform the consensus tests once per project. QA should also test a minimum of one QC retained sample per project. For large projects, enough QC retained samples should be tested to ensure that QC is performing the tests correctly. These testing requirements are minimums and should be increased as necessary. During production, the following tolerances are applied (see Standard Specification Sections 403.2.1 through 403.2.5 and Consensus Testing).

Property	Tolerance
FAA	2% below the minimum
CAA	5% below the minimum
Clay Content	5% below the minimum
Thin, Elongated Particles	2% ~~below the minimum~~above the maximum

Moisture Content (Sec 403.5.9)

See also Asphalt Binder Content in Plant Inspection.

Contamination (Sec 403.5.10)

See Material Acceptance in Paving Operations.

403.1.6 Field Laboratory (Sec 403.6)

See Field Laboratory in Plant Inspection.

403.1.7 Bituminous Mixing Plants (Sec 403.7)

See Batch Plants and Drum-mix Plants in Plant Inspection.

403.1.8 Hauling Equipment (Sec 403.8)

See Haul Trucks in Paving Equipment.

403.1.9 Pavers (Sec 403.9)

See Pavers in Paving Equipment.

403.1.10 Construction Requirements (Sec 403.10)

Weather Limitations (Sec 403.10.1)

See Weather Conditions in Paving Operations.

Substitutions (Sec 403.10.2)

The intent of this specification is that there be no additional cost to MoDOT as a result of the allowed substitution. Payment should be made for the mixture originally set up in the contract. Material codes for the substitute mixture should be entered in AWP on the line for which payment is being made. For example: Assume that the contractor wishes to use SP125 in lieu of the SP190 that is set up in the plans and that the SP125 has a higher contract unit price. Payment for the substitute mix should be paid as SP190. Material codes for SP125 should be added to the line for SP190 so that material quantities can be tracked and documented.

403.1.11 Field Adjustments of Job Mix Formulas (Sec 403.11)

When test results indicate that the mixture does not meet the specification requirements, the contractor may adjust the JMF in the field. The total binder content may be adjusted by a maximum of 0.3% from the original JMF. Virgin aggregate fractions may be adjusted as necessary except that they may not be eliminated entirely unless they are 5% or less of the original JMF. Consult the Field Office before eliminating virgin aggregate fractions greater than 5%. The addition of any new fraction will require a new mix design. The RAS fraction may be adjusted by a maximum of 3% from the original JMF. The RAP fraction may be adjusted by a maximum of 15% from the original JMF.

Any time that adjustments are made to the plant percentages, including the hot bin percentages, the inspector and RE must be notified immediately. The resulting combined aggregate gradation of the adjusted mix must be within the master range for that particular type of mix (see Standard Specification Section 403.3.1). During production of the adjusted mix, the combined aggregate gradation must be within the limits of Standard Specification Section 403.5.1.1 or 403.5.1.2, whichever is applicable. If the cold feed settings have been adjusted, the composition of the mix has been changed. Therefore, the new bulk specific gravity of the combined aggregate (G_{sb}) must be calculated using the adjusted cold feed percentages so that the VMA can be accurately calculated during production. If an adjustment from the job mix is made, the contractor should be required to recalculate the porphyry/Non-carbonate percentage to assure that is still meets the contract requirements. The Durable Aggregate Calculation spreadsheet has been developed to assist in checking the contractor's calculation. If the percentage of RAS or RAP is increased from the original JMF the percent virgin effective binder replacement (P_{bv}) should be recalculated to assure compliance with section 403.2.5 of the Standard Specifications. The P_{bv} should also be recalculated when the percent of binder in the RAP changes as determined by Section 403.19.3.

Field Mix Redesign (Sec 403.11.1)

If a new mix design is required, the contractor may redesign the mix in the field. All requirements of Standard Specification Section 403.4 will apply. A representative sample of a minimum of 50 lbs. shall be submitted with the new mix design to the Central Laboratory for verification testing.

Approval (Sec 403.11.1.1)

Construction and Materials will grant approval and assign a new mix number to the mix upon successful verification.

Resume Production (Sec 403.11.1.2)

No mix shall be produced or placed by the contractor or accepted for use by an inspector without approval of the new field mix design from the Materials Field Office. Once the mix design has been approved, production can resume.

403.1.12 Application of Prime or Tack (Sec 403.12)

See Surface Preparation in Paving Operations

403.1.13 Spreading and Finishing (Sec 403.13)

Standard Specification Section 403.13 puts restrictions on the minimum compacted lift thickness. See also Spreading and Hand Spreading in Paving Operations.

Paving Widths (Sec 403.13.1)

Standard Specification Section 403.13.1 puts restrictions on the paving widths and lengths if the pavement is constructed under traffic.

Segregation (Sec 403.13.2)

See Material Acceptance in Paving Operations.

Release to Traffic (Sec 403.13.3)

Traffic must not be allowed on the pavement until its surface temperature is 140°F or less. Otherwise, the traffic will overconsolidate the mat while it is still hot and cause the pavement to be more susceptible to rutting during its early life.

Draindown (Sec 403.13.4)

See Material Acceptance in Paving Operations.

Shoulder Substitutions (Sec 403.13.5)

The same Superpave mix that was used on the travel lanes may also be used on the shoulders. The density shall be in accordance with Standard Specification Section 403.5.2.1 if nonintegral shoulders are placed or 403.5.2.2 if integral shoulders are placed.

403.1.14 Spot Wedging and Leveling Course (Sec 403.14)

See Surface Preparation in Paving Operations.

403.1.15 Compaction (Sec 403.15)

Vibratory rollers shall be operated in static mode when the mix temperature is below 225°F. Pneumatic tire rollers shall not be used on SMA mixes. See Compaction in Paving Operations.

Rolling (Sec 403.15.1)

Defective Mixture (Sec 403.15.2)

See Material Acceptance in Paving Operations.

Non-traffic Areas (Sec 403.15.3)

Mixes used for non-traffic areas (medians, shoulders, and similar areas) shall be compacted to the required density. Density testing for Superpave mixes placed on the shoulders may be waived, at the RE's discretion, once the contractor has established a roller pattern that has been shown to produce the required density. This means that cores must be taken until the RE is confident that density will be obtained consistently with this roller pattern. If testing has been waived, density must still be obtained and coring may be necessary to ensure that it is. Density testing will again be required at any time that changes in the material, mix temperatures, or roller pattern are made. The intent of the specification is to attain the required density on the shoulders, particularly on full depth pavements. On resurfacing projects, the existing shoulders may not be able to withstand the compactive effort needed to attain density. In this situation, the RE can relax the density requirements, but only to the point that conditions will allow. In other words, get the most density possible without tearing up the shoulders.

Density Measurement (Sec 403.15.4)

See Density in Plant Inspection and Density Samples in Paving Operations.

403.1.16 Joints (Sec 403.16)

See Transverse Joints and Longitudinal Joints in Paving Operations.

Joint Composition (Sec 403.16.1)

Unconfined joint density should be measured on the first pass in the 6 inches adjacent to the vertical edge (if the contractor is taking 6-inch density cores the location should be adjusted as necessary to avoid the vertical face). After the second paver pass closes the unconfined joint, the entire width of

the lane may be used for random density testing, including the entire wedge portion of a notched wedge section.

The density requirements in this section apply to the traveled way pavement within 6 in. of the longitudinal joint, and excludingincluding the pavement on the traveled way side of the shoulder joint. All mixes, except for SMA, shall have a minimum unconfined joint density of 90.0%. SMA mixes shall have a minimum unconfined joint density of 92.0%. Confined joint densities will be evaluated with the remainder of the mat and must meet the density requirements of Standard Specification Section 403.5.2.

403.1.17 Quality Control (Sec 403.17)

Quality Control Operations (Sec 403.17.1)

Under QC/QA, the contractor doesperforms the quality control (QC) testing. while MoDOT does the inspection and quality assurance (QA) testing to verify the QC results. MoDOT is also responsible for independent assurance sampling (IAS) to verify that both QC and QA are performing the testing correctly. The contractor is paid based on the results of the randomly located QC tests for Superpave mixes. Beyond random QC tests, quality control by the contractor consists of constantly monitoring materials integrity, mix production and laydown operations to ensure overall acceptability.In addition, the contractor controls the materials, mix, and the plant and paving operations.

The approved quality control plan (QC Plan) for Superpave mixes shall include the contact information of the contractor's QC representative, lot and sublot sizes and how they will be designated, the test method for determining asphalt binder content, the number of cores to be cut for density determination, and the independent third party for dispute resolution. A QC Plan is not required for bituminous base (BB) and pavement (BP) mixes.

The inspector will do less sampling and testing, allowing more time for actual inspection. The inspector also has the authority to require the contractor to conform to the approved QC Plan as a part of the contract. The contractor's technicians and the MoDOT inspectors will be certified technicians, having demonstrated proficiency in sampling and testing the mix for the properties required in the QC/QA specifications.

Occasionally, the QC test may not represent the population or, due to individual differences in sampling and testing procedures, the QA and QC test results may not compare within the required limits. One of the first steps in resolution could be an immediate computation check, comparison of sampling and testing procedures, or split sample retests. Testing of the QC split sample or joint sampling and testing could determine if variations in the mix production or sampling and testing procedures are responsible for the differences. If resolution is not possible at the project level, either party may request that the approved independent third party test the mix. Third party test results will be binding upon both parties. The party whose results were incorrect will pay for the third party testing. Third party testing is costly and time consuming and should only be used when project level reconciliation is not possible.

It is not intended that any mix be produced outside the specification limits. Operating out of the specifications may reduce the contractor's pay and/or the pavement service life. When QC tests are out of specification tolerances, the contractor should adjust the production to bring the mix back in. When QA tests are out of specification tolerances, the contractor should be notified immediately. The contractor is responsible for deciding when adjustments are made to control the mix. Some test properties may be allowed to deviate beyond specification limits occasionally, provided that adjustments are made and the following tests show that production is back within limits.

Production may be required to cease if the QC or QA test results are either out of specifications far enough to indicate that the mix may be subject to failure or beyond the specification removal limits. Production should cease until the problem is corrected. An order record should be written describing the deficiency and the location and amount of mix affected. The contractor may elect to continue production in order to run more tests. If so, the order record should state that any mix

~~produced after the order record was issued is at the contractor's risk. Final disposition of the mix can then be made based on all tests and observations and may consist of acceptance at a reduced price or removal and replacement.~~

~~Superpave mixes contain a quality level analysis with statistically based incentive/disincentive pay factors. The QC tests are analyzed on each lot of mix and the pay is based on the percentage of the mix that statistically falls within the limits of the specifications. It is possible to have a given lot of mix with all tests falling within the specifications, but because of a large amount of deviation between test results, the percent within limits would be very low, giving the contractor a correspondingly low pay factor. Very consistent test results, with a correspondingly low standard deviation and high percent within limits, will produce high pay factors. Test results that are consistent may produce bonus pay factors while those that fluctuate within the specification limits will produce low pay factors~~

~~See Quality Control/Quality Assurance.~~

Asphalt Test Results (Sec 403.17.1.1)

A copy of all random QC test results shall be furnished to the QA inspector no later than the beginning of the day after testing has been performed. All raw data and printouts must be included with the testing records. Raw data consists of all weights, measurements, etc. used to arrive at the final test results. Printouts include the gyration/height data from the gyratory compactor and the asphalt content ticket from the binder ignition oven or nuclear gauge. The QC testing records must be made available to the QA inspector at all times.

it is QC's responsibility to take appropriate action if unsatisfactory mix is being produced. This may include making adjustments to the plant to bring the mix back into specification, sampling the mix from the roadway and performing informational testing, removing mix from the roadway, etc.

Informational Tests

~~A~~n ~~self-test~~informational test is a test that QC may perform between random testing to determine whether or not the mix is within specifications. ~~Self-test~~Informational testing is not required and may be performed at any time and at any frequency. Generally, ~~self-test~~informational testing will be performed early in the production period. The ~~self-test~~informational test may not be completed in full. For example, QC may only compact the gyratory specimens. Doing so will yield specimen heights and the contractor may or may not make production adjustments based on these heights. ~~Self-test~~Informational test samples must be clearly marked as such if they are tested and stored in the field laboratory.

QC is not required to provide the QA inspector with informational test results, since informational tests cannot be used in the QC process to determine pay factors, The timing of random number locations being given to the contractor, typically 100 to 150 tons in advance, is meant to protect the integrity of the statistical sampling process. QA always has the option of taking its own informational samples.

~~Self-test~~Informational test data may be used to determine asphalt removal limits if it is adequately documented. It should not be used for QLA under any circumstances. To be considered adequately documented the following criteria should be met:

- The gyratory pucks should be clearly identified and labeled and made available for verification.
- The gyratory printout should be available.
- The printout from the AC test should be available.

If the preceding conditions are met and the gyratory specimens are used to troubleshoot the placement, the specimens can then be weighed and bulked to determine the volumetric properties. Data from ~~self-test~~informational tests is approximate. Its only legitimate use to the QA inspector is to help determine the point on the roadway where the mixture transitioned either above or below the removal limits. We don't want to remove acceptable mix or leave unacceptable mix in place.

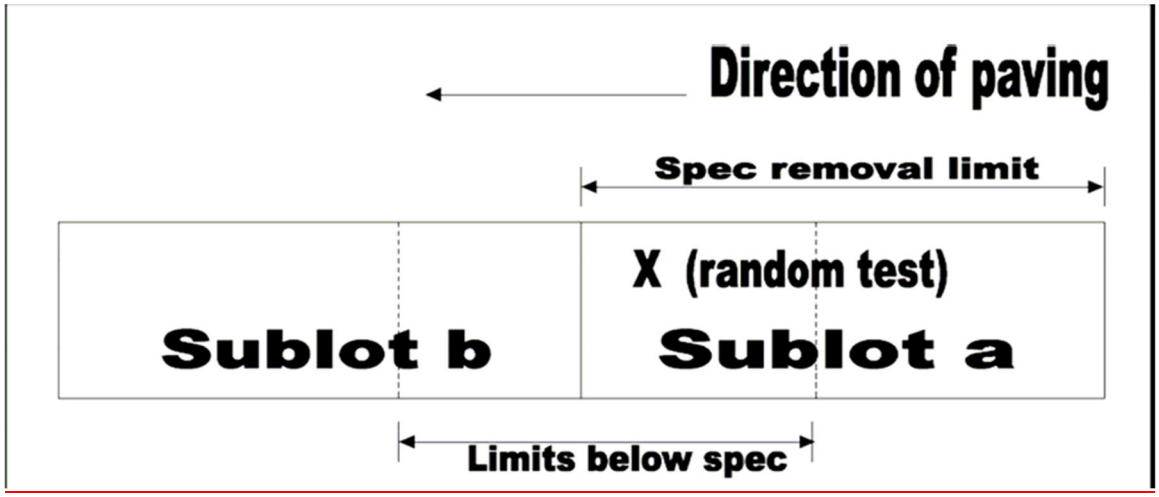
Removal Limits

As an example of how informational tests may be used to designate removal limits of failing QC samples, the following situation is provided. The random QC sample shown in the diagram below fell late in sublot 'a' and test results indicated that voids were below the limits for removal. By specification sublot 'a' should be removed. By the time the test results were available and corrective action was taken, the contractor had crossed into sublot 'b'. Assuming that mix properties were acceptable at the beginning of sublot 'a', the actual limits of unacceptable material are indicated by the dashed lines.

Adhering strictly to the specification, it is likely that acceptable material early in sublot 'a' will be removed, and it is also likely that unacceptable material early in sublot 'b' will be left in place. An adequately documented informational test may be used to zero in on the transitions out of, and back into, acceptable mix. It doesn't matter that the data is approximate, only that it is above the limit for removal.

Random tests within removal limits are to be replaced by an equal number of random QC test locations, regardless of tonnage. For example, if 750 tons replace an area covered by two random tests, the new tests would be randomly chosen in each 375 ton portion of the replaced mixture.

The resident engineer has the option to determine removal limits based on puck height, provided that the informational test data is consistent with previous production.



~~See the Figure Appropriate Use of Self Tests~~.

~~It is QC's responsibility to take appropriate action if unsatisfactory mix is being produced. This may include making adjustments to the plant to bring the mix back into specification, sampling the mix from the roadway and performing complete testing, removing mix from the roadway, etc. QC is not required to provide the QA inspector with self-test results. Self-test results will never be used to determine pay factors. However, if the self-test is well documented, the results may be used to determine removal limits, if necessary. A self-test is considered well-documented if the gyratory specimen(s), gyration/height printout, and asphalt content ticket are available for QA's review. The compacted specimens should be clearly marked as self-test specimens and may be tested if necessary.~~

When the random QC density core is below or above the removal limits, additional cores may be cut using the following procedure to determine the removal limits. A location 250' parallel to the centerline ahead and back of the failing location will be determined by the engineer. Cores will be cut in these locations and tested. If both sets of cores are outside of the removal limits the 500' section will be removed and replace with acceptable material and a new random QC core will be

cut with-in the new pavement. If either set of the cores are within the removal limits the whole sublot or the area in which the density core represents is subject to removal.

Any sublot of material with air voids in the compacted specimens less than 2.5 percent shall be evaluated with Hamburg testing and removed and replaced with acceptable material by the contractor if the rut depth is greater than 14.0 mm.

Inertial Profiler Test Results (Sec 610)

Surface of the pavement should be thoroughly tested with an inertial profiler or straightedge as required by Sec 610. The procedures for testing with an inertial profiler and analyzing the results with the ProVAL software program are set forth in EPG 106.3.2.59 TM-59, Determination of the International Roughness Index.

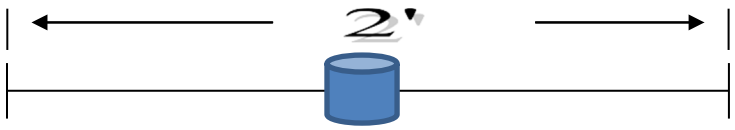
Bituminous Quality Control Plan (Sec 403.17.2)

~~See Quality Control/Quality Assurance.~~

The contractor documents the QC method with a quality control plan (QC Plan*). The QC plan for Superpave mixes shall include the contact information of the contractor's QC representative, lot and sublot sizes and how they will be designated, the test method for determining asphalt binder content, the number of cores to be cut for density determination, and the independent third party for dispute resolution. The QC plan is approved by MoDOT and used as a contract document during mix production. Contractor technicians who perform materials testing shall be certified through the MoDOT Technician Certification Program (TCP).

- Note: A QC Plan is not required for bituminous base (BB) and pavement (BP) mixes.

Up to 3 cores are allowed at each random location, but only if spelled out in the QC plan. In the drawing below, the cylinder represents the station and offset of the random location. Best management practice is for QA to mark that location on the pavement. The first density core should have that marking on it. Any additional cores should be taken along a straight line, parallel to the centerline, within 1 foot either side of the random location.



Plant Calibration (Sec 403.17.2.2)

See Bituminous Mixing Plants.

Retained Samples (Sec 403.17.2.3)

QC must retain the portion of each sample that is not tested after the sample has been reduced to testing size. This includes gradation, consensus, TSR, and volumetrics samples. The retained samples must be clearly identified in accordance with Standard Specification Section 403.17.2.3 and stored in the field laboratory for a minimum of 7 days. Also, all cores must be retained for a minimum of 7 days. Notwithstanding the 7 day minimum, retained samples should not be

discarded until all comparison issues with the lot are resolved. If space at the field lab is an issue, the sample should be stored at the project office.

There is no legitimate reason for unidentified samples to be in the field laboratory. The QA inspector should insist that all test specimens in the field laboratory be marked as soon as they are cool enough. The identifying mark should be permanent, unique, and indicate what the sample is.

When running a QC split sample, the comparisons should be within the tolerances shown in the following table.

Loose Mix Property	Tolerance
Gmb	0.010
Gmm	0.010
AC %	0.1%

~~Gmm should be within 0.005, Gmb should be within 0.010, and AC within 0.1%. If variances are larger both QA and QC should scrutinize sampling, splitting and testing procedures to identify the cause of the difference.~~

~~Isn't that a pretty tight comparison range for G_{mb}?~~

~~Yes, but for two technicians in the same lab it is attainable. If there are comparison problems, the retests should be run together to ascertain the cause of the discrepancy.~~

~~The 7-day requirement in Sec 403.17.2.3 notwithstanding, retained samples should not be discarded until all comparison issues with the lot are resolved. If space at the field lab is an issue, the sample should be stored at the project office.~~

Gradation Sample (Sec 403.17.2.3.1)

QC will retain the portion of their gradation sample that is not tested. This includes the sample of the combined cold feed from a drum plant and all hot bin samples from a batch plant.

Loose Mix Sample (Sec 403.17.2.3.2)

~~A companion sample for all loose mix samples shall be taken and retained. However, the contractor is encouraged to sample a large amount of mix from the roadway, thoroughly blend the mix together, and then reduce the sample down to the necessary testing size. The portion that is not tested will be retained for possible use in the dispute resolution process. This is the preferred method because both halves should yield similar results.~~

A loose mix sample consisting of roughly 100 lbs. will be taken from the roadway behind the paver, in accordance with AASHTO T168, at the required frequency. The sample will be thoroughly mixed and quartered in accordance with AASHTO R47, or with an approved splitting/quartering device. Two opposite quarters will be retained for testing during the dispute resolution process, if necessary. The remaining two quarters will be mixed together and quartered again.

The required weight of mix, as listed on the JMF, will be taken from one quarter and used to compact a specimen in accordance with AASHTO T312. The mix will be compacted to N_{des} gyrations while the mix temperature is within the molding range listed on the JMF. Using the opposite quarter, follow the same procedure for the second specimen. The G_{mb} of each specimen will be determined and the average will be used to calculate the air voids V_a and the voids in the mineral aggregate (VMA). By specification, a minimum of two compacted specimens must be used to calculate these properties.

A third quarter will be used to determine the G_{mm} of the mix in accordance with AASHTO T209. The minimum sample size for each type of mix can be found in the training manual. This property is used to calculate the V_a and density. The volume of the sample, which is needed in the calculation, can be determined by either the weigh-in-air method or the weigh-in-water method. The weigh-in-air method consists of weighing the sample and container (with the lid) completely filled with water in air. The weigh-in-water method consists of weighing the sample and container (without the lid) completely submerged in water.

The remaining mix should be mixed together and quartered again. To determine the binder content using the nuclear gauge, enough mix should be taken from opposite quarters. The required weight of mix is listed on the JMF. A moisture content sample should be taken from the same quarters. To determine the binder content using the binder ignition oven, enough mix should be taken from one quarter. The minimum sample size for each type of mix can be found in the training manual. A moisture content sample should be taken from the same quarter. Sometimes the ignition oven may not shut itself off. The oven may be shut off manually as long as 3 consecutive readings show less than 0.01% loss. The sample should be examined to assure that a complete burn has been achieved. This will be considered a valid test.

Quality Control Laboratory (Sec 403.17.3)

The contractor is required to provide an appropriately equipped QC laboratory, however, it is not required to be at the plant. The contractor is also required to provide office space at the asphalt plant for the QA inspector to work on records and reports. Usually, these two requirements are met with one structure, but not always. The intent of the specification will be met if the QA inspector is provided with suitable facilities at the plant, but the lab is located offsite at another location, such as between the jobsite and the plant.

Calibration Schedule (Sec 403.17.3.1)

Calibrations and verifications of the testing equipment are very important. If the equipment has not been calibrated or verified as required, false test results may be obtained. The maximum intervals are given in Standard Specification Section 403.17.3.1. These frequencies are taken from the AASHTO test methods and/or the manufacturer's recommendations.

Calibration Records (Sec 403.17.3.1.2)

Periodically, the QA inspector should check the QC calibration records to ensure that the equipment has been calibrated or verified in accordance with Standard Specification Section 403.17.3.1.

403.1.18 Quality Assurance (Sec 403.18)

~~See Quality Control/Quality Assurance.~~

Assurance Testing (Sec 403.18.1)

Under QC/QA, MoDOT performs quality assurance (QA) testing. QA testing is used to verify the QC results. MoDOT is also responsible for independent assurance sampling (IAS) to verify that both QC and QA are performing the testing correctly.

All QA samples will be at independent random locations from QC. Not testing at random locations introduces statistical bias that is not in the interest of either MoDOT or the contractor. As with informational QC tests for the contractor, the MoDOT inspector may select specific locations for informational QA loose mix or core samples at any time if there is concern about a problem area, however, these may not be used for PWL calculations.

For volumetric testing, QA must sample enough loose mix material to retain an adequate amount for a second test~~a sample~~. This retained sample, as with the QC retained sample, may be used during dispute resolution. QA will randomly sample the mix from the roadway once per lot, or once per four sublots for a superlot, and perform volumetric testing. At the beginning of the project, QC and QA should be given the opportunity to witness each other's sampling and testing procedures. Any discrepancies should be immediately resolved at the project level, if possible. QA should test a QC retained volumetric sample once per day to ensure that both QC and QA are testing correctly. These samples should also be chosen at random (do not consistently test the retained sample from the same sublot every lot or develop a pattern).

For density testing, QA cores shall also be randomly located within a sublot at a frequency of one per lot or one per four sublots in a superlot. However, in the interest of public safety a random QA core test location, such as one middle of a busy intersection, should be moved to the closest safe location at the same random transverse offset.

When both QC and QA are confident in each other's testing procedures and favorable comparisons have been obtained on the retained samples, testing of the QC retained volumetric samples may be performed at a reduced frequency as determined by the MoDOT inspector~~on days that an independent sample is not taken~~. QA should test a QC retained gradation sample at a minimum of once per week. A minimum of one QC retained consensus sample should be tested per project. ~~Again, all of the testing requirements previously mentioned are minimums and should be increased as necessary.~~ QA test results will be furnished to the contractor no later than the day after testing has been performed. A QA/QC Checklist is attached.~~ For additional information see QA/QC Questions and Answers.~~

QA Test Type	Minimum by Spec	Early in project	Later in project
Random QA for PWL	1/4 sublots	1/4 sublots	1/4 sublots
QC Split	1/week	1/day	On days when there is no random QA

For single lift overlays and small quantity, QA cores shall be cut in the same location as the QC core.

QA Core Chain of Custody (Sec 403.18.2)

The roadway inspector should ensure that the QA density cores taken from the roadway are the same ones tested in the lab. The preferred procedure is for a MoDOT inspector to take possession of the cores as soon as they are cut and deliver them directly to QA at the plant, so that testing can proceed without delay. When job circumstances make this procedure impractical and the contractor has to deliver the core, the roadway inspector should dry the core with a paper towel and mark the side with identifying marks, including lot and sublot, using a permanent felt-tipped marker. Regardless of who delivers the QA core to the lab, the core shall be placed in a tamper proof bag.

Aggregate Comparison (Sec 403.18.~~2~~3)

A favorable comparison will be obtained when the independent QA sample(s) meets specifications. In addition, the QA test results of a QC retained sample must be within the following tolerances from the QC test results:

Property	Percentage Points
¾ in. sieve and larger	±5.0
½ in. sieve	±5.0

3/8 in. sieve	±4.0
#4 sieve	±4.0
#8 sieve	±3.0
#16 sieve	±3.0
#30 sieve	±3.0
#50 sieve	±2.0
#100 sieve	±2.0
#200 sieve	±1.0
CAA	±5.0
FAA	±2.0
Clay Content	±5.0
Thin, Elongated Particles	±1.0

If a favorable comparison is not obtained, dispute resolution procedures should be initiated.

403.1.19 Acceptance of Material (Sec 403.19)

Random Numbers (Sec 403.19.1)

All random numbers for QC loose mix samples and cores shall be generated prior to the start of the project for every four sublots. A printout of those numbers will be sealed in an envelope, which will be signed and dated by both QA and QC parties. The QA inspector will keep the envelopes in his/her possession in a secure location. The envelope for every four sublots will be provided to QC at the end of the previous four sublots.~~All random numbers will be generated by QA at least one lot~~

~~in advance. This includes the random numbers for the core locations and loose mix sample locations.~~

It is critical that QC (and QA) samples be taken at random locations, because any manipulation of the locations introduces bias. QC test results are used to statistically define a population of data and bias causes inaccuracy in that statistical calculation.

Random numbers shall be generated by using the Asphalt Random Locations spreadsheet, in order to eliminate any question of bias. MoDOT inspectors can locate the sheet on the internal site at the following link: http://eprojects/Templates/Forms/AllItems.aspx

Sheet Name: Asphalt_Random_Locations

~~A copy of the random numbers will be sealed in an envelope and given to the contractor upon completion of the lot.~~ QC samples that are used to determine the pay factors must be taken at the locations designated by the random numbers, unless circumstances warrant relocation. This could include close proximity to another QC sample location in the same production period (when QC is at a critical point in testing the previous sample), areas where mix must be placed by hand, etc. In these cases, using good judgment, QA has the authority to separate ~~If necessary, the~~ random samples ~~may be separated~~ by up to 200 tons. QC and QA need to work together in good faith to make this process run smoothly.

QC should be notified of the core location after rolling has been completed. QC should be notified of the loose mix sample location approximately 100 to 150 tons before the test. The intent is to give QC enough time to conclude any ongoing tests and collect the next samples. When the sampling for every four sublots is completed, the envelope for those sublots will be opened to demonstrate that the random numbers were not manipulated during production.

The independent QA sample must be taken at the location designated by ~~the~~ a random number unless circumstances warrant relocation. This could include close proximity to a QC sample location in the same production period, areas where mix must be placed by hand, etc. If necessary, the random samples may be separated by 200 tons. The QA inspector shall place and seal the QA core in a tamper-proof bag immediately after extraction and mark the bag label with the project number, lot number, location and inspector signature. The test results from the independent QA sample will be compared to the QC test results to determine ~~whether or not~~if the QC test results adequately define the characteristics of the entire lot. However, QA may take additional samples to determine if an area of concern complies with the specifications. The test results of these additional samples will not be compared to any QC test results.

Lots (Sec 403.19.2)

For the purposes of pay factor determination, the mat will be divided into lots with a minimum of 4 sublots per lot. The maximum sublot size is 1000 tons. If a full lot cannot be completed, the extra sublots will be added to the previous full lot and the pay factors will be determined on the large lot. If there is no previous lot, the mix will be treated as small quantities and Standard Specification Section 403.23.7.4.1 will apply.

A contractor may elect to use a 'superlot' in their QC plan. A superlot may have a maximum of 28 sublots. In this case, QA testing will still be at a four sublot frequency. If the project total is more

than 28 sublots, but less than 32 sublots, the remaining portion above 28 sublots may be combined with the first 28 sublots for PWL calculations. Also, the portion above 28 sublots will be combined with sublot numbers 25 -28 for the QA testing evaluation of those sublots.

If the target binder content is adjusted from the original JMF, a new lot shall begin. This will ensure that the binder content pay factor will represent the population of the adjusted mix. If the cold feed settings are adjusted from the original JMF alone, a new lot is not required. Adjusting the cold feed settings will change the G_{sb} and, therefore, the VMA of the mix. However, the VMA specification limits are based on the type of mix (see Voids in the Mineral Aggregate (VMA) (Sec 403.5.4) and do not change. The VMA is required to be within this range, even if changes are made to the JMF. A new lot sequence shall begin when a new mix design is established. The limits of adjustment can be found in Standard Specification Section 403.11.

Test and Pay Factor Items (Sec 403.19.3)

~~The minimum sampling and testing requirements for both QC and QA, as shown in the table in Standard Specification Section 403.19.3, have been modified as a result of the QC/QA Process Team. The guidelines set forth in this document should be followed. In regards to~~Regarding N~~n~~ote 'b', one core equals one sample and the results will be used to determine the density pay factor for the corresponding sublot. However, if stated in the QC Plan, a maximum of two additional cores may be taken per sublot. This gives a maximum total of three cores per sublot. One core must be taken at the location selected by random numbers. The remaining cores must be taken at the same transverse offset within one foot longitudinally of the location selected by the random numbers. If more than one core is taken per sublot, all of the cores will be combined into one sample. This means that the average density of the cores will be used to determine the density pay factor for the corresponding sublot.

Test Method Modification (Sec 403.19.3.1)

Binder Ignition Modification (Sec 403.19.3.1.1)

This specification adjusts the temperature of the binder ignition oven due to the breakdown of certain aggregate formations as a result of intense heat.

Rice Test (Sec 403.19.3.1.2)

If the absorption of any aggregate fraction used in the mix is greater than 2.0%, AASHTO T209 must be modified in accordance with Standard Specification Section 403.19.3.1.2. This procedure is called the dry-back method. The final surface-dry weight will be recorded in the APIW as "A2". If necessary, the dry-back method should be performed on all samples taken in the first lot of mix produced. If the initial G_{mm} and the dry-back G_{mm} of a sample are within 0.002 of each other in all sublots of the first lot, the dry-back may be reduced to every fourth sublot. Otherwise, the dry-back will be required every sublot.

Miscellaneous Applications (Sec 403.19.3.2)

Small Quantities (Sec 403.19.3.2.1)

A mix that requires less than ~~3000~~ 4000 tons on a project is referred to as small quantities. Testing frequencies will be as stated in Standard Specification Section 403.19.3.2.1(b). If a project is initially setup with less than ~~3000~~ 4000 tons, pay factors will not be determined unless an adjustment is made to the approved QC plan~~contract~~ to before production begins. If a project is initially setup with more than ~~3000~~ 4000 tons but less than ~~3000~~ 4000 tons are placed, pay factor determination is not required and Standard Specification Section 403.23.7.4.1 will apply.

Dispute Resolution (Sec 403.19.4)

The vast majority of issues between QC and QA can be resolved by consulting the QC Plan, the Test Method or the contract documents. Dispute decisions should always be timely and made at the lowest **appropriate** level. However, if a dispute cannot be resolved within a few hours of taking these initial steps, it should be escalated.

Occasionally, the QC test may not represent the population or, due to individual differences in sampling and testing procedures, the QA and QC test results may not compare within the required limits. One of the first steps in resolution could be an immediate computation check, comparison of sampling and testing procedures, or split sample retests. Testing of the QC split sample or joint sampling and testing could determine if variations in the mix production or sampling and testing procedures are responsible for the differences. If resolution is not possible at the project level, either party may request that the approved independent third party test the mix. Third party test results will be binding upon both parties. The party whose results were incorrect will pay for the third party testing. Third party testing is costly and time consuming and should only be used when project level reconciliation is not possible.

~~See Quality Control/Quality Assurance~~

403.1.20 Method of Measurement (Sec 403.22)

Weight Determination (Sec 403.22.1)

If a batch plant is used to produce the mix, the weight of the load will be determined by the batch weights. If the mix is produced in a drum plant, the weight of the load will be determined by weighing each load of mix. This can be accomplished with either a silo scale or a truck scale. These individual load weights will be added together for the total tonnage accepted for the project and rounded to the nearest 0.1 ton.

Full Depth (Sec 403.22.2)

(Sec 403.22.2.1)

The final driving surface area (length multiplied by width) of the pavement will be used as the area of all underlying lifts and courses. Any mix that is placed outside of this area, including the mix used to construct the 1:1 slope, will not be directly paid for.

(Sec 403.22.2.2)

Full depth pavements will be paid for by the square yard. If authorized changes are made to the contract quantity during construction or if errors are found in the contract quantity, the applicable completed pavement will be measured to the nearest 0.1 yd^2. The revision or correction will be added to or deducted from the contract quantity. If no changes are made or errors found, the pavement will not be measured and the contractor will be paid for the quantity of mix as shown in the contract.

Alternate Overlay (Sec 403.22.3)

An overlay project may be bid as Portland cement concrete or asphalt.

Field Established Quantity (Sec 403.22.3.1)

The field established plan quantity is the tonnage of mix that is determined from the set or adjusted profile. This will be the contract quantity for an asphalt overlay.

Overlay Measurement (Sec 403.22.3.2)

Overlays will be paid for by the ton. If authorized changes are made to the contract quantity during construction, the applicable completed pavement will be measured to the nearest 0.1 ton. The revision will be added to or deducted from the contract quantity. If no changes are made, the

pavement will not be measured and the contractor will be paid for the quantity of mix as shown in the contract.

Pavement Testing (Sec 403.22.4)

See Density Samples in Paving Operations.

403.1.21 Basis of Payment (Sec 403.23)

Aggregate Variation (Sec 403.23.1)

The specific gravity of the aggregates used in the mix may fluctuate because of a variation in the quality of the rock within the quarry ledge. The gradation of the aggregate may also cause some fluctuation. However, this contribution is usually negligible. Because of such fluctuations, the quantity of aggregate used in the mix may vary from the quantity specified in the contract. Since this is expected and unavoidable, the contract unit price will not be adjusted.

Compacted Samples (Sec 403.23.2)

The cost of cutting QC cores is included in the contract. Therefore, no direct payment will be made. QA samples will be paid for at $75.00 per sample, per Standard Specification Section 109.15. If one QA core is cut per location, that core is equal to one sample. If more than one QA core is cut per location, the test results will be averaged and those cores will equal one sample.

Smoothness Adjustment (Sec 610.5)

Diamond Grinding

Diamond Grinding (Sec 403.23.4.1)

Areas of the final driving surface that must be corrected by diamond grinding will be considered as a marred surface (Sec 610.5.3). A tack coat will not be applied to these areas. No direct payment will be made for diamond grinding.

Tensile Strength Retained Adjustment (Sec 403.23.5)

The tonnage represented by each QC TSR sample is subject to a pay adjustment that depends on the test results. The adjustments to the contract unit price are given in Standard Specification Section 403.23.5.

Continuing with the sampling example in Tensile Strength Ratio (TSR) (Sec 403.5.6), the contractor takes ten samples that represent 10,000 tons each. The last two samples represent 6,480 tons each. The contractor's test results are shown in order in the table below. The price per ton is $35.00. The contract adjustment is calculated as follows:

Contract Adjustment = ((Percent of Contract Price-100)/100) * Price/ton * Tons

TSR	Tonnage	Percent of Contract Price	Contract Adjustment (Bonus/Deduct)$
84	10,000	100	0
87	10,000	102	7,000
88	10,000	102	7,000
92	10,000	103	10,500
86	10,000	102	7,000
83	10,000	100	0
81	10,000	100	0
76	10,000	100	0
74	10,000	98	-7,000
80	10,000	100	0
78	6,480	100	0
85	6,480	102	4,536
Total	112,960		20,036

The Pay Factor Worksheet will automatically calculate the contract adjustment once the appropriate information has been entered. The contractor's TSR results should be recorded in the Pay Factor Worksheet that corresponds with the lot that the sample was taken in.

Density Adjustment (Sec 403.23.6)

QC will take one unconfined longitudinal joint core per sublot, if applicable. These cores will be taken within 6 in. of the unconfined longitudinal joint. Unconfined joint cores can either be located at the same longitudinal location as the corresponding mat density cores or separate random numbers can be generated. The test results for each lot will be averaged to determine compliance with the specifications. Pay adjustments will be in accordance with the following table and will be applied to the corresponding tonnage represented by the core(s):

Longitudinal Joint Density (Percent of G_{mm})	**Pay Factor (Percent of Contract Unit Price)**
For all SP mixtures other than SP125xSM	
90.0 to 96.0 inclusive	100
96.1 to 96.5 or 89.5 to 89.9 inclusive	90
96.6 to 97.0 or 89.0 to 89.4 inclusive	85
97.1 to 97.5 or 88.5 to 88.9 inclusive	80
97.6 to 98.0 or 88.0 to 88.4	75
Above 98.0 or Below 88.0	Remove and Replace
For SP125xSM mixtures:	
≥92.0	100
91.5 to 91.9 inclusive	90
91.0 to 91.4 inclusive	85
90.5 to 90.9 inclusive	80

90.0 to 90.4 inclusive	75
Below 90.0	Remove and Replace

If pay reductions are necessary, the lower adjusted contract unit price of the PWL or the unconfined joint density adjustment will apply to the corresponding tonnage. For example, assume that the lot size is 4000 tons and that 1000 tons in the lot has an unconfined joint. The total pay factor for the lot due to volumetric testing is 105%. A longitudinal joint core is taken as required and the pay factor due to the unconfined joint density is 90%. As a result, a 10% reduction to the contract unit price will be applied to the 1000 tons represented by the unconfined joint and a 5% bonus will be paid for the remaining tonnage in the lot (3000 tons). On the other hand, if the pay factor due to the unconfined joint density were 100%, the 5% bonus would be paid for the entire lot. Longitudinal joint density is very important and this is an attempt to ensure that density is achieved. If it is not, the joint will ravel.

Percent Within Limits (PWL) (Sec 403.23.7)

Superpave mixes contain a quality level analysis with statistically based incentive/disincentive pay factors. The QC tests are analyzed on each lot of mix and the pay is based on the percentage of the mix that statistically falls within the limits of the specifications. It is possible to have a given lot of mix with all tests falling within the specifications, but because of a large amount of deviation between test results, the percent within limits would be very low, giving the contractor a correspondingly low pay factor. Very consistent test results, with a correspondingly low standard deviation and high percent within limits, will produce high pay factors. Test results that are consistent may produce bonus pay factors while those that fluctuate within the specification limits will produce low pay factors

The mean (x_a), standard deviation (s), Upper Quality Index (Q_u), Lower Quality Index(Q_l), and total percent within limits (PWLt) are calculated for each pay factor item in each lot using the equations given in Standard Specification Section 403.23.7. The PWL for an item can be determined using Table III in Standard Specification Section 502.15.8. To use this table, calculate the Q_u of the item and round the result to two digits (X.XX). Find the result in the left hand column of the table and move along the row to the right until reaching the column with the corresponding n-value. The n-value is the number of test results for the item in the lot. This process yields the upper percent within limits (PWL_u) of the item. Repeat this process to determine the lower percent within limits (PWL_l) of the item using the Q_l. Finally, calculate the PWL_t. If a Q-value is negative, subtract the PWL-value from 100. The Pay Factor Worksheet will automatically calculate the PWL_t for each pay factor item in each lot.

Quality Level Analysis (Sec 403.23.7.1)

Best management practice is for QA to review the QLA with QC before processing the report. Sec 403.23.7.1 requires QA to make the QLA no more than 24 hours after receipt of the contractor's test results.

Acceptance (Sec 403.23.7.1.1)

~~(Sec 403.23.7.1.1.1)~~ The QC test results will be used to determine the PWL as long as QC and QA compare favorably. If a favorable comparison is not obtained, dispute resolution procedures

should be initiated. If dispute resolution is carried out to independent third party testing and the QC test results have been determined to be correct by the third party, the QC test results will be used to calculate the PWL. If the QA test results have been determined to be correct by the third party, the QA test results will be included in the PWL calculation.

During the project, QA and QC should be given the opportunity to witness each other's sampling, splitting and testing. Doing so will help avoid future conflict.

For comparison of QC and QA cores, the density for the QA core will be calculated using the G_{mm} from the corresponding QC loose mix sample from the same sublot.

Comparison (Sec 403.23.7.1.~~1~~.2)

Copies of all test methods should be readily available in the field laboratory. Testing procedures must follow an approved test method. If either party has an issue with the other's sampling, splitting or testing procedures, an objection should be raised at that time. By doing this promptly, the issue can be resolved while it is still possible to re-create the test. If a decision is made to test a retained sample, the test should be run jointly so that the testing procedure is removed as a possible variable for explaining the difference in results.

~~-~~A favorable comparison is obtained when the QA test results of a random, independent sample are within two standard deviations of the average of the QC test results. This determination cannot be made until all random testing for the lot has been completed. If the QC test results vary within the specification tolerances, the standard deviation will be large. In fact, as the variability in the QC test results increases, the standard deviation also increases. This results in a wide comparison range and low pay factors. On the other hand, if there is little variability in the QC test results, the standard deviation will be small. The comparison range will be narrow and the pay factors will increase. In this case, a favorable comparison is obtained when the QA test results are within one-half of the specification tolerances of the QC average. For example, the specification tolerances for VMA are –0.5% to +2.0%. One-half of this range is 1.25%. Therefore, a favorable comparison is obtained if the QA test result is within ±0.6% of the QC average.

If the comparison is not favorable, the first step is to review both QC and QA test results to see if there is any noticeable error. If no errors are found, testing of the retained samples may be performed. Judgment must be used in determining which retained sample(s) to test. When testing a retained sample, the entire suite of tests (%AC, Va, and VMA) should be performed to verify the validity of the original test results. If the test results of the retained sample confirm the original test results, the original test results are used to determine the PWL. If the test results of the retained sample verify that the original test results were incorrect, the test results of the retained sample are used to determine the PWL.

If the QC and QA test results have been determined to be valid and the comparison is still unfavorable, the test results from the random, independent QA sample will be included in the PWL calculation. The QA test results of QC retained samples or the test results from any additional QA samples will not be used in the PWL calculation. As an example, lot 3 has been completed and consists of 4 sublots. A favorable comparison was not obtained but it was determined that the QC and QA test results are valid. Therefore, the PWL calculation will include the QC test results from all 4 of the sublots and the test results of the random, independent QA sample (n = 5).

When the random QA test results are included in the PWL calculation, all volumetric properties (%AC, VMA & V_A) for that sample will be used, even if only one of the three properties has an unfavorable comparison.

For the random split sample comparisons of QC loose mix, a~~A~~ favorable comparison is obtained when the QA test results of a QC retained volumetric sample are within 0.005 of the QC Gmm test results, within 0.010 of the QC Gmb test results, and within 0.1% of the QC asphalt content test results. If larger variances occur, both QC and QA should investigate the sampling and testing procedures to identify and rectify the cause of the discrepancy.

Outliers (Sec 403.23.7.1.3~~2~~)

If it is suspected that an individual QC test result is an outlier, the entire lot of QC test results may be checked in accordance with Standard Specification Section 403.23.7.1.2. The eligible measured test results are G_{mb}, G_{mc}, G_{mm}, and %AC. G_{mb}, G_{mc}, and G_{mm} shall be carried out to three decimal places (X.XXX) and the %AC shall be carried out to two decimal places (X.XX). On the other hand, V_a, VMA, and density are not eligible because these are calculated volumetric properties.

If an outlier is found, QC may test the retained sample from the corresponding sublot. Again, the entire suite of tests (%AC, G_{mb}, and G_{mm}) must be performed. If the test results from the retained sample confirm the original test results, the original test results will be used to calculate the PWL. If the test results from the retained sample do not confirm the original test results, the test results from the retained sample will be used to calculate the PWL.

When any change is made in the JMF, the previous test results cannot be used for future outlier calculations since the mix has changed. For example, if the contractor has made a change in sublot 2B and wants to check for an outlier in sublot 2D, the results from sublot 2A cannot be used since the mix is not the same.

Random Sampling (Sec 403.23.7.1.4)

See Random Numbers in EPG 403.2.19 Acceptance of Material (Sec 403.19).

Pay Factors (Sec 403.23.7.2)

The density ($PF_{density}$), asphalt content (PF_{AC}), VMA (PF_{VMA}), and air voids (PF_{Va}) pay factors are calculated for each lot using the corresponding PWL_t and the equations in Standard Specification Section 403.23.7.2. The total pay factor (PFT) is then calculated for each lot using the average of the individual pay factors. If coring is not required, such as on a leveling course or non-integral shoulders, the PFT will be calculated for each lot using the average of the PF_{AC}, PF_{VMA}, and PF_{Va}.

The contract adjustment is used to adjust the contractor's pay to reflect the quality of the mix. The contractor may receive a bonus if the quality of the mix is good. On the other hand, if the quality of the mix is poor, a deduction will be applied. The contract adjustment is calculated by subtracting 100% from the PFT. The dollar amount of the bonus or deduction is determined by multiplying the unit bid price, the quantity of mix in the lot, and the contract adjustment (in decimal form) together.

Mix is typically produced and measured by the ton. Therefore, in order to eliminate confusion and excessive conversions on square yard projects (full depth pavements), the lots will be tracked by tonnage. When the pay factors are calculated at the end of the lot, the "Square Yard Calculator" in the Pay Factor Worksheet can be used to determine the square yards in the lot. This is best explained with an example:

On a full-depth paving project, the total thickness of the pavement is 12 in. and the contractor is placing two lifts of SP190, one 6 in. lift and one 4.25 in. lift. The final lift of SP125 is 1.75 in. thick. The lot size is 3000 tons. Suppose that one lot of SP190 has been completed. The total thickness of the pavement and the lift thicknesses are entered in the appropriate cells in the "Square Yard Calculator". The length and width of the lot must be measured manually. The

width of the lot is 12 ft., the length of the first lift is 4650 ft., and the length of the second lift is 3300 ft. Therefore, the area of the first lift is 6200.0 yd^2 (12 ft. * 4650 ft. = 55800 ft^2 * (1 yd^2/9 ft^2) = 6200 yd^2) and is entered in the appropriate cell. The area of the second lift is 4400.0 yd^2(12 ft. * 3300 ft. = 39600 ft^2 * (1 yd^2/9ft^2) = 4400 yd^2) and is entered in the appropriate cell. The square yardage represented by each lift is calculated by multiplying the square yards by the lift thickness divided by the total pavement thickness. Therefore, the square yardage of the first lift is 3100.0 yd^2 (6200 yd^2 * (6 in./12 in.) = 3100 yd^2) and the square yardage of the second lift is 1558.3 yd^2 (4400 yd^2 * (4.25 in./12 in.) = 1558.3 yd^2). This lot represents 4658.3 square yards. This procedure is followed for the remaining lots.

Density Pay Factor (Sec 403.23.7.2.1)

Density is calculated using the G_{mb} of the core and the G_{mm} of the mix. The $PF_{density}$ for each lot is calculated using the density test results of all of the sublots. Cores that are cut in half, as required by Standard Specification Section 403.15.4, will double the number of test results used to determine PFdensity. For example, suppose that the contractor is placing SP190 in 8” lifts and 4 cores are taken per lot, 1 per sublot. The lift is being placed thicker than 6 times the nominal maximum size aggregate used in the mix. By specification, the cores are to be cut in half and the density of each half determined separately. Therefore, 8 test results (as opposed to 4) will be used to determine the $PF_{density}$ for the lot.

Asphalt Content Pay Factor (Sec 403.23.7.2.2)

The PFAC for each lot is calculated using the binder content test results of all of the sublots.

Voids in the Mineral Aggregate and Air Voids Pay Factor (Sec 403.23.7.2.3)

The V_a, VMA, and VFA are calculated using the average G_{mb} of the compacted gyratory specimens, the G_{mm} of the mix, the percent stone (P_s) of the mix, and the G_{sb} of the combined aggregate. The P_s is determined by subtracting the percent binder (P_b) from 100%. The G_{sb} will be that listed on the JMF. The PFV_a and PF_{VMA} for each lot are calculated using the V_a and VMA test results of all of the sublots.

Removal of Material (Sec 403.23.7.3)

If the PF_T for a lot is less than 50.0, the entire lot must be removed and replaced at the contractor’s expense. If the QC test results for density and/or air voids fall below the removal limits in any sublot, the affected mix must be removed and replaced at the contractor’s expense. The specifications state that the entire sublot must be removed. However, in some cases only a portion of the affected sublot(s) may require removal. Therefore, the limits of removal will be left up to the Resident Engineer's discretion. QC ~~self test~~informational test results may be used to help define the limits of removal as long as the ~~self test~~informational test(s) are well documented (see Asphalt Test Results (Sec 403.17.1.1) for the documentation requirements). The replacement mix will be sampled and tested as required. These test results will be used to calculate the PWL for the lot.

If the QA test results fall below the removal limits for density and/or air voids, the mix should stay in place if a favorable comparison has been obtained with the QC test results. Again, a favorable comparison signifies that the QC test results adequately define the characteristics of the lot and are, therefore, acceptable. If the QA test results fall below the removal limits and a favorable comparison has not been obtained, dispute resolution should be initiated to determine if~~whether or not~~ the mix should stay in place.

For small quantities, if the laboratory compacted air voids are less than 2.5%, or the roadway density is less than 90.0% or more than 98%, the material should be removed and replaced. If asphalt content is above or below the target value by more than 0.3%, or if the roadway density

is between 91.5% and 90%, the mixture may be allowed to remain in place with an appropriate deduction.

Miscellaneous Applications (Sec 403.23.7.4)

Small Quantities (Sec 403.23.7.4.1)

For small quantity projects consisting of less than ~~3000~~ 4000 tons, the statistical analysis of the mix is not required. Therefore, pay factors will not be determined. However, the mix must meet density, binder content, VMA, and V_a specifications. The testing frequencies are stated in Standard Specification Section 403.19.3.2.1(b). Density will be adjusted in accordance with the table in Standard Specification Section 403.23.7.4.1(b). TSR testing is also required.

The contractor may use the PWL deductions for a small quantity if they are specified in their QC plan.

Base Widening and Entrances (Sec 403.23.7.4.2)

Single Lift or Leveling Course Work (Sec 403.23.7.4.3)

This specification does not apply to “mill and fill” projects.

~~460.1 Quality Control/Quality Assurance~~

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~~Under QC/QA, the contractor does the quality control (QC) testing while MoDOT does the inspection and quality assurance (QA) testing to verify the QC results. MoDOT is also responsible for independent assurance sampling (IAS) to verify that both QC and QA are performing the testing correctly. The contractor is paid based on the results of the QC tests. In addition, the contractor controls the materials, mix, and the plant and paving operations. The approved quality control plan (QC Plan) for Superpave mixes shall include the contact information of the contractor's QC representative, lot and sublot sizes and how they will be designated, the test method for determining asphalt binder content, the number of cores to be cut for density determination, and the independent third party for dispute resolution. A QC Plan is not required for bituminous base (BB) and pavement (BP) mixes.~~

~~The inspector will do less sampling and testing, allowing more time for actual inspection. The inspector also has the authority to require the contractor to conform to the approved QC Plan as a part of the contract. The contractor's technicians and the MoDOT inspectors will be certified technicians, having demonstrated proficiency in sampling and testing the mix for the properties required in the QC/QA specifications.~~

~~Occasionally, the QC test may not represent the population or, due to individual differences in sampling and testing procedures, the QA and QC test results may not compare within the required limits. One of the first steps in resolution could be an immediate computation check, comparison of sampling and testing procedures, or split sample retests. Testing of the QC split sample or joint sampling and testing could determine if variations in the mix production or sampling and testing procedures are responsible for the differences. If resolution is not possible at the project level, either party may request that the approved independent third party test the mix. Third party test results will be binding upon both parties. The party whose results were incorrect will pay for the third party testing. Third party testing is costly and time consuming and should only be used when project level reconciliation is not possible.~~

~~It is not intended that any mix be produced outside the specification limits. Operating out of the specifications may reduce the contractor's pay and/or the pavement service life. When QC tests are~~

~~out of specification tolerances, the contractor should adjust the production to bring the mix back in. When QA tests are out of specification tolerances, the contractor should be notified immediately. The contractor is responsible for deciding when adjustments are made to control the mix. Some test properties may be allowed to deviate beyond specification limits occasionally, provided that adjustments are made and the following tests show that production is back within limits.~~

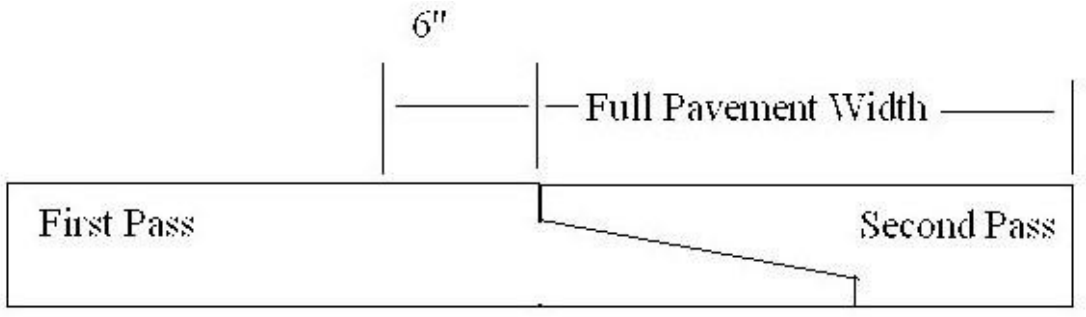
~~Production may be required to cease if the QC or QA test results are either out of specifications far enough to indicate that the mix may be subject to failure or beyond the specification removal limits. Production should cease until the problem is corrected. An order record should be written describing the deficiency and the location and amount of mix affected. The contractor may elect to continue production in order to run more tests. If so, the order record should state that any mix produced after the order record was issued is at the contractor's risk. Final disposition of the mix can then be made based on all tests and observations and may consist of acceptance at a reduced price or removal and replacement.~~

~~Superpave mixes contain a quality level analysis with statistically based incentive/disincentive pay factors. The QC tests are analyzed on each lot of mix and the pay is based on the percentage of the mix that statistically falls within the limits of the specifications. It is possible to have a given lot of mix with all tests falling within the specifications, but because of a large amount of deviation between test results, the percent within limits would be very low, giving the contractor a correspondingly low pay factor. Very consistent test results, with a correspondingly low standard deviation and high percent within limits, will produce high pay factors. Test results that are consistent may produce bonus pay factors while those that fluctuate within the specification limits will produce low pay factors~~.

460.6.9 Longitudinal Joints

Longitudinal joints in the final surface shall be placed at the locations specified on the plans, generally at or outside of the lane lines of the roadway. However, pavement markings shall not be placed on a longitudinal joint. The longitudinal joints in the underlying lifts shall be offset by a minimum of 6 in. so that the joints do not fall in the same location throughout the full depth of the pavement.

Asphalt pavers are typically outfitted with a notched wedge strike-off attachment to form an unconfined longitudinal joint as shown in the diagram below -



In construction of the first pass, the paver should run as straight as possible so that the joint can be matched on the next pass. Also, the unconfined edge must be properly compacted so that the joint will not deteriorate under traffic. The roller should make as many passes over the unconfined edge as it

does over the rest of the mat. Also, the roller should extend over the unconfined edge by approximately 6 in. to ensure that the compactive effort of the roller is applied in a vertical direction and to reduce lateral displacement of the mix during compaction. No edge differential shall be left in place for more than 7 days, unless approval is granted from the RE.

In construction of the second pass, the exposed edge may be lightly tacked, if directed by the RE, to help seal the joint. The adjacent lane should be overlapped by approximately 1 in. or more to ensure that sufficient mix is available to properly seal the joint. If excessive overlapping occurs, the joint should be "bumped" or the excess mix should be removed. Hand manipulation of the mix should be minimal so that unsightly surface texture is avoided. Again, the uncompacted mix should be placed between 120% and 125% of the compacted lift thickness to account for roll down into the joint when the mix is compacted. If too much or too little mix is placed at the joint, the elevation of the adjacent lane will not be matched and the required density may not be achieved. The longitudinal joint should be compacted on the hot side of the mat with the roller extending approximately 6 in. over the joint. This does not necessarily have to be accomplished with the first pass. The joint should not be rolled to the extent that degradation of the aggregate occurs.

Other methods of constructing a longitudinal joint may be used if satisfactory results are obtained. However, the completed longitudinal joint should be well sealed, flush, and along true lines.