MAY

Edition 2022

SUPERPAVE

MoDOT

May 2022
Superpave
QC/QA

MoDOT

SUPERPAVE

TABLE OF CONTENTS

MoDOT

SUPERPAVE

2022 – Updates

- 2022 – Entire Manual has been updated.
    - Several updates for TSR testing – Jeff will go over this.
    - Updated MoDOT Spreadsheets to current.

TAB

Module 1

Module 1

Mix Design Overview

MoDOT SUPERPAVE CERTIFICATION COURSE

MODULE 1

MIX DESIGN OVERVIEW

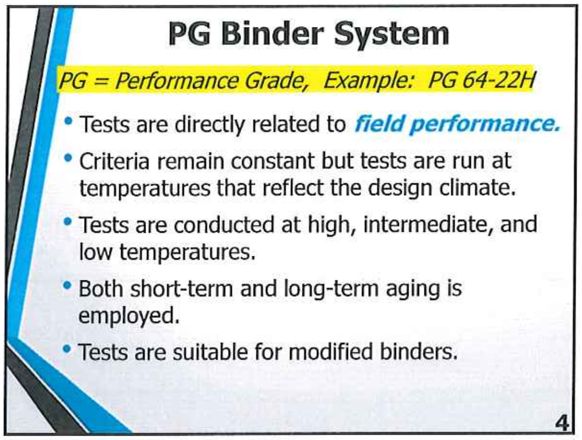
AASHTO Test Methods

- R35 Volumetric Design Practice
- M323 Volumetric Mix Design Specifications
- R30 Mix Conditioning
- T 312 Gyratory Compactor Operation (Gyro)
- T 166 Bulk Specific Gravity of Compacted Specimens (Pucks)
- T 209 Maximum Specific Gravity of Voidless Mix (Rice)
- T 283 Moisture Sensitivity

MoDOT Specifications & Guides

- Missouri Standard Specifications
  - Sections: 403, 401, 610, 1002, 1004 etc.
- Engineering Policy Guide
  - Sections same as above.

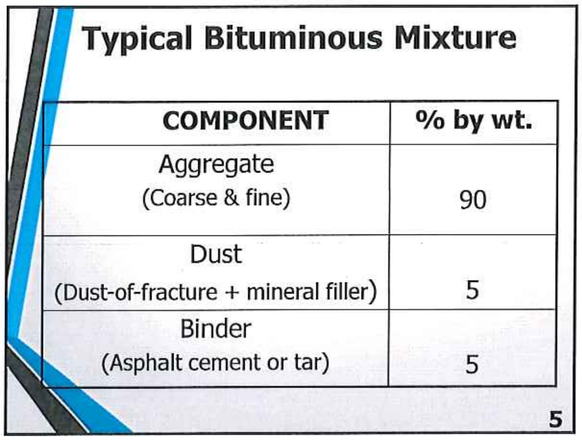
Other sections are referenced when applicable.



PG Binder System

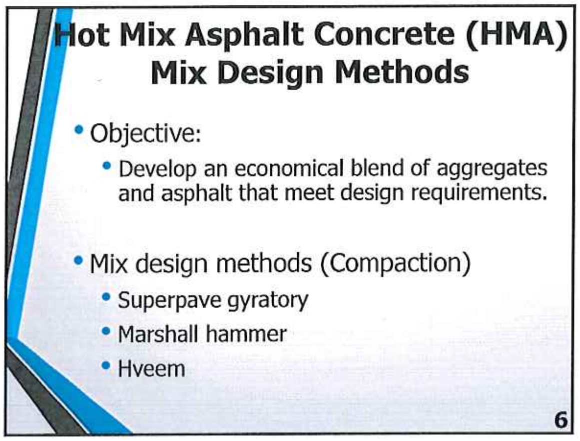
PG = Performance Grade, Example: PG 64-22H

- Tests are directly related to ***field performance.***
- Criteria remain constant but tests are run at temperatures that reflect the design climate.
- Tests are conducted at high, intermediate, and low temperatures.
- Both short-term and long-term aging is employed.
- Tests are suitable for modified binders.



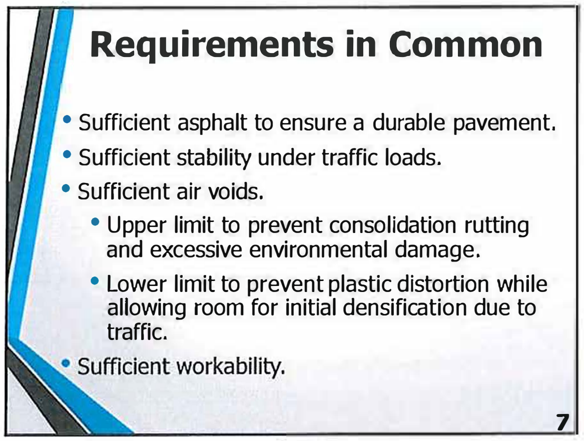
Typical Bituminous Mixture

COMPONENT	% by wt.
Aggregate (Coarse & fine)	90
Dust (Dust-of-fracture + mineral filler)	5
Binder (Asphalt cement or tar)	5



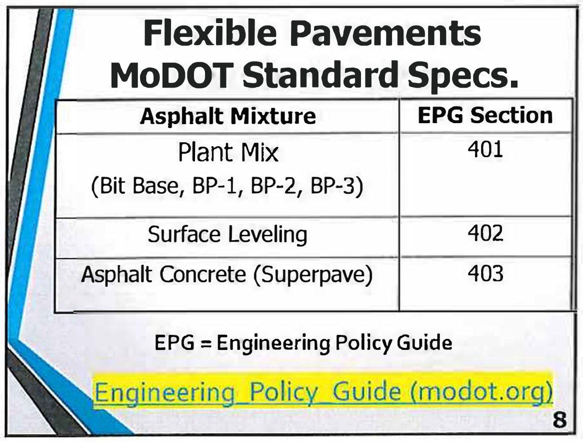
Hot Mix Asphalt Concrete (HMA) Mix Design Methods

- Objective:
  - Develop an economical blend of aggregates and asphalt that meet design requirements.
- Mix design methods (Compaction)
  - Superpave gyratory
  - Marshall hammer
  - Hveem



Requirements in Common

- Sufficient asphalt to ensure a durable pavement.
- Sufficient stability under traffic loads.
- Sufficient air voids.
  - Upper limit to prevent consolidation rutting and excessive environmental damage.
  - Lower limit to prevent plastic distortion while allowing room for initial densification due to traffic.
- Sufficient workability.

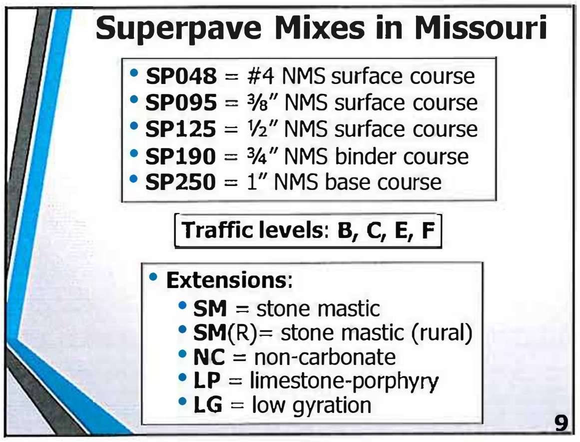


Flexible Pavements MoDOT Standard Specs.

Asphalt Mixture	EPG Section
Plant Mix (Bit Base, BP-1, BP-2, BP-3)	401
Surface Leveling	402
Asphalt Concrete (Superpave)	403

EPG = Engineering Policy Guide

Engineering Policy Guide (modot.org)

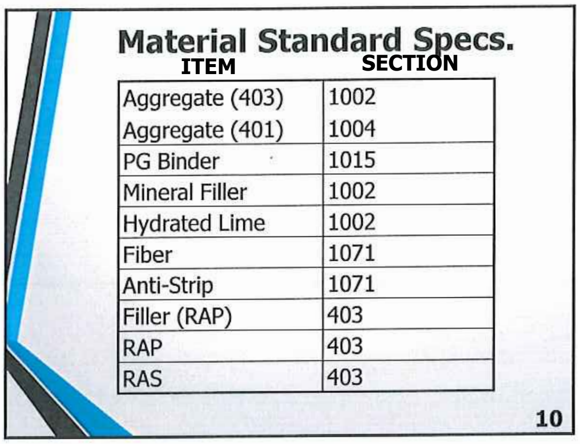


Superpave Mixes in Missouri

- **SP048** = #4 NMS surface course
- **SP095** = ⅜″ NMS surface course
- **SP125** = ½″ NMS surface course
- **SP190** = ¾″ NMS binder course
- **SP250** = 1″ NMS base course

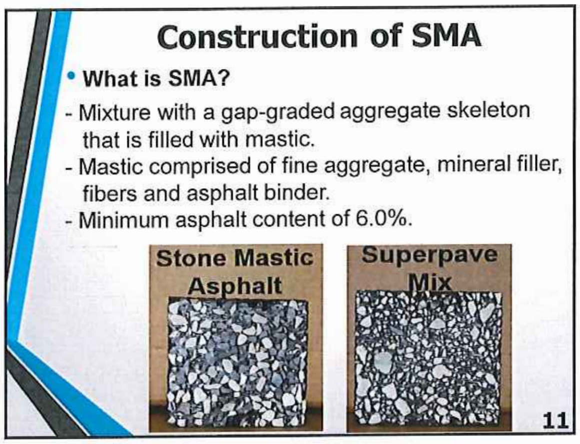
Traffic levels: **B, C, E, F**

- **Extensions**:
  - **SM** = stone mastic
  - **SM**(R)= stone mastic (rural)
  - **NC** = non-carbonate
  - **LP** = limestone-porphyry
  - **LG** = low gyration



Material Standard Specs.

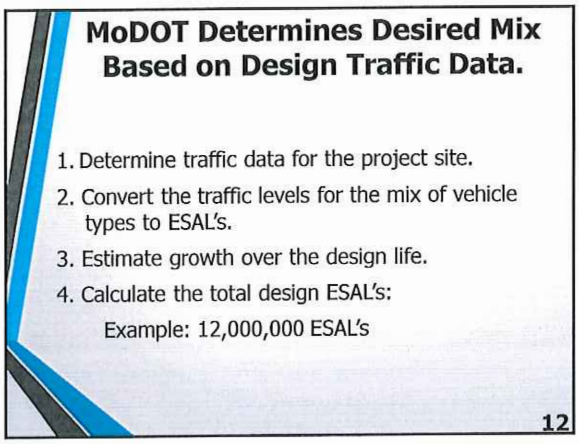
ITEM	SECTION
Aggregate (403)	1002
Aggregate (401)	1004
PG Binder	1015
Mineral Filler	1002
Hydrated Lime	1002
Fiber	1071
Anti-Strip	1071
Filler (RAP)	403
RAP	403
RAS	403



Construction of SMA

- **What is SMA?**

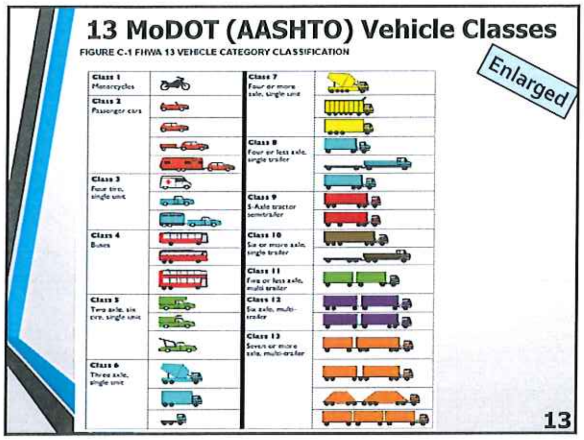
- Mixture with a gap-graded aggregate skeleton that is filled with mastic.
- Mastic comprised of fine aggregate, mineral filler, fibers and asphalt binder.
- Minimum asphalt content of 6.0%.



MoDOT Determines Desired Mix Based on Design Traffic Data.

1. Determine traffic data for the project site.
2. Convert the traffic levels for the mix of vehicle types to ESAL's.
3. Estimate growth over the design life.
4. Calculate the total design ESAL's:

   Example: 12,000,000 ESAL's

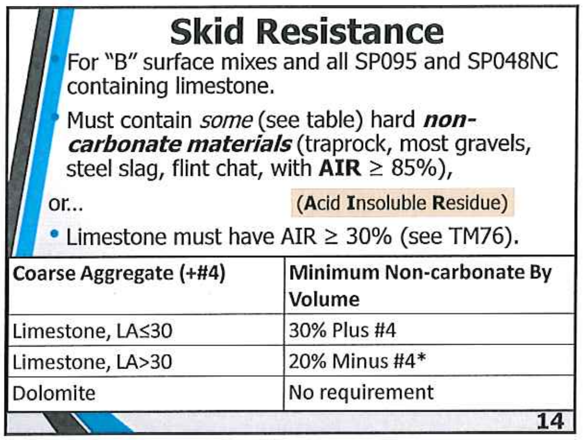


13 MoDOT (AASHTO) Vehicle Classes

FIGURE C-1 FHWA 13 VEHICLE CATEGORY CLASSIFICATION

Enlarged

Class 1	Motorcycles
Class 2	Passenger cars
Class 3	Four tire, single unit
Class 4	Buses
Class 5	Two axle, six tire, single unit
Class 6	Three axle, single unit
Class 7	Four or more axle, single unit
Class 8	Four or less axle, single trailer
Class 9	5-Axle tractor semitrailer
Class 10	Six or more axle, single trailer
Class 11	Five or less axle, multi trailer
Class 12	Six axle, multi-trailer
Class 13	Seven or more axle, multi-trailer



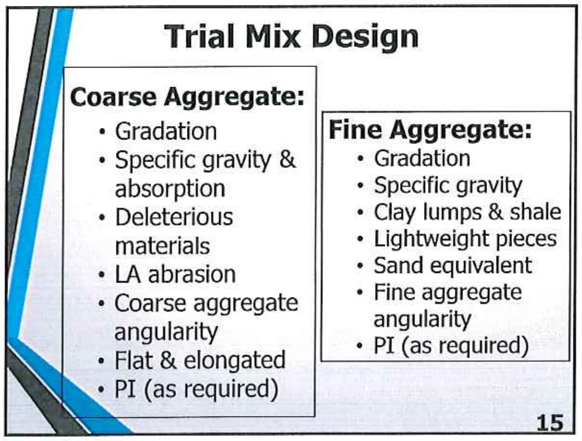
Skid Resistance

- For "B" surface mixes and all SP095 and SP048NC containing limestone.
- Must contain *some* (see table) hard ***non-carbonate materials*** (traprock, most gravels, steel slag, flint chat, with **AIR** ≥ 85%),

or... (**A**cid **I**nsoluble **R**esidue)

- Limestone must have AIR ≥ 30% (see TM76).

Coarse Aggregate (+#4)	**Minimum Non-carbonate By Volume**
Limestone, LA≤30	30% Plus #4
Limestone, LA>30	20% Minus #4*
Dolomite	No requirement



Trial Mix Design

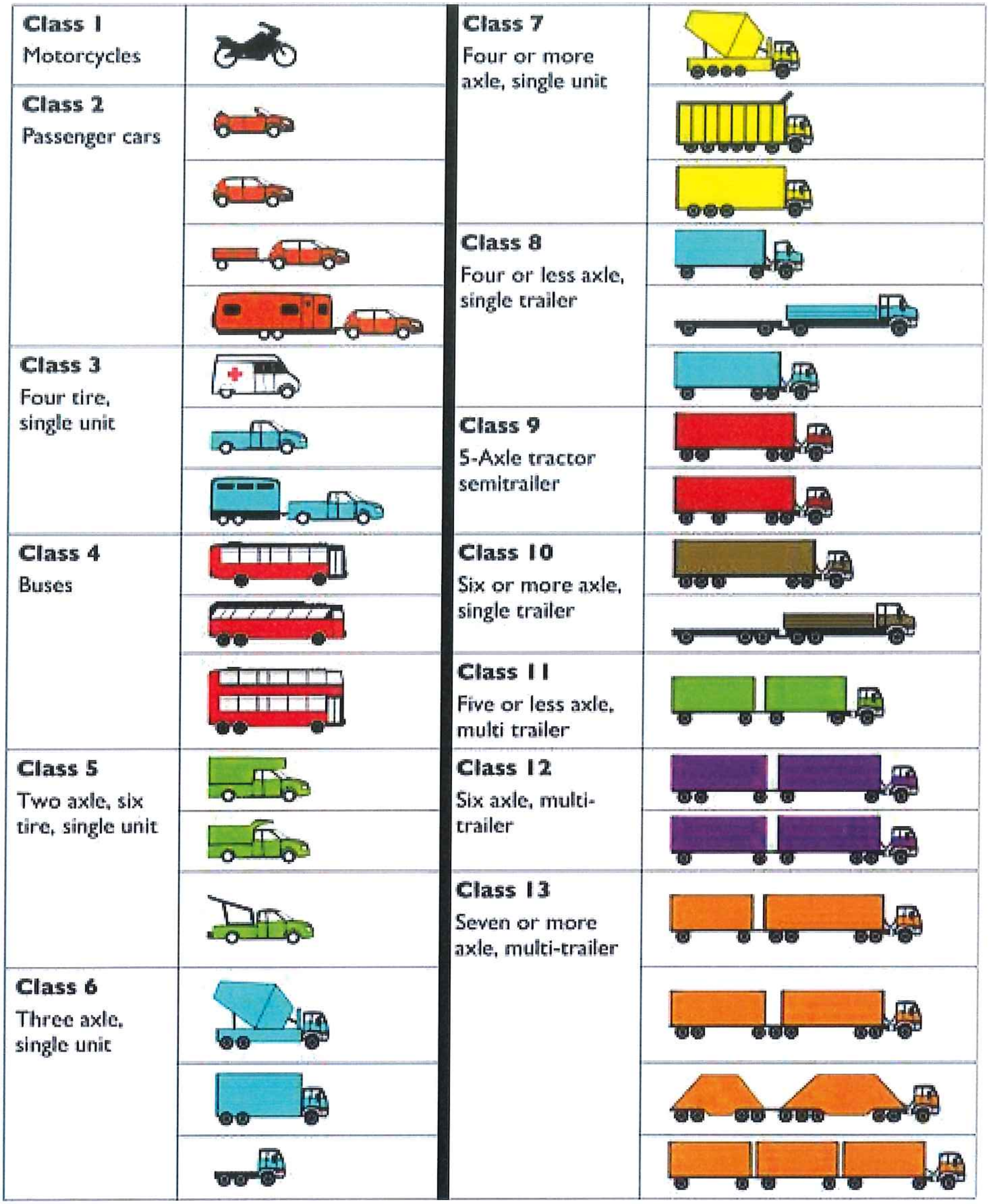
Coarse Aggregate:

- Gradation
- Specific gravity & absorption
- Deleterious materials
- LA abrasion
- Coarse aggregate angularity
- Flat & elongated
- PI (as required)

Fine Aggregate:

- Gradation
- Specific gravity
- Clay lumps & shale
- Lightweight pieces
- Sand equivalent
- Fine aggregate angularity
- PI (as required)

FIGURE C-1 FHWA 13 VEHICLE CATEGORY CLASSIFICATION



Trial Mix Design

Blended aggregate must meet Superpave "Consensus" criteria:

- Fine aggregate angularity
- Coarse aggregate fractured face count
- Coarse aggregate flat and elongated
- Sand equivalent

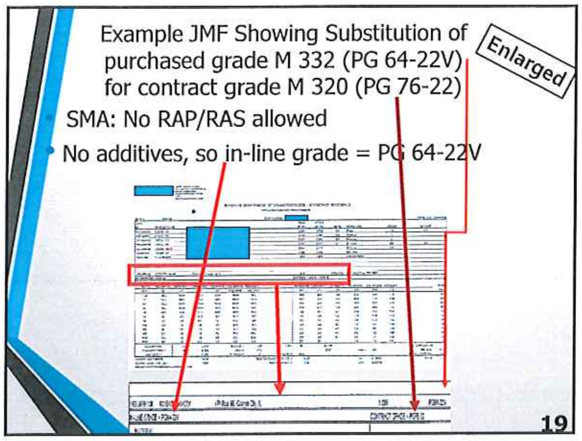
Selection of
PG Binder Grade

- Based on:
  - Climate
  - Depth in pavement
  - Volume of traffic
  - Vehicle speed
  - Desired level of reliability
  - RAS (shingle) content
  - RAP content

RAP/RAS Binders

- ***RAP*** **-** Has aged- stiffer than virgin binder
- ***RAS*** **-** Roofing binder is much stiffer
- ***Combined*** **-** Virgin & recycled binder → stiffer

May be too hard unless combined with softer Oil.



Example JMF Showing Substitution of purchased grade M 332 (PG 64-22V) for contract grade M 320 (PG 76-22)

- SMA: No RAP/RAS allowed
- No additives, so in-line grade = PG 64-22V

What's My Grade?

Different Example

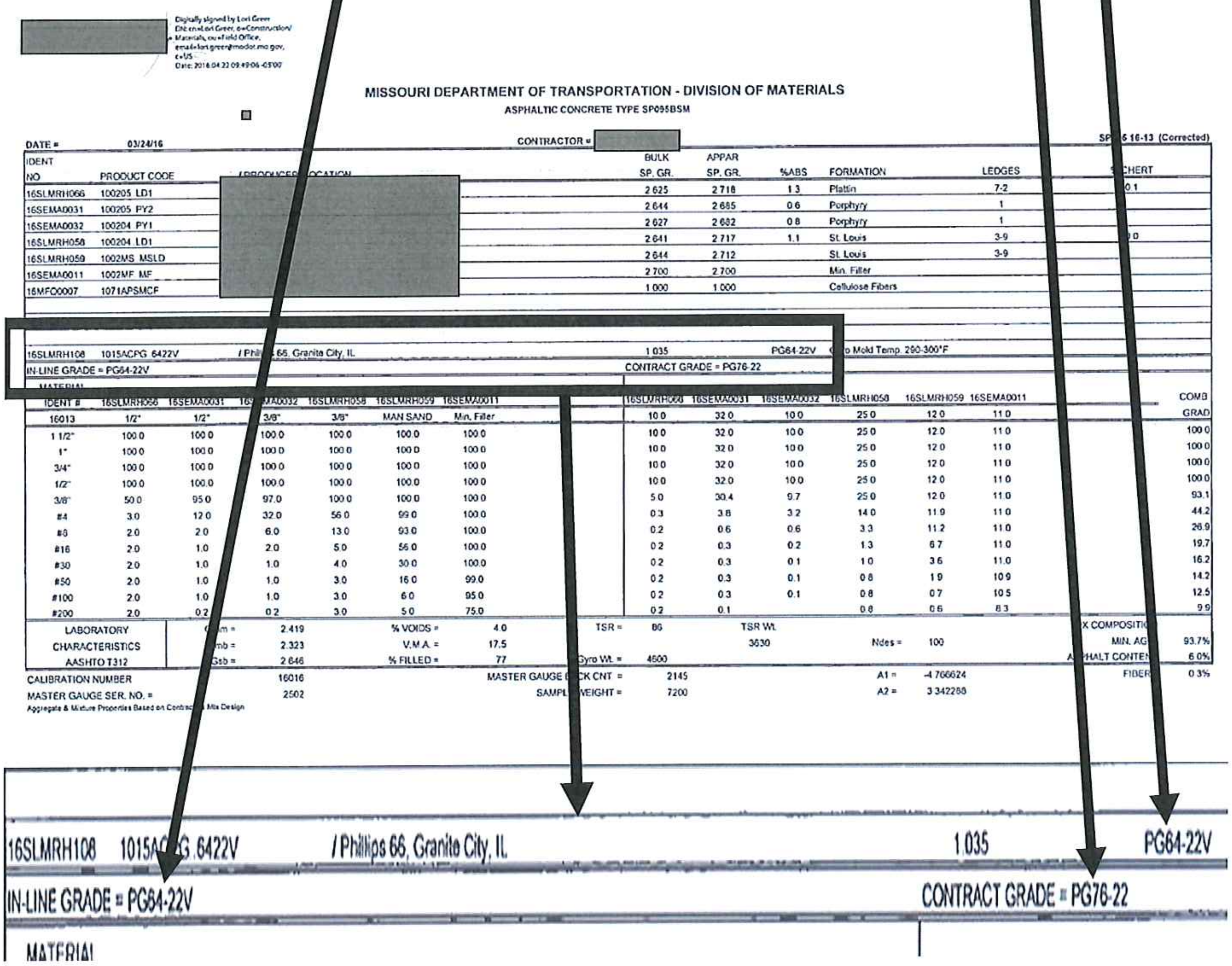
- ***"Contract Grade"*** = the PG grade in the contract, e.g., PG 70-22
- ***"Purchased Grade"*** = what contractor buys from supplier (terminal), e.g., PG 58-28 (if RAP/RAS will be used)
- ***"In-line Grade"*** = Purchased grade + ***additive*** (warm mix, anti-strip, etc.) e.g., PG 58-28
- ***"In-line Grade"*** = Purchased grade + ***modifier*** (rejuvenator) e.g., PG 52-28

Volumetrics

- "Volumetrics" involves the space (volume) between the aggregate particles.
- During mix design, several gradations are tried, and volumetrics are calculated until proper VMA, VFA, and Va (air voids) are obtained.
- Space is dependent on aggregate gradation, particle shape, aggregate toughness, and aggregate absorption.

Example JMF Showing Substitution of purchased grade M 332 (PG 64-22V) for contract grade M 320 (PG 76-22)

- SMA: No RAP/RAS allowed
- No additives, so in-line grade = PG 64-22V



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DN: cn=Lori Green, o=Construction/Materials, ou=Field Office, email=lori.green@modot.mo.gov, c=US
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MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS
ASPHALTIC CONCRETE TYPE SP095BSM

DATE = 03/24/16 CONTRACTOR = [redacted] SP 6 16-13 (Corrected)

IDENT NO	PRODUCT CODE	/ PRODUCER / LOCATION	BULK SP. GR.	APPAR SP. GR.	%ABS	FORMATION	LEDGES	CHERT
16SLMRH066	100205 LD1	[redacted]	2.625	2.718	1.3	Plattin	7-2	0.1
16SEMA0031	100205 PY2		2.644	2.685	0.6	Porphyry	1	
16SEMA0032	100204 PY1		2.627	2.682	0.8	Porphyry	1	
16SLMRH058	100204 LD1		2.641	2.717	1.1	St. Louis	3-9	0
16SLMRH059	1002MS MSLD		2.644	2.712		St. Louis	3-9	
16SEMA0011	1002MF MF		2.700	2.700		Min. Filler		
16MFO0007	1071APSMCF		1.000	1.000		Cellulose Fibers		

16SLMRH108 1015ACPG 6422V / Phil 66, Granite City, IL 1.035 PG64-22V o Mold Temp. 290-300°F

IN-LINE GRADE = PG64-22V CONTRACT GRADE = PG76-22

MATERIAL IDENT #	16SLMRH066	16SEMA0031	16 MA0032	16SLMRH058	16SLMRH059	16SEMA0011	16SLMRH066	16SEMA0031	16SEMA0032	16SLMRH058	16SLMRH059	16SEMA0011	COMB GRAD
16013	1/2"	1/2"	3/8"	3/8"	MAN SAND	Min. Filler	10.0	32.0	10.0	25.0	12.0	11.0	
1 1/2"	100.0	100.0	100.0	100.0	100.0	100.0	10.0	32.0	10.0	25.0	12.0	11.0	100.0
1"	100.0	100.0	100.0	100.0	100.0	100.0	10.0	32.0	10.0	25.0	12.0	11.0	100.0
3/4"	100.0	100.0	100.0	100.0	100.0	100.0	10.0	32.0	10.0	25.0	12.0	11.0	100.0
1/2"	100.0	100.0	100.0	100.0	100.0	100.0	10.0	32.0	10.0	25.0	12.0	11.0	100.0
3/8"	50.0	95.0	97.0	100.0	100.0	100.0	5.0	30.4	9.7	25.0	12.0	11.0	93.1
#4	3.0	12.0	32.0	56.0	99.0	100.0	0.3	3.8	3.2	14.0	11.9	11.0	44.2
#8	2.0	2.0	6.0	13.0	93.0	100.0	0.2	0.6	0.6	3.3	11.2	11.0	26.9
#16	2.0	1.0	2.0	5.0	56.0	100.0	0.2	0.3	0.2	1.3	6.7	11.0	19.7
#30	2.0	1.0	1.0	4.0	30.0	100.0	0.2	0.3	0.1	1.0	3.6	11.0	16.2
#50	2.0	1.0	1.0	3.0	16.0	99.0	0.2	0.3	0.1	0.8	1.9	10.9	14.2
#100	2.0	1.0	1.0	3.0	6.0	95.0	0.2	0.3	0.1	0.8	0.7	10.5	12.5
#200	2.0	0.2	0.2	3.0	5.0	75.0	0.2	0.1		0.8	0.6	8.3	9.9

LABORATORY CHARACTERISTICS AASHTO T312
m = 2.419 % VOIDS = 4.0 TSR = 86 TSR Wt.
mb = 2.323 V.M.A. = 17.5 3630 Ndes = 100
Gsb = 2.646 % FILLED = 77 Gyro Wt. = 4600

X COMPOSITIO
MIN. AG 93.7%
A HALT CONTEN 6.0%
FIBER 0.3%

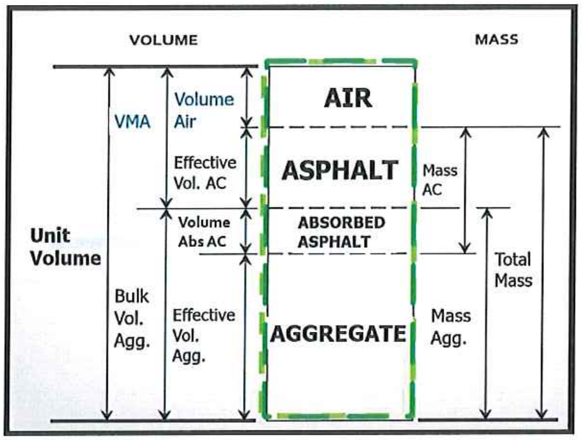
CALIBRATION NUMBER 16016 MASTER GAUGE CK CNT = 2145 A1 = -4.766624
MASTER GAUGE SER. NO. = 2502 SAMPL WEIGHT = 7200 A2 = 3.342288

Aggregate & Mixture Properties Based on Contrac Mix Design

16SLMRH108 1015AC G 6422V / Phillips 66, Granite City, IL 1.035 PG64-22V

IN-LINE GRADE = PG64-22V CONTRACT GRADE = PG76-22

MATERIAL



Aggregate Structure Selection

Aggregate structure=gradation

- The design gradation will be a blend of up to 8 different aggregate fractions plus mineral filler such as hydrated lime.
- Vary the percentages of each fraction to make the total gradation ***blend.***
- The ***blend*** must meet the aggregate consensus test criteria.

Aggregate Structure

(Gradation)

- Gradation is usually plotted on ***0.45 power graph paper.***
- The ***maximum density line*** represents the densest *possible* gradation for a given maximum aggregate size - is just a reference line.

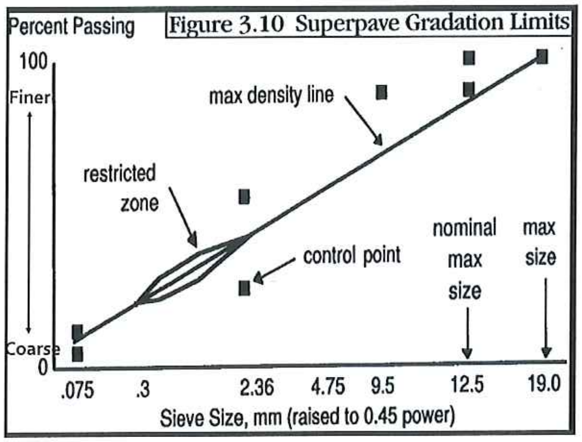


Figure 3.10 Superpave Gradation Limits

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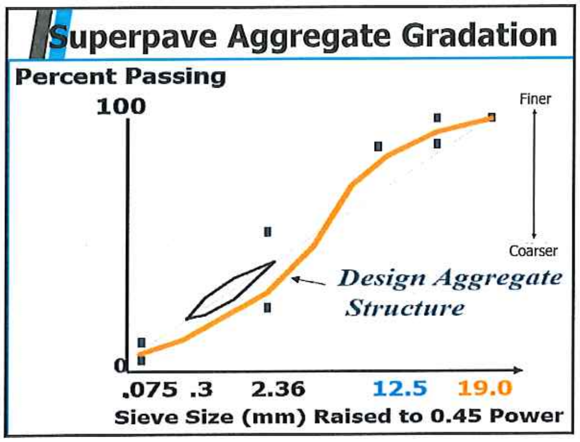

Superpave Aggregate Gradation

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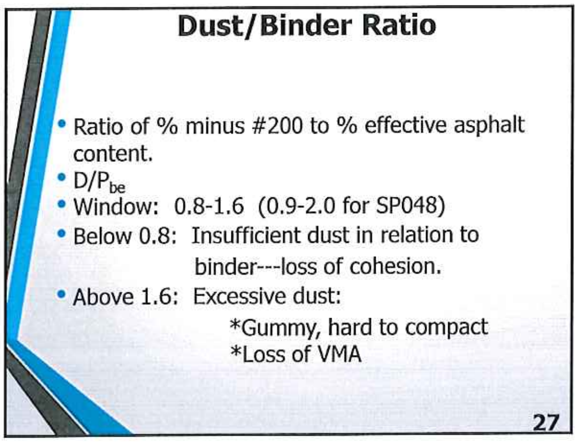

Dust/Binder Ratio

- Ratio of % minus #200 to % effective asphalt content.
- D/P_{be}
- Window: 0.8-1.6 (0.9-2.0 for SP048)
- Below 0.8: Insufficient dust in relation to binder---loss of cohesion.
- Above 1.6: Excessive dust:
  - *Gummy, hard to compact
  - *Loss of VMA

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Bag House Dust

- Baghouse dust return should be closely regulated to:
  - Preserve proper dust/asphalt ratio
  - Preserve proper VMA

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VMA

- "Voids in the Mineral Aggregate"
- Space between the aggregate particles
- Contains binder and air voids
- Must have sufficient VMA to accommodate proper binder and air void contents

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To Increase VMA

"Use a More Angular Sand"

- More angular aggregate will provide more voids for a given gradation
- Replace some natural sand with manufactured sand

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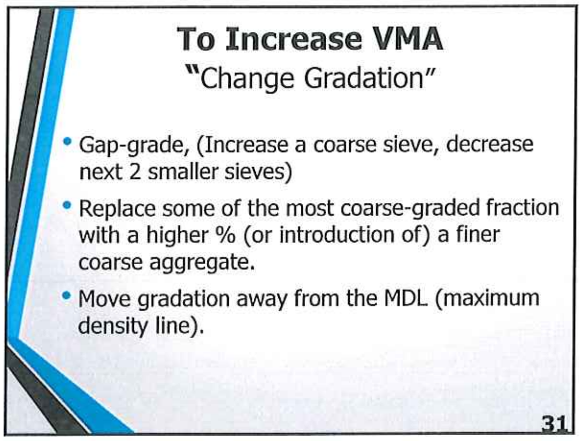
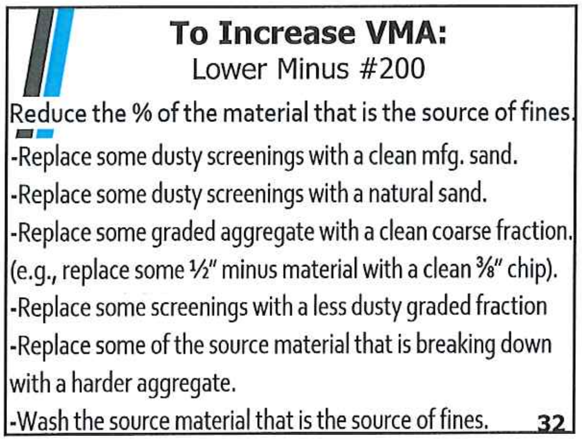


To Increase VMA
"Change Gradation"

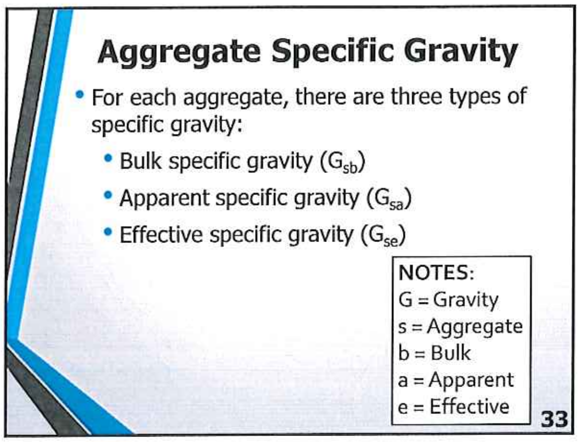
- Gap-grade, (Increase a coarse sieve, decrease next 2 smaller sieves)
- Replace some of the most coarse-graded fraction with a higher % (or introduction of) a finer coarse aggregate.
- Move gradation away from the MDL (maximum density line).



To Increase VMA:
Lower Minus #200

Reduce the % of the material that is the source of fines.

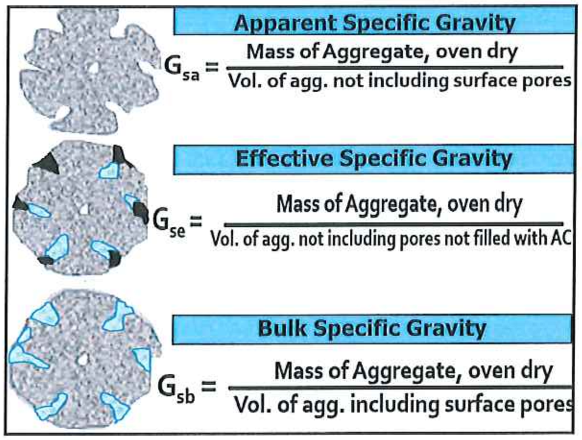
-Replace some dusty screenings with a clean mfg. sand.
-Replace some dusty screenings with a natural sand.
-Replace some graded aggregate with a clean coarse fraction.
(e.g., replace some ½" minus material with a clean ⅜" chip).
-Replace some screenings with a less dusty graded fraction
-Replace some of the source material that is breaking down with a harder aggregate.
-Wash the source material that is the source of fines.



Aggregate Specific Gravity

- For each aggregate, there are three types of specific gravity:
  - Bulk specific gravity (G_{sb})
  - Apparent specific gravity (G_{sa})
  - Effective specific gravity (G_{se})

NOTES:
G = Gravity
s = Aggregate
b = Bulk
a = Apparent
e = Effective



Apparent Specific Gravity

$$G_{sa} = \frac{\text{Mass of Aggregate, oven dry}}{\text{Vol. of agg. not including surface pores}}$$

Effective Specific Gravity

$$G_{se} = \frac{\text{Mass of Aggregate, oven dry}}{\text{Vol. of agg. not including pores not filled with AC}}$$

Bulk Specific Gravity

$$G_{sb} = \frac{\text{Mass of Aggregate, oven dry}}{\text{Vol. of agg. including surface pores}}$$

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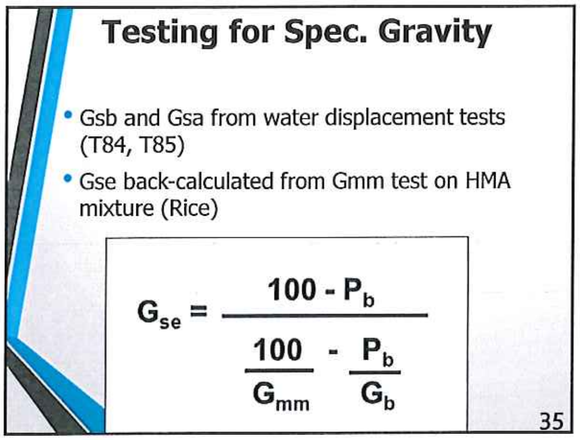

Testing for Spec. Gravity

- Gsb and Gsa from water displacement tests (T84, T85)
- Gse back-calculated from Gmm test on HMA mixture (Rice)

$$G_{se} = \frac{100 - P_b}{\dfrac{100}{G_{mm}} - \dfrac{P_b}{G_b}}$$

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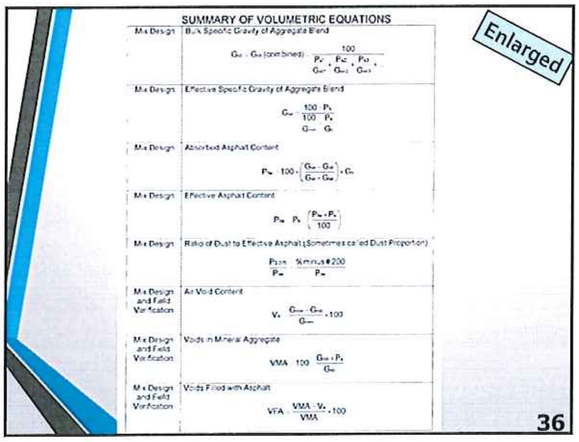

Enlarged

SUMMARY OF VOLUMETRIC EQUATIONS

Mix Design	Bulk Specific Gravity of Aggregate Blend
Mix Design	Effective Specific Gravity of Aggregate Blend
Mix Design	Absorbed Asphalt Content
Mix Design	Effective Asphalt Content
Mix Design	Ratio of Dust to Effective Asphalt (Sometimes called Dust Proportion)
Mix Design and Field Verification	Air Void Content
Mix Design and Field Verification	Voids in Mineral Aggregate
Mix Design and Field Verification	Voids Filled with Asphalt

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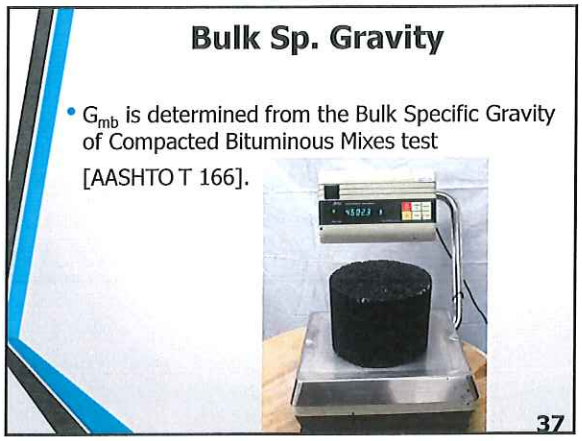
SUMMARY OF VOLUMETRIC EQUATIONS

Mix Design	Bulk Specific Gravity of Aggregate Blend $G_{sb} = G_{sb}\,(\text{combined}) = \dfrac{100}{\dfrac{P_{s1}}{G_{sb1}} + \dfrac{P_{s2}}{G_{sb2}} + \dfrac{P_{s3}}{G_{sb3}} + \ldots}$
Mix Design	Effective Specific Gravity of Aggregate Blend $G_{se} = \dfrac{100 - P_b}{\dfrac{100}{G_{mm}} - \dfrac{P_b}{G_b}}$
Mix Design	Absorbed Asphalt Content $P_{ba} = 100 \times \left(\dfrac{G_{se} - G_{sb}}{G_{sb} \times G_{se}} \right) \times G_b$
Mix Design	Effective Asphalt Content $P_{be} = P_b - \left(\dfrac{P_{ba} \times P_s}{100} \right)$
Mix Design	Ratio of Dust to Effective Asphalt (Sometimes called Dust Proportion) $\dfrac{P_{0.075}}{P_{be}} = \dfrac{\%\text{minus}\#200}{P_{be}}$
Mix Design and Field Verification	Air Void Content $V_a = \dfrac{G_{mm} - G_{mb}}{G_{mm}} \times 100$
Mix Design and Field Verification	Voids in Mineral Aggregate $VMA = 100 - \dfrac{G_{mb} \times P_s}{G_{sb}}$
Mix Design and Field Verification	Voids Filled with Asphalt $VFA = \dfrac{VMA - V_a}{VMA} \times 100$



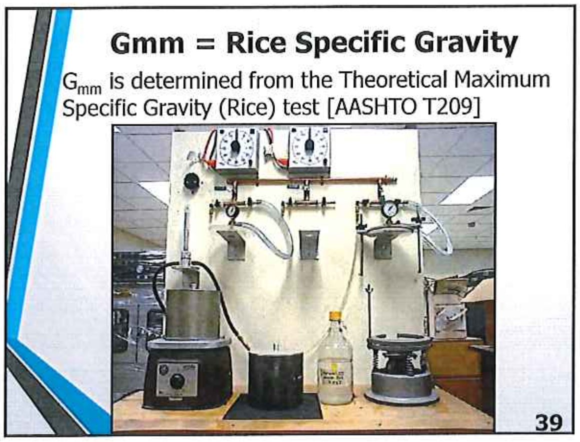
Bulk Sp. Gravity

- G_{mb} is determined from the Bulk Specific Gravity of Compacted Bituminous Mixes test [AASHTO T 166].

Air Voids

$$V_a = \left(\frac{G_{mm} - G_{mb}}{G_{mm}} \right) \times 100$$

- V_a = % Air Voids
- ***G_{mm}=maximum specific gravity of the Voidless mix (Rice sp gravity).***
- G_{mb}= sp. gravity of the compacted mix.



Gmm = Rice Specific Gravity

G_{mm} is determined from the Theoretical Maximum Specific Gravity (Rice) test [AASHTO T209]

9 Steps to find Aggregate Structure and Optimum Target AC%

1. Choose 3 or more trial aggregate gradations based on experience.

2. Estimate the required "initial" binder content based on experience or standard procedure.

3. Mix aggregate and binder. Condition for 2 hours at the compaction temperature. This allows binder to be absorbed.

4. Compact duplicate mixture specimens of each trial gradation at the initial binder content using the gyratory compactor.

- During design, specimens are compacted using the gyratory compactor. The number of gyrations applied is a function of design traffic level.

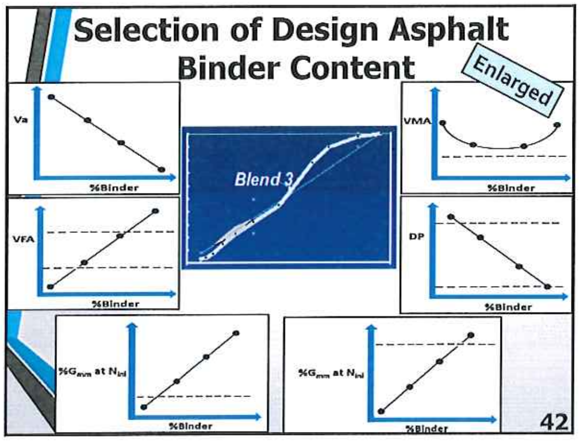
5. Measure compacted puck specific gravity.

6. Run Rice for maximum specific gravity (Gmm).

7. Calculate volumetrics (VMA, VFA, air voids) for each trial blend.

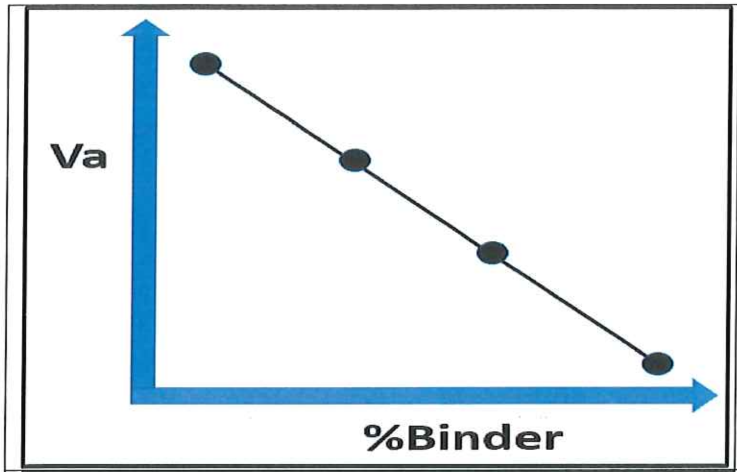
8. At N_{des} adjust (calculate) % binder to achieve V_a=4.0%. Calculate what VMA, VFA, and dust/effective asphalt would be.

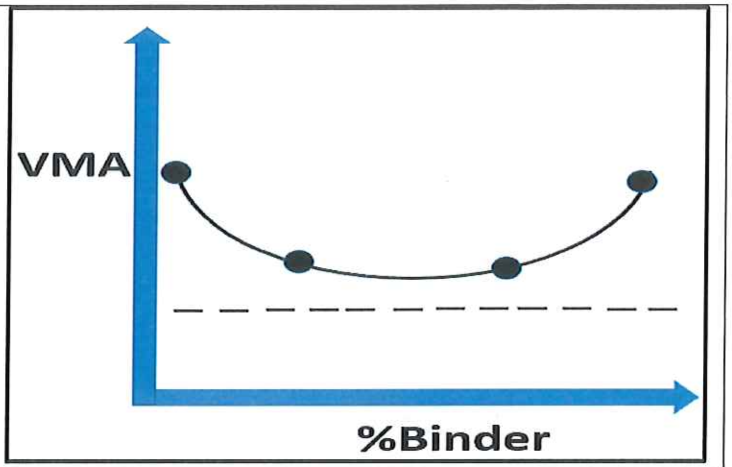
9. compared to criteria. Choose blend that best meets criteria, economy, and chance of success.

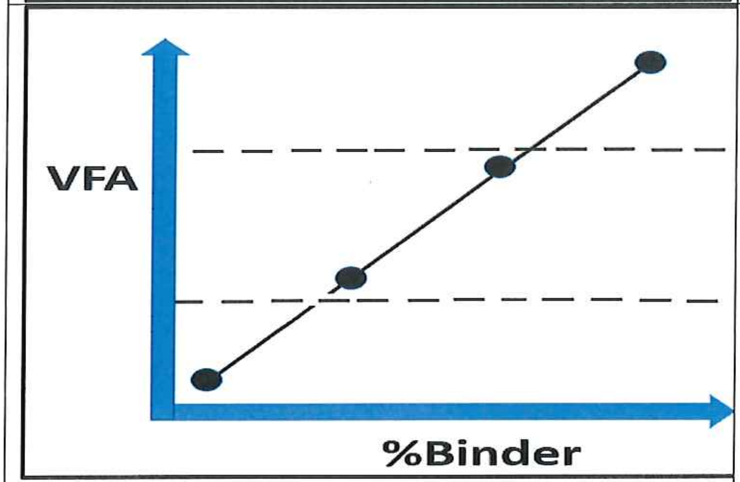


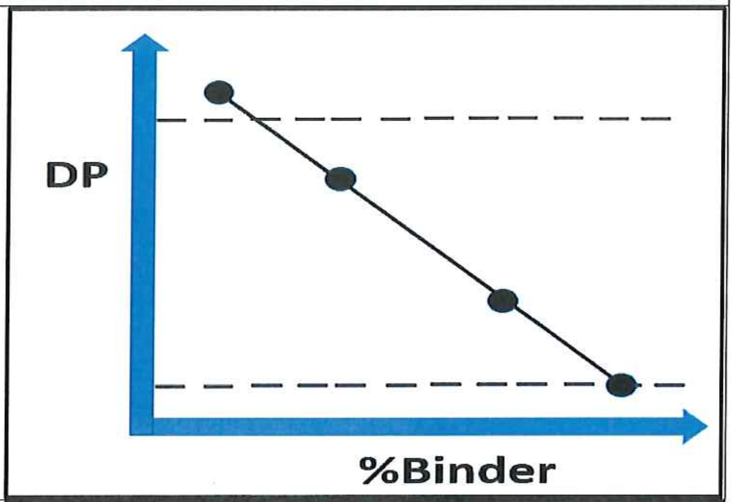
Selection of Design Asphalt Binder Content

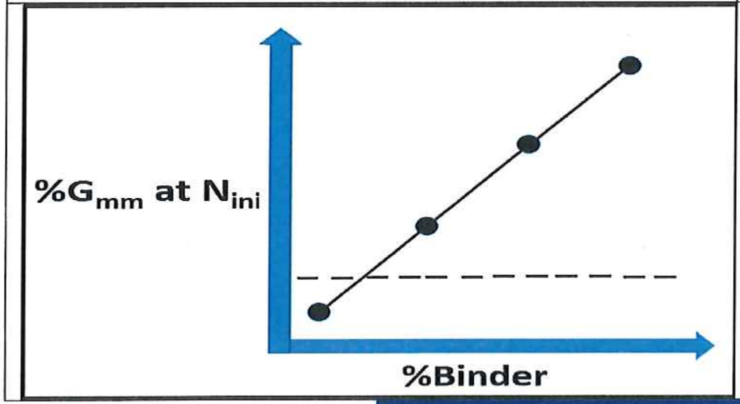
Selection of Design Asphalt Binder Content

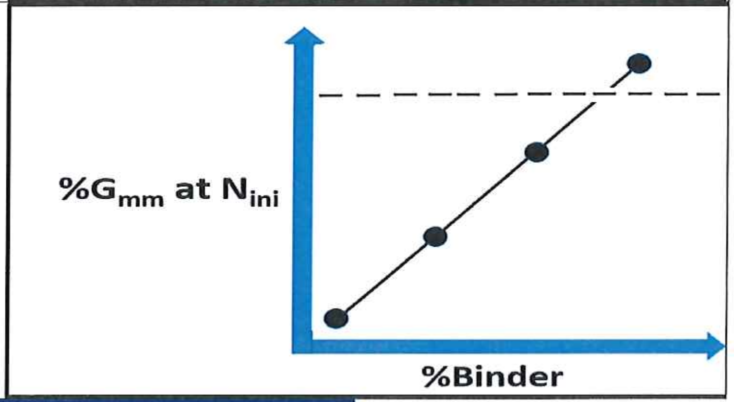


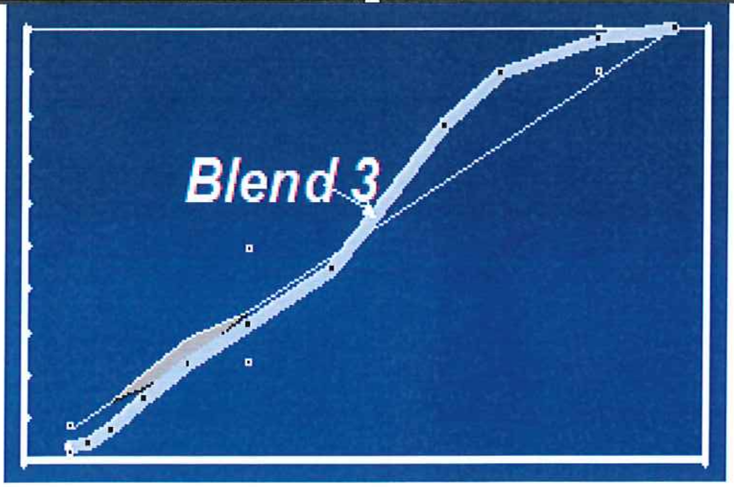


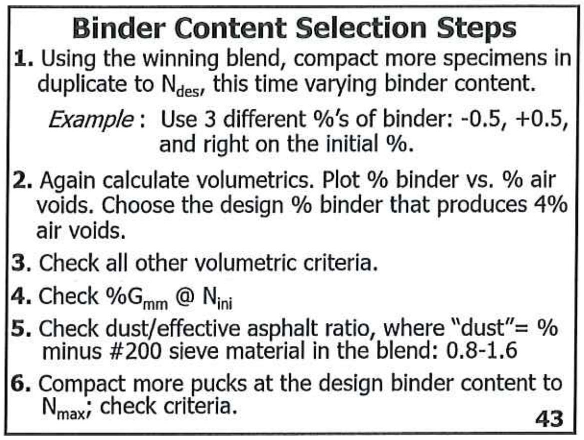










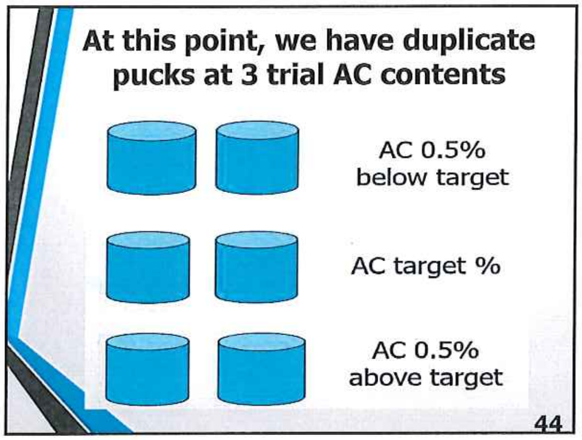


Binder Content Selection Steps

1. Using the winning blend, compact more specimens in duplicate to N_{des}, this time varying binder content.

   Example : Use 3 different %'s of binder: -0.5, +0.5, and right on the initial %.

2. Again calculate volumetrics. Plot % binder vs. % air voids. Choose the design % binder that produces 4% air voids.
3. Check all other volumetric criteria.
4. Check $\%G_{mm}$ @ N_{ini}
5. Check dust/effective asphalt ratio, where "dust"= % minus #200 sieve material in the blend: 0.8-1.6
6. Compact more pucks at the design binder content to N_{max}; check criteria.

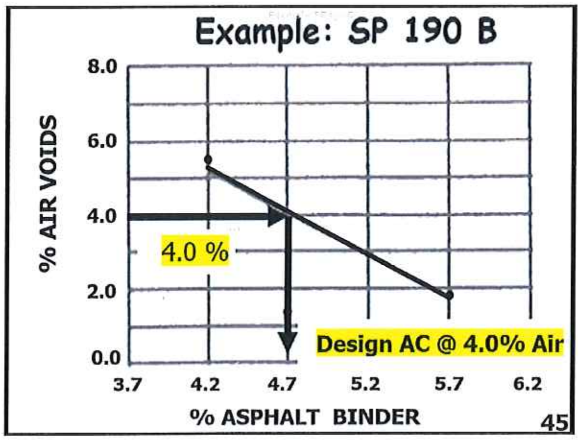


At this point, we have duplicate pucks at 3 trial AC contents

AC 0.5%
below target

AC target %

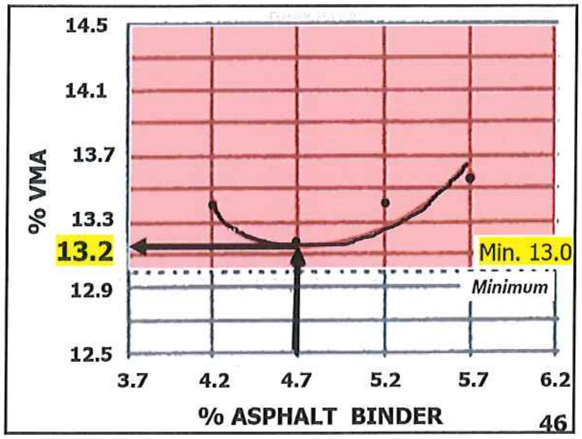
AC 0.5%
above target



Example: SP 190 B

4.0 %

Design AC @ 4.0% Air



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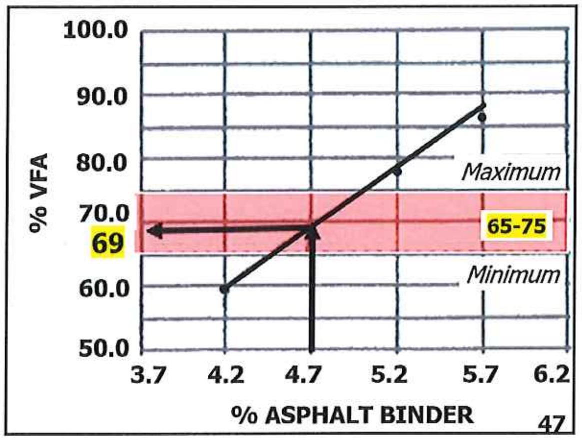

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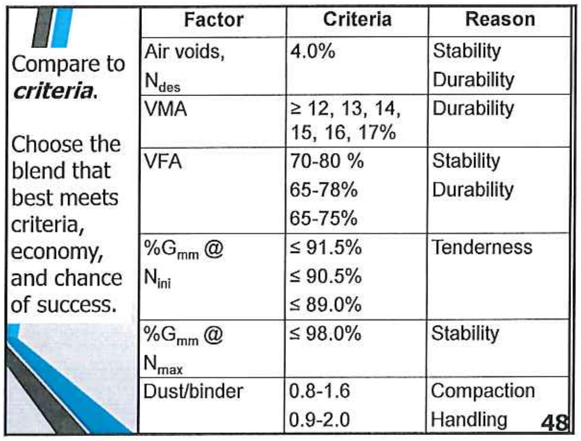


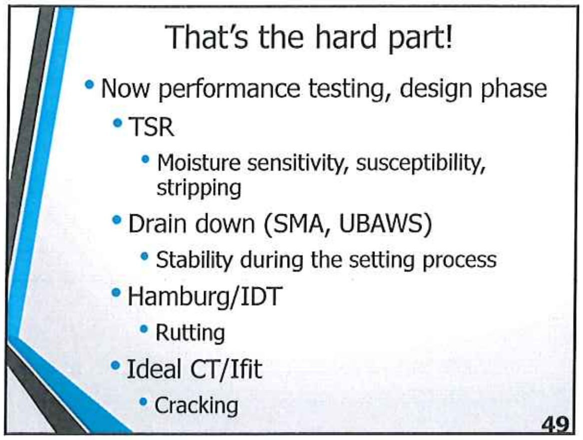
Compare to ***criteria***.

Choose the blend that best meets criteria, economy, and chance of success.

Factor	Criteria	Reason
Air voids, N_{des}	4.0%	Stability Durability
VMA	≥ 12, 13, 14, 15, 16, 17%	Durability
VFA	70-80 % 65-78% 65-75%	Stability Durability
$\%G_{mm}$ @ N_{ini}	≤ 91.5% ≤ 90.5% ≤ 89.0%	Tenderness
$\%G_{mm}$ @ N_{max}	≤ 98.0%	Stability
Dust/binder	0.8-1.6 0.9-2.0	Compaction Handling

48

48



That's the hard part!

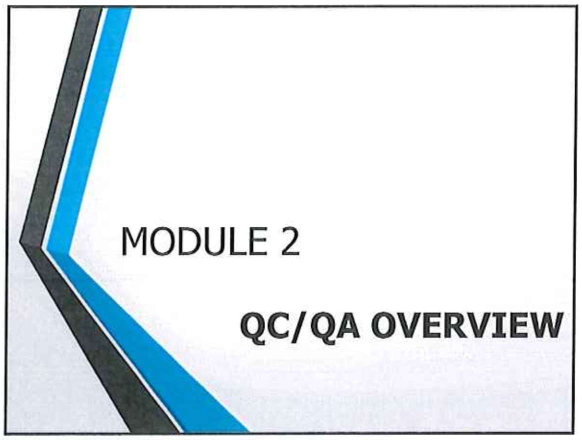
- Now performance testing, design phase
  - TSR
    - Moisture sensitivity, susceptibility, stripping
  - Drain down (SMA, UBAWS)
    - Stability during the setting process
  - Hamburg/IDT
    - Rutting
  - Ideal CT/Ifit
    - Cracking

TAB

Module 2

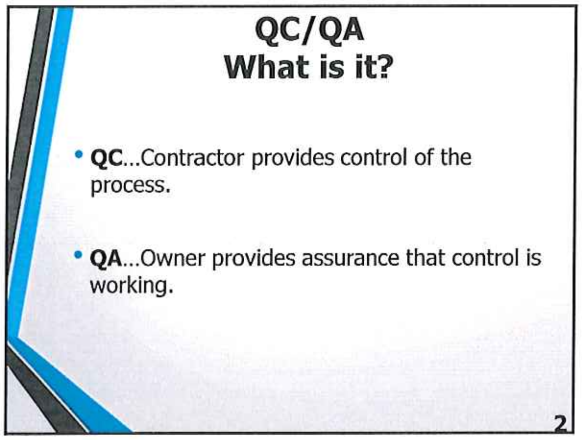
Module 2

QC/QA
Overview



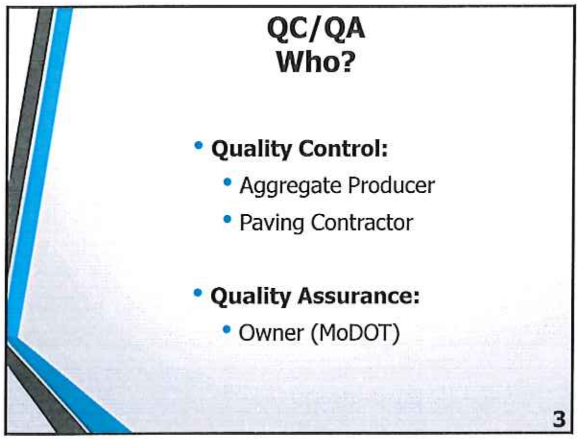
MODULE 2

QC/QA OVERVIEW



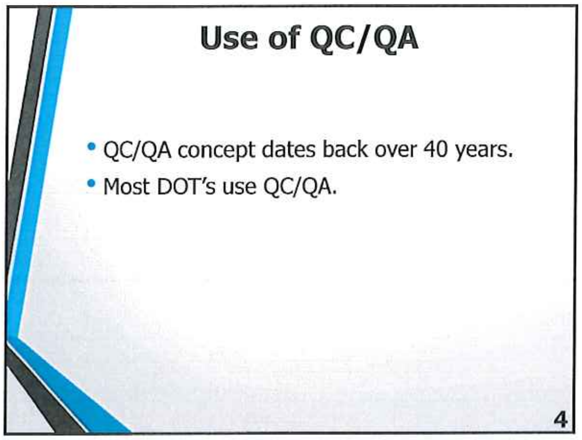
QC/QA
What is it?

- **QC**...Contractor provides control of the process.
- **QA**...Owner provides assurance that control is working.



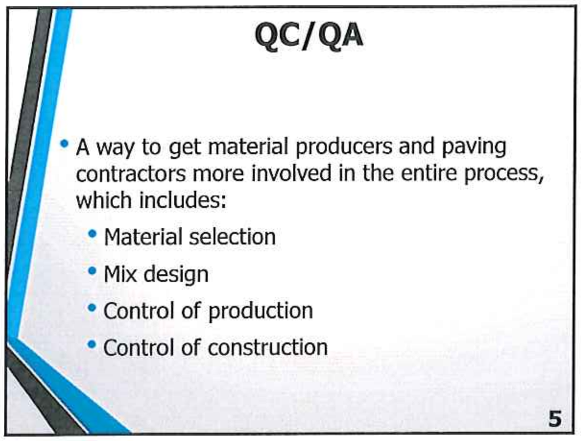
QC/QA
Who?

- **Quality Control:**
  - Aggregate Producer
  - Paving Contractor
- **Quality Assurance:**
  - Owner (MoDOT)



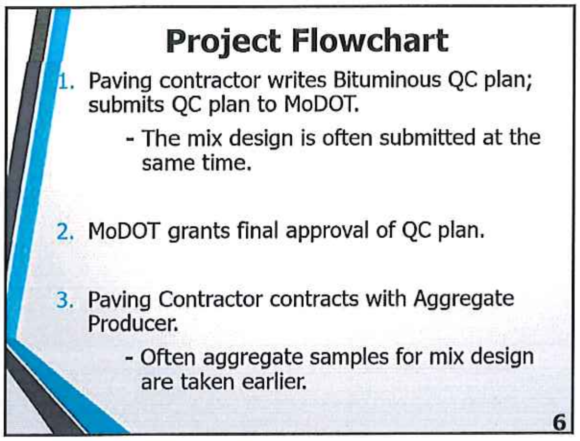
Use of QC/QA

- QC/QA concept dates back over 40 years.
- Most DOT's use QC/QA.



QC/QA

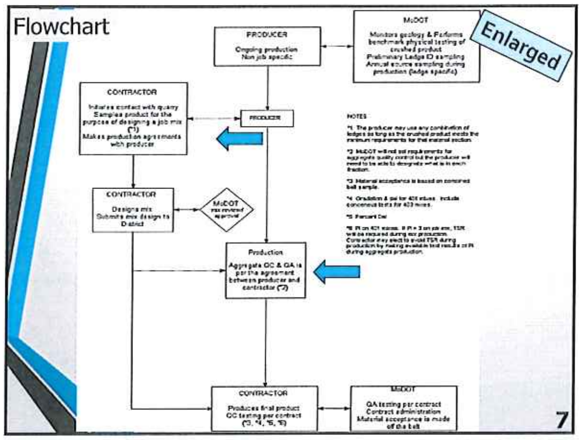
- A way to get material producers and paving contractors more involved in the entire process, which includes:
  - Material selection
  - Mix design
  - Control of production
  - Control of construction



Project Flowchart

1. Paving contractor writes Bituminous QC plan; submits QC plan to MoDOT.
   - The mix design is often submitted at the same time.
2. MoDOT grants final approval of QC plan.
3. Paving Contractor contracts with Aggregate Producer.
   - Often aggregate samples for mix design are taken earlier.

Flowchart

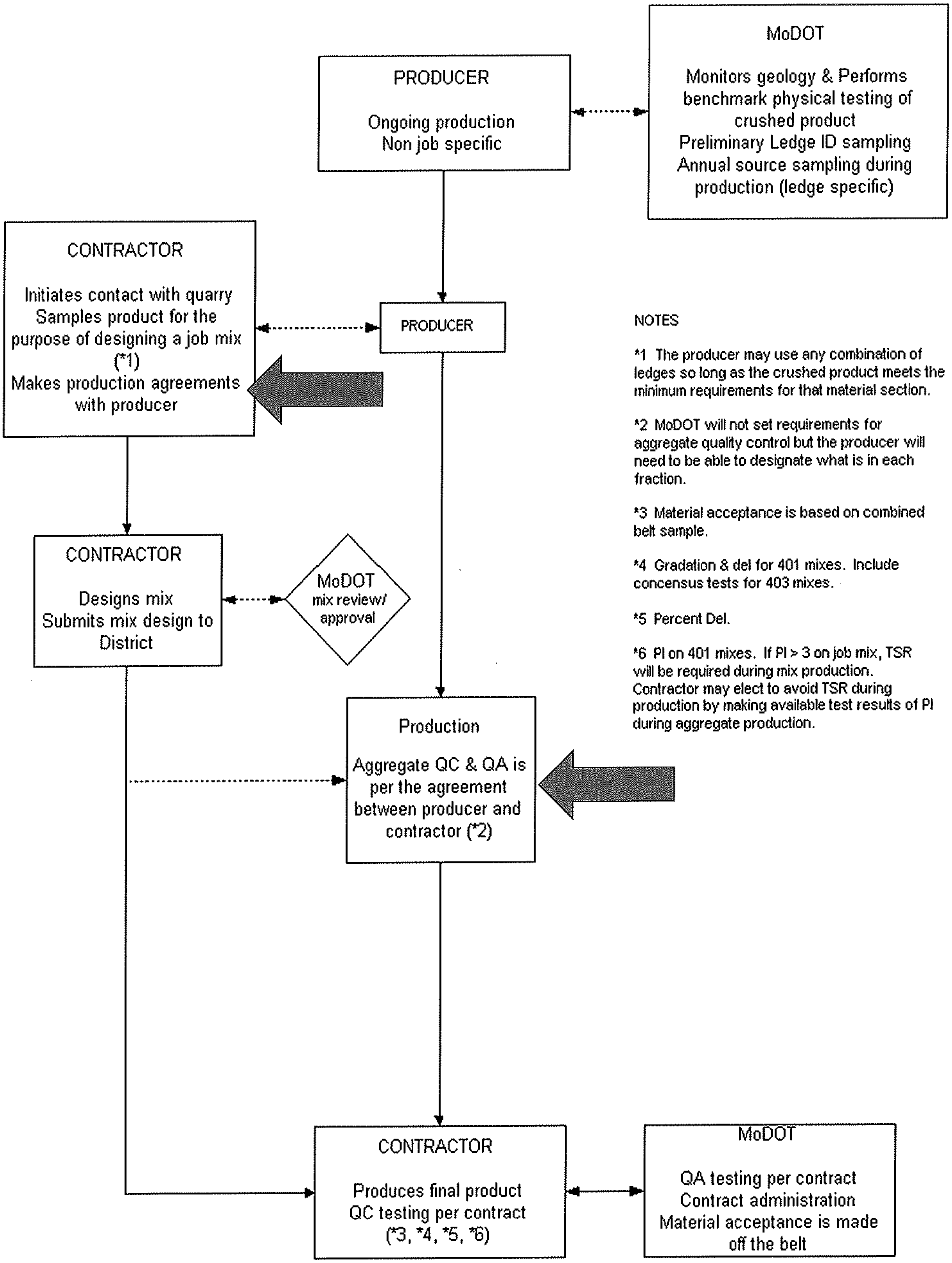


Flowchart, cont'd.

4. Paving contractor submits mix design information (Job Mix Formula = JMF) to MoDOT through the district.
5. MoDOT Field Office handles JMF approval.
6. Aggregate production begins.
   (actually, Superpave rock is more common now.)
7. Asphalt production begins.

Specification Hierarchy

- **Asphalt Mix Design Limits**
  - Limits controlling aspects of the mixture during the design phase.
    - Gradation, AC%, Dust limit, Aggregate quality, etc.
- **Production Limits**
  - Tolerances controlling production of asphalt.
    - Va, VMA, AC%, Density, Gradation, Consensus.
- **Comparison Limits**
  - Insure validity of QC/QA test results.
- **Removal Limits**
  - Specification limits requiring the removal and replacement of out of spec material.



NOTES

*1 The producer may use any combination of ledges so long as the crushed product meets the minimum requirements for that material section.

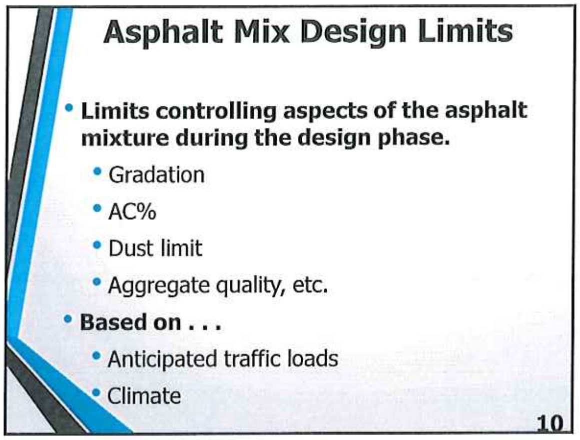
*2 MoDOT will not set requirements for aggregate quality control but the producer will need to be able to designate what is in each fraction.

*3 Material acceptance is based on combined belt sample.

*4 Gradation & del for 401 mixes. Include concensus tests for 403 mixes.

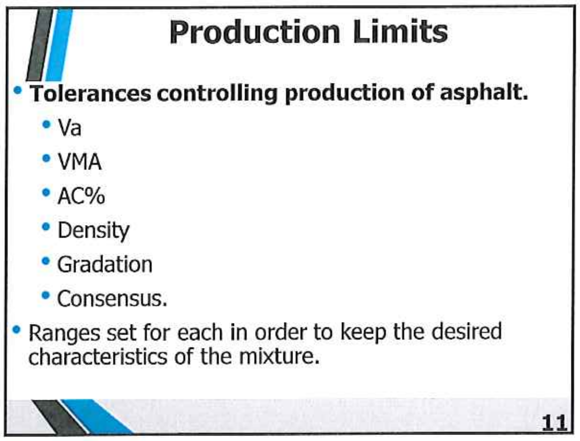
*5 Percent Del.

*6 PI on 401 mixes. If PI > 3 on job mix, TSR will be required during mix production. Contractor may elect to avoid TSR during production by making available test results of PI during aggregate production.



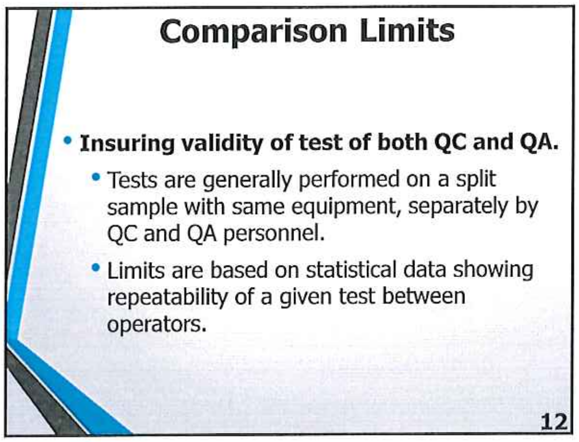
Asphalt Mix Design Limits

- **Limits controlling aspects of the asphalt mixture during the design phase.**
  - Gradation
  - AC%
  - Dust limit
  - Aggregate quality, etc.
- **Based on . . .**
  - Anticipated traffic loads
  - Climate



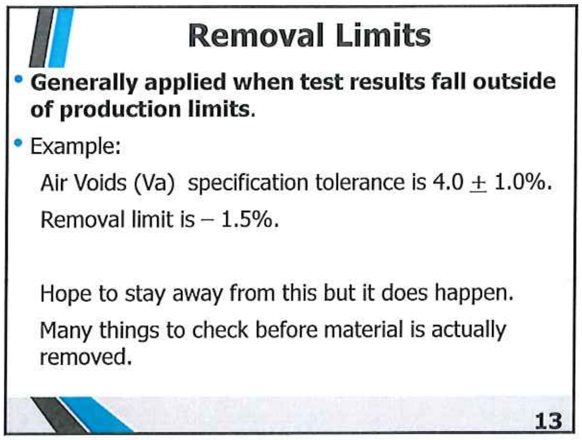
Production Limits

- **Tolerances controlling production of asphalt.**
  - Va
  - VMA
  - AC%
  - Density
  - Gradation
  - Consensus.
- Ranges set for each in order to keep the desired characteristics of the mixture.



Comparison Limits

- **Insuring validity of test of both QC and QA.**
  - Tests are generally performed on a split sample with same equipment, separately by QC and QA personnel.
  - Limits are based on statistical data showing repeatability of a given test between operators.



Removal Limits

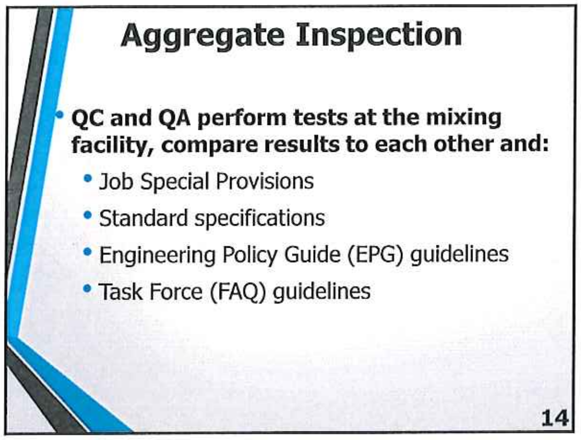
- **Generally applied when test results fall outside of production limits.**
- Example:

Air Voids (Va) specification tolerance is 4.0 ± 1.0%.

Removal limit is – 1.5%.

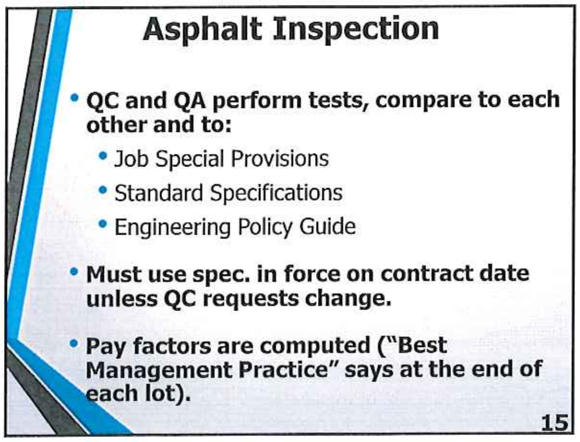
Hope to stay away from this but it does happen.

Many things to check before material is actually removed.



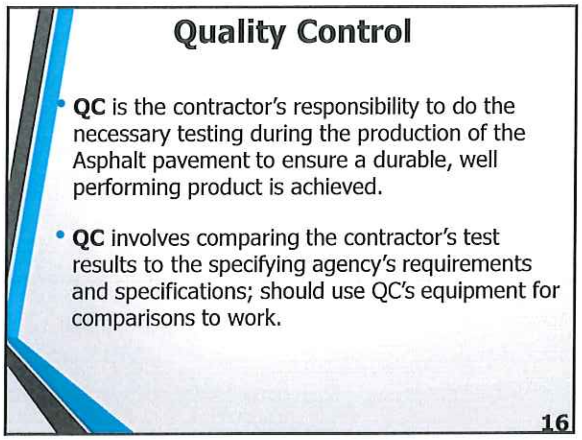
Aggregate Inspection

- **QC and QA perform tests at the mixing facility, compare results to each other and:**
  - Job Special Provisions
  - Standard specifications
  - Engineering Policy Guide (EPG) guidelines
  - Task Force (FAQ) guidelines



Asphalt Inspection

- **QC and QA perform tests, compare to each other and to:**
  - Job Special Provisions
  - Standard Specifications
  - Engineering Policy Guide
- **Must use spec. in force on contract date unless QC requests change.**
- **Pay factors are computed ("Best Management Practice" says at the end of each lot).**

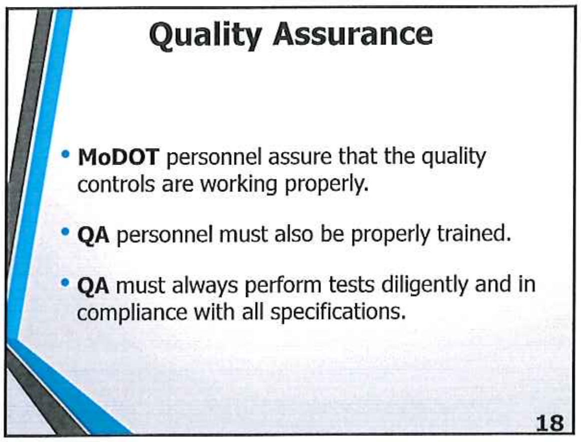


Quality Control

- **QC** is the contractor's responsibility to do the necessary testing during the production of the Asphalt pavement to ensure a durable, well performing product is achieved.
- **QC** involves comparing the contractor's test results to the specifying agency's requirements and specifications; should use QC's equipment for comparisons to work.

Quality Control

- The **contractor** provides control of all steps of the process: aggregate, binder, additives, mix design, asphalt production, and compaction.
- The **contractor** is responsible for providing properly trained personnel and testing equipment.
- **QC** must always perform tests diligently and in compliance with all specifications.



Quality Assurance

- **MoDOT** personnel assure that the quality controls are working properly.
- **QA** personnel must also be properly trained.
- **QA** must always perform tests diligently and in compliance with all specifications.

Asphalt Quality Control Plans

- Prior to the approval of the trial mix design the Asphalt contractor will submit a QC Plan to the District which adds traffic and then sends to MoDOT Construction & Materials in Jefferson City.
- Generally, a "Short Form" QC plan is used once a companies' standard practices are established.

QC PLAN

- Company name
- Contract name
- Contract #
- Job #
- Route
- Contractor rep. in charge of QC plus contact information.
- List Personnel conducting acceptance testing.
- ***Lot & sublot sizes and how they will be designated.***
- Name, address, and phone number of the third-party testing lab that will be used for dispute resolution.

QC Plan cont.

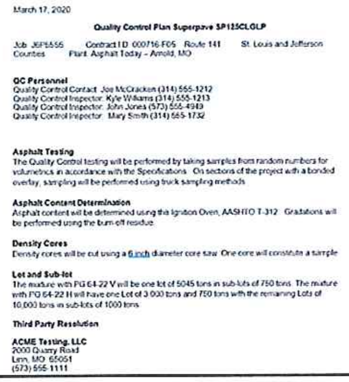
- Information on which method will be used for %AC determination
- Where the gradation will be sampled
- Size and number of cores per sample

Notes

- Lot sizes can be different for the same project. (e.g., 3000 tons first lot, 10,000 thereafter).
- Third party cannot be the one that performed the mix design.

Example QC Plan

Enlarged



March 17, 2020

Quality Control Plan Superpave SP125CLGLP

Job J6P5556 Contract I.D. 000716-F05 Route 141 St. Louis and Jefferson Counties Plant: Asphalt Today – Arnold, MO

QC Personnel
Quality Control Contact: Joe McCracken (314) 555-1212
Quality Control Inspector: Kyle Williams (314) 555-1213
Quality Control Inspector: John Jones (573) 555-4949
Quality Control Inspector: Mary Smith (314) 555-1732

Asphalt Testing
The Quality Control testing will be performed by taking samples from random numbers for volumetrics in accordance with the Specifications. On sections of the project with a bonded overlay, sampling will be performed using truck sampling methods.

Asphalt Content Determination
Asphalt content will be determined using the Ignition Oven, AASHTO T-312. Gradations will be performed using the burn-off residue.

Density Cores
Density cores will be cut using a 6 inch diameter core saw. One core will constitute a sample.

Lot and Sub-lot
The mixture with PG 64-22 V will be one lot of 5045 tons in sub-lots of 750 tons. The mixture with PG 64-22 H will have one Lot of 3,000 tons and 750 tons with the remaining Lots of 10,000 tons in sub-lots of 1000 tons.

Third Party Resolution

ACME Testing, LLC
2000 Quarry Road
Linn, MO 65051
(573) 555-1111

RECORD KEEPING
Samples

- Contractor samples retained for the engineer:
  - clean covered containers
  - readily accessible
  - ***ID'd: Job mix no. , sampler, sample location, time & date sampled***
  - stored until test results accepted)
- QC gradation samples: retain the portion of the QC sample not tested after reducing the sample to testing size.

****All samples labeled***

March 17, 2020

Quality Control Plan Superpave SP125CLGLP

Job: J6P5555 Contract I.D. 000716-F05 Route 141 St. Louis and Jefferson Counties Plant: Asphalt Today – Arnold, MO

QC Personnel

Quality Control Contact: Joe McCracken (314) 555-1212
Quality Control Inspector: Kyle Williams (314) 555-1213
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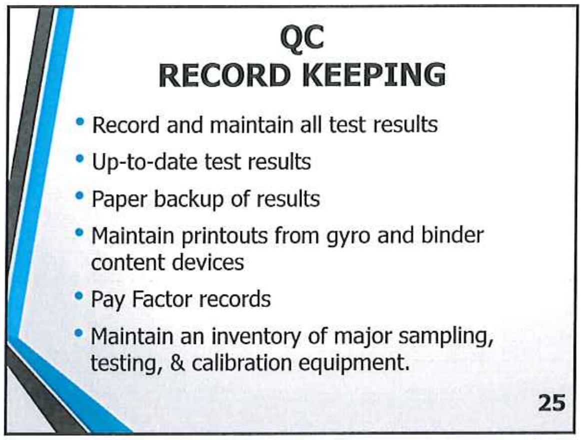
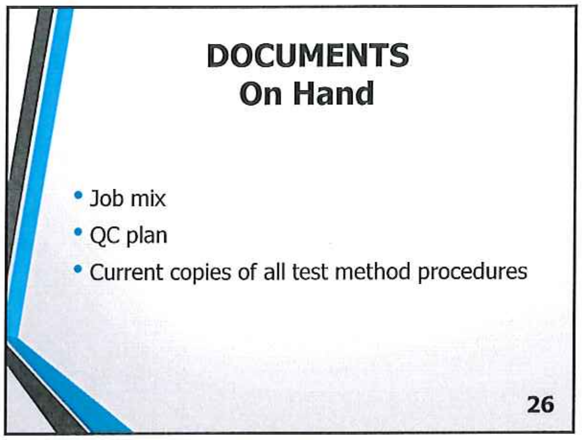


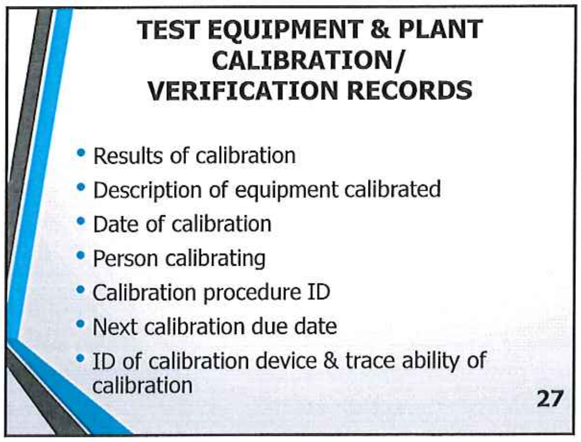
QC
RECORD KEEPING

- Record and maintain all test results
- Up-to-date test results
- Paper backup of results
- Maintain printouts from gyro and binder content devices
- Pay Factor records
- Maintain an inventory of major sampling, testing, & calibration equipment.



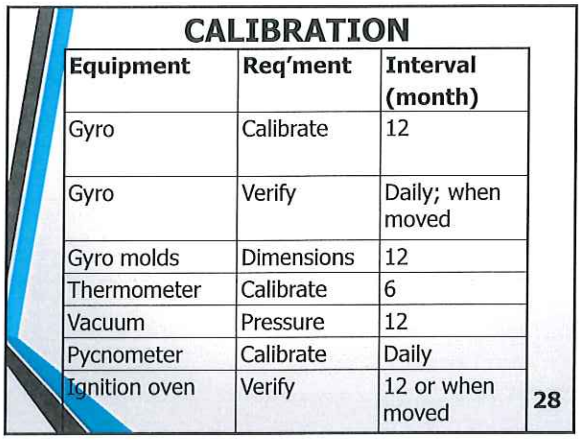
DOCUMENTS
On Hand

- Job mix
- QC plan
- Current copies of all test method procedures



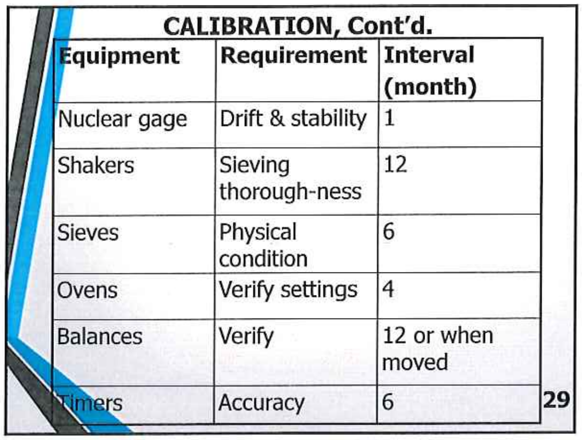
TEST EQUIPMENT & PLANT CALIBRATION/ VERIFICATION RECORDS

- Results of calibration
- Description of equipment calibrated
- Date of calibration
- Person calibrating
- Calibration procedure ID
- Next calibration due date
- ID of calibration device & trace ability of calibration



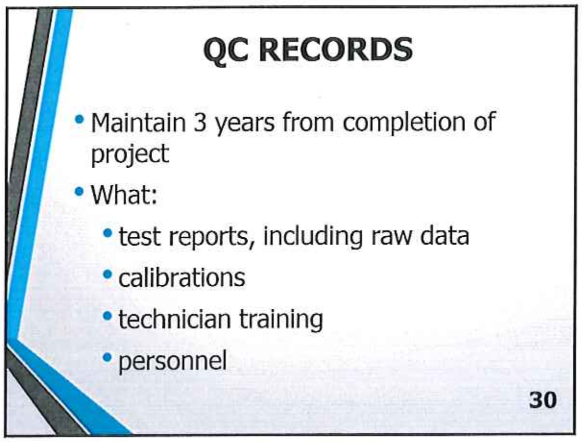
CALIBRATION

Equipment	Req'ment	Interval (month)
Gyro	Calibrate	12
Gyro	Verify	Daily; when moved
Gyro molds	Dimensions	12
Thermometer	Calibrate	6
Vacuum	Pressure	12
Pycnometer	Calibrate	Daily
Ignition oven	Verify	12 or when moved



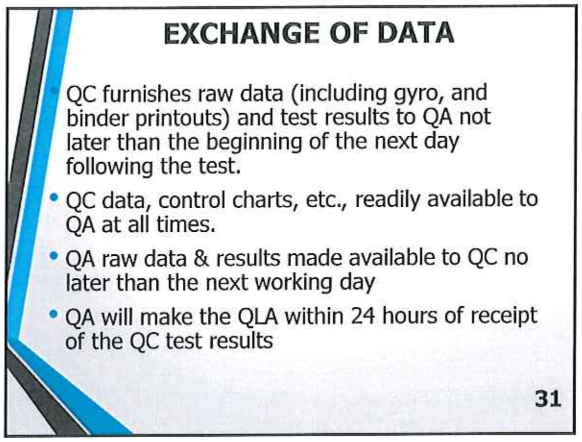
CALIBRATION, Cont'd.

Equipment	Requirement	Interval (month)
Nuclear gage	Drift & stability	1
Shakers	Sieving thorough-ness	12
Sieves	Physical condition	6
Ovens	Verify settings	4
Balances	Verify	12 or when moved
Timers	Accuracy	6



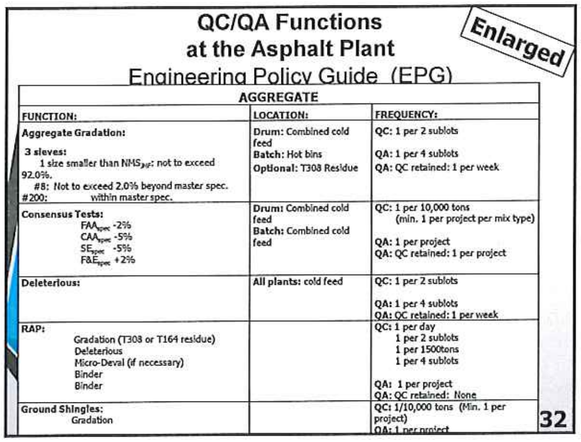
QC RECORDS

- Maintain 3 years from completion of project
- What:
  - test reports, including raw data
  - calibrations
  - technician training
  - personnel



EXCHANGE OF DATA

- QC furnishes raw data (including gyro, and binder printouts) and test results to QA not later than the beginning of the next day following the test.
- QC data, control charts, etc., readily available to QA at all times.
- QA raw data & results made available to QC no later than the next working day
- QA will make the QLA within 24 hours of receipt of the QC test results

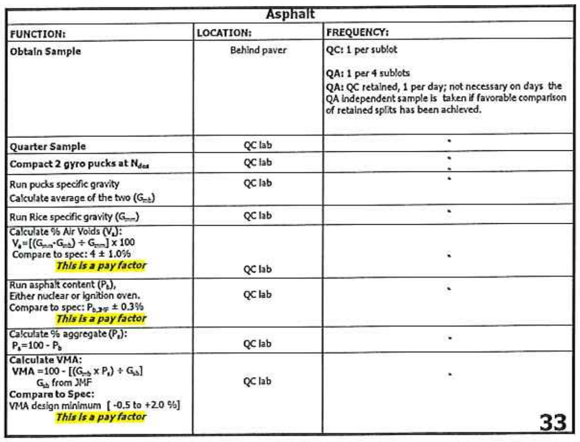


QC/QA Functions at the Asphalt Plant

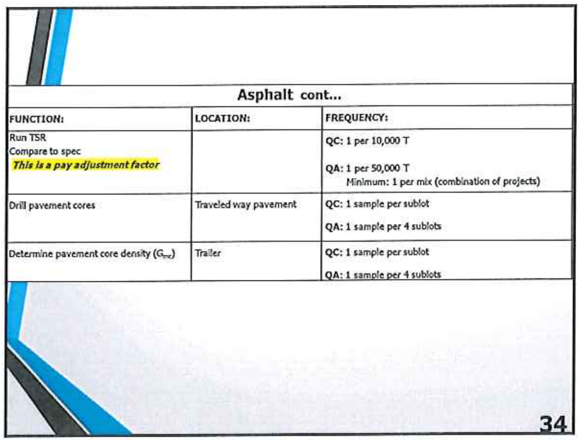
Engineering Policy Guide (EPG)

Enlarged

AGGREGATE		
FUNCTION:	**LOCATION:**	**FREQUENCY:**
Aggregate Gradation: **3 sieves:** 1 size smaller than NMS_{JMF}: not to exceed 92.0%. #8: Not to exceed 2.0% beyond master spec. #200: within master spec.	**Drum:** Combined cold feed **Batch:** Hot bins **Optional:** T308 Residue	**QC:** 1 per 2 sublots **QA:** 1 per 4 sublots **QA:** QC retained: 1 per week
Consensus Tests: FAA_{spec} -2% CAA_{spec} -5% SE_{spec} -5% $F\&E_{spec}$ +2%	**Drum:** Combined cold feed **Batch:** Combined cold feed	**QC:** 1 per 10,000 tons (min. 1 per project per mix type) **QA:** 1 per project **QA:** QC retained: 1 per project
Deleterious:	**All plants:** cold feed	**QC:** 1 per 2 sublots **QA:** 1 per 4 sublots **QA:** QC retained: 1 per week
RAP: Gradation (T308 or T164 residue) Deleterious Micro-Deval (if necessary) Binder Binder		**QC:** 1 per day 1 per 2 sublots 1 per 1500tons 1 per 4 sublots **QA:** 1 per project **QA:** QC retained: None
Ground Shingles: Gradation		**QC:** 1/10,000 tons (Min. 1 per project) **QA:** 1 per project

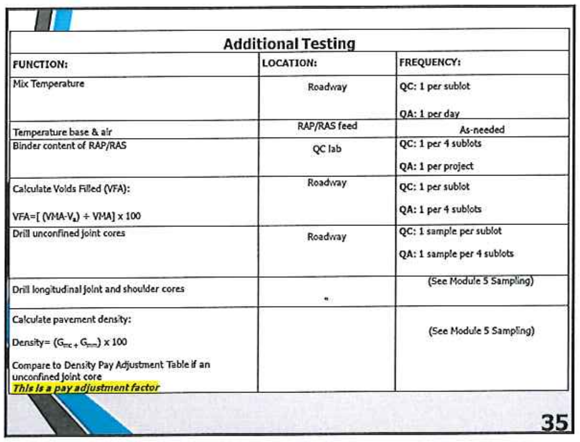


Asphalt		
FUNCTION:	**LOCATION:**	**FREQUENCY:**
Obtain Sample	Behind paver	**QC:** 1 per sublot **QA:** 1 per 4 sublots **QA:** QC retained, 1 per day; not necessary on days the QA independent sample is taken if favorable comparison of retained splits has been achieved.
Quarter Sample	QC lab	•
Compact 2 gyro pucks at N_{des}	QC lab	• •
Run pucks specific gravity Calculate average of the two (G_{mb})	QC lab	•
Run Rice specific gravity (G_{mm})	QC lab	•
Calculate % Air Voids (V_a): V_a=[(G_{mm}-G_{mb}) ÷ G_{mm}] x 100 Compare to spec: 4 ± 1.0% ***This is a pay factor***	QC lab	•
Run asphalt content (P_b), Either nuclear or ignition oven. Compare to spec: $P_{b,JMF}$ ± 0.3% ***This is a pay factor***	QC lab	•
Calculate % aggregate (P_s): P_s=100 - P_b	QC lab	•
Calculate VMA: VMA =100 - [(G_{mb} x P_s) ÷ G_{sb}] G_{sb} from JMF **Compare to Spec:** VMA design minimum [-0.5 to +2.0 %] ***This is a pay factor***	QC lab	•



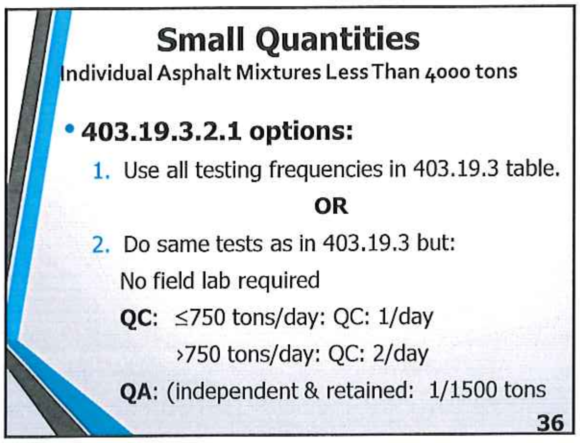
Asphalt cont…

FUNCTION:	LOCATION:	FREQUENCY:
Run TSR Compare to spec ***This is a pay adjustment factor***		**QC:** 1 per 10,000 T **QA:** 1 per 50,000 T Minimum: 1 per mix (combination of projects)
Drill pavement cores	Traveled way pavement	**QC:** 1 sample per sublot **QA:** 1 sample per 4 sublots
Determine pavement core density (G_{mc})	Trailer	**QC:** 1 sample per sublot **QA:** 1 sample per 4 sublots



Additional Testing

FUNCTION:	LOCATION:	FREQUENCY:
Mix Temperature	Roadway	**QC:** 1 per sublot **QA:** 1 per day
Temperature base & air	RAP/RAS feed	As-needed
Binder content of RAP/RAS	QC lab	**QC:** 1 per 4 sublots **QA:** 1 per project
Calculate Voids Filled (VFA): VFA=[(VMA-V_a) ÷ VMA] x 100	Roadway	**QC:** 1 per sublot **QA:** 1 per 4 sublots
Drill unconfined joint cores	Roadway	**QC:** 1 sample per sublot **QA:** 1 sample per 4 sublots
Drill longitudinal joint and shoulder cores	"	(See Module 5 Sampling)
Calculate pavement density: Density= (G_{mc} + G_{mm}) x 100 Compare to Density Pay Adjustment Table if an unconfined joint core ***This is a pay adjustment factor***		(See Module 5 Sampling)



Small Quantities

Individual Asphalt Mixtures Less Than 4000 tons

- **403.19.3.2.1 options:**
  1. Use all testing frequencies in 403.19.3 table.

     OR

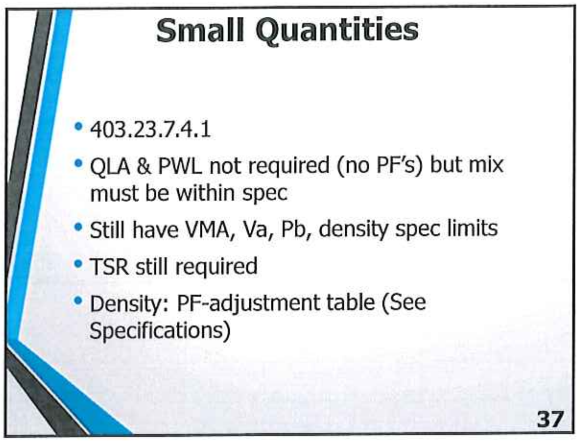
  2. Do same tests as in 403.19.3 but:

     No field lab required

     QC: ≤750 tons/day: QC: 1/day

     >750 tons/day: QC: 2/day

     QA: (independent & retained: 1/1500 tons



Small Quantities

- 403.23.7.4.1
- QLA & PWL not required (no PF's) but mix must be within spec
- Still have VMA, Va, Pb, density spec limits
- TSR still required
- Density: PF-adjustment table (See Specifications)

QC/QA Functions at the Hot Mix Plant
Engineering Policy Guide (EPG)

AGGREGATE

FUNCTION:	**LOCATION:**	**FREQUENCY:**
Aggregate Gradation: **3 sieves:** 1 size smaller than NMS_{JMF}: Not to exceed 92.0%. #8: Not to exceed 2.0% beyond master spec. #200: Within master spec.	**Drum**: Combined cold feed **Batch**: Hot bins **Optional**: T308 Residue	**QC**: 1 per 2 sublots **QA**: 1 per 4 sublots **QA**: QC retained: 1 per week
Consensus Tests: FAA_{spec} -2% CAA_{spec} -5% SE_{spec} -5% $F\&E_{spec}$ +2%	**Drum:** Combined cold feed **Batch:** Combined cold feed	**QC:** 1 per 10,000 tons (min. 1 per project per mix type) **QA:** 1 per project **QA:** QC retained: 1 per project
Deleterious:	**All plants:** cold feed	**QC:** 1 per 2 sublots **QA:** 1 per 4 sublots **QA:** QC retained: 1 per week
RAP: Gradation (T308 or T164 residue) Deleterious Micro-Deval (if necessary) Binder Binder		**QC:** 1 per day 1 per 2 sublots 1 per 1500tons 1 per 4 sublots **QA:** 1 per project **QA:** QC retained: None
Ground Shingles: Gradation		**QC:** 1/10,000 tons (Min. 1 per project) **QA:** 1 per project

HMA

FUNCTION:	**LOCATION:**	**FREQUENCY:**
Obtain Sample	Behind paver	**QC:** 1 per sublot **QA:** 1 per 4 sublots **QA:** QC retained, 1 per day; not necessary on days the QA independent sample is taken if favorable comparison of retained splits has been achieved.
Quarter Sample	QC lab	"
Compact 2 gyro pucks at N_{des}	QC lab	"
Run pucks specific gravity Calculate average of the two (G_{mb})	QC lab	"
Run Rice specific gravity (G_{mm})	QC lab	"
Calculate % Air Voids (V_a): $V_a=[(G_{mm}-G_{mb}) \div G_{mm}] \times 100$ Compare to spec: 4 ± 1.0% ***This is a pay factor***	QC lab	"
Run asphalt content (P_b), Either nuclear or ignition oven. Compare to spec: $P_{b,JMF} \pm 0.3\%$ ***This is a pay factor***	QC lab	"
Calculate % aggregate (P_s): $P_s=100 - P_b$	QC lab	"
Calculate VMA: **VMA** $=100 - [(G_{mb} \times P_s) \div G_{sb}]$ G_{sb} from JMF **Compare to Spec**: VMA design minimum [-0.5 to +2.0 %] ***This is a pay factor***	QC lab	"

HMA cont...

FUNCTION:	**LOCATION:**	**FREQUENCY:**
Run TSR Compare to spec ***This is a pay adjustment factor***		**QC**: 1 per 10,000 T **QA**: 1 per 50,000 T Minimum: 1 per mix (combination of projects)
Drill pavement cores	Traveled way pavement	**QC**: 1 sample per sublot **QA**: 1 sample per 4 sublots
Determine pavement core density (G_{mc})	Trailer	**QC**: 1 sample per sublot **QA**: 1 sample per 4 sublots

Additional Testing

FUNCTION:	**LOCATION:**	**FREQUENCY:**
Mix Temperature	Roadway	**QC**: 1 per sublot **QA**: 1 per day
Temperature base & air	RAP/RAS feed	As needed
Binder content of RAP/RAS	QC lab	**QC**: 1 per 4 sublots **QA**: 1 per project
Calculate Voids Filled (VFA): $VFA=[(VMA-V_a) \div VMA] \times 100$	Roadway	**QC**: 1 per sublot **QA**: 1 per 4 sublots
Drill unconfined joint cores	Roadway	**QC**: 1 sample per sublot **QA**: 1 sample per 4 sublots
Drill longitudinal joint and shoulder cores	Roadway	See Module 5, Sampling
Calculate pavement density: $Density= (G_{mc} \div G_{mm}) \times 100$ Compare to Density Pay Adjustment Table if an unconfined joint core ***This is a pay adjustment factor***		See Module 5, Sampling

TAB

Module 3

Module 3

Plant Operations Overview

MoDOT

MODULE 3

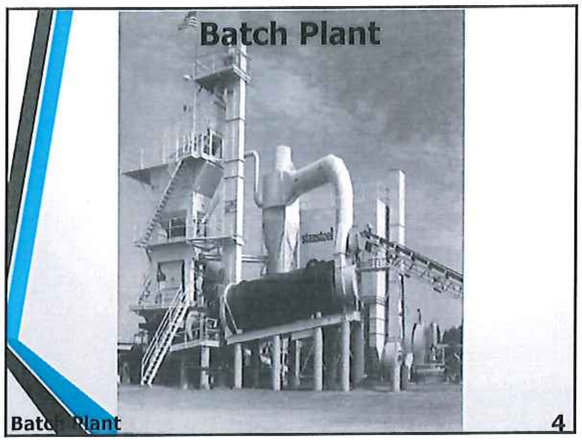
PLANT OPERATIONS OVERVIEW

Outline

- ***Plant equipment***
- Plant problems
- Aggregate sampling & testing
- RAP & RAS sampling & testing

Types of Asphalt Plants

- **Batch Plants**
- **Drum Mix Plants**



Batch Plant

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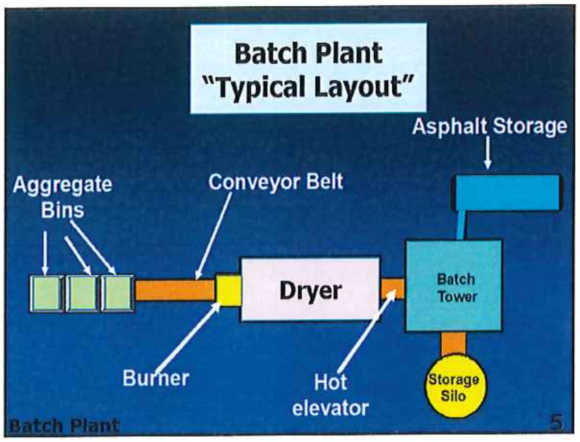


Batch Plant "Typical Layout"

Asphalt Storage

Aggregate Bins

Conveyor Belt

Dryer

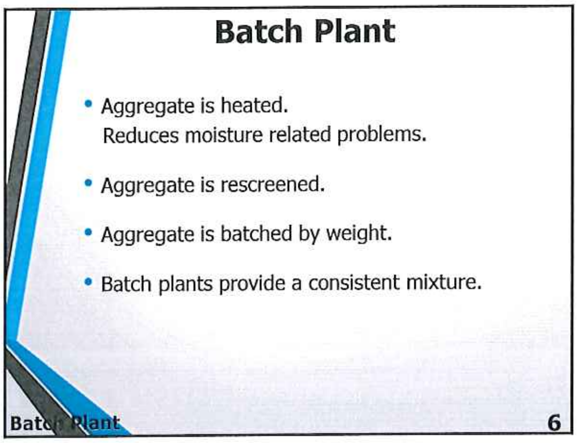
Batch Tower

Burner

Hot elevator

Storage Silo

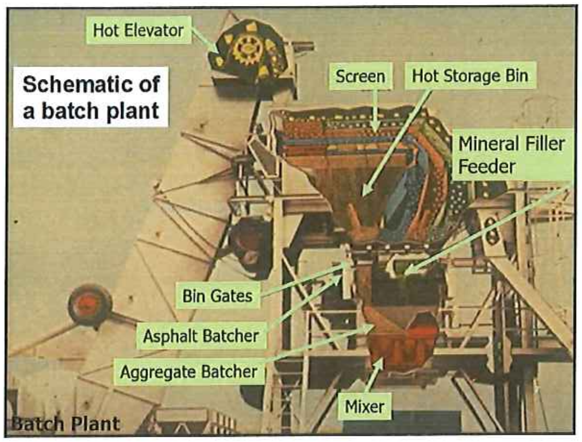
5



Batch Plant

- Aggregate is heated.
  Reduces moisture related problems.
- Aggregate is rescreened.
- Aggregate is batched by weight.
- Batch plants provide a consistent mixture.

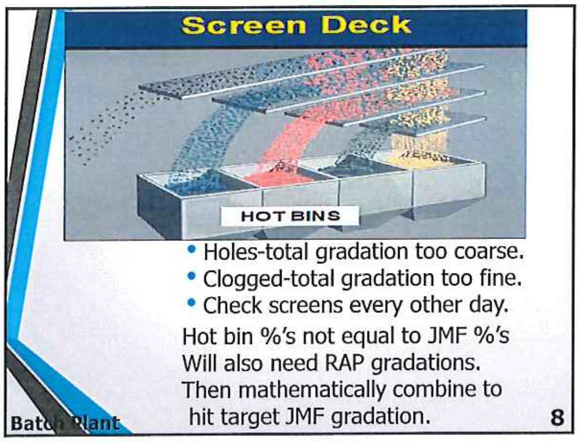
6



Schematic of a batch plant

Batch Plant

7



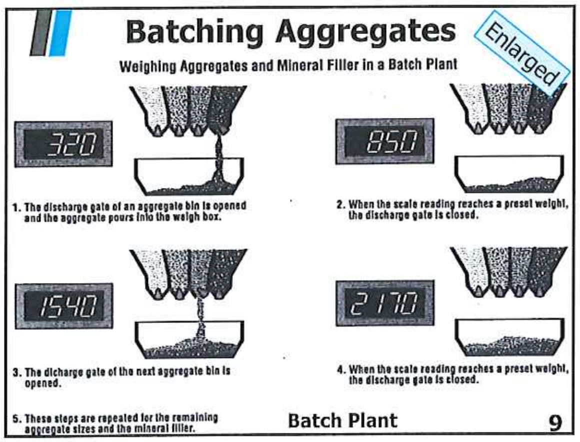
Screen Deck

- Holes-total gradation too coarse.
- Clogged-total gradation too fine.
- Check screens every other day.

Hot bin %'s not equal to JMF %'s
Will also need RAP gradations.
Then mathematically combine to hit target JMF gradation.

Batch Plant 8

8



Batching Aggregates

Enlarged

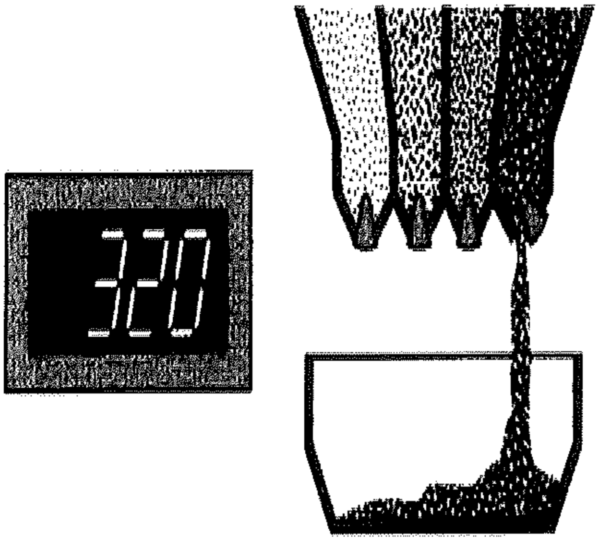
Weighing Aggregates and Mineral Filler in a Batch Plant

1. The discharge gate of an aggregate bin is opened and the aggregate pours into the weigh box.
2. When the scale reading reaches a preset weight, the discharge gate is closed.
3. The dicharge gate of the next aggregate bin is opened.
4. When the scale reading reaches a preset weight, the discharge gate is closed.
5. These steps are repeated for the remaining aggregate sizes and the mineral filler.

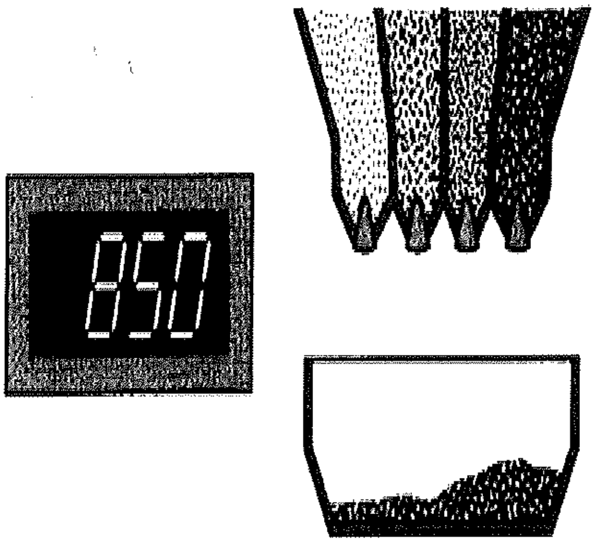
Batch Plant 9

9

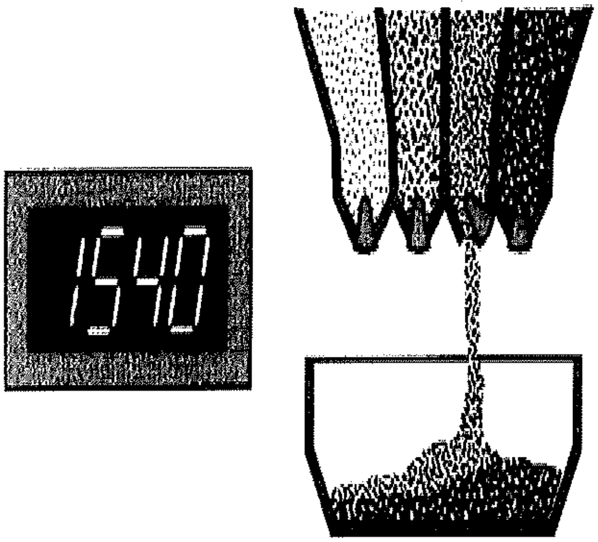
Weighing Aggregates and Mineral Filler in a Batch Plant



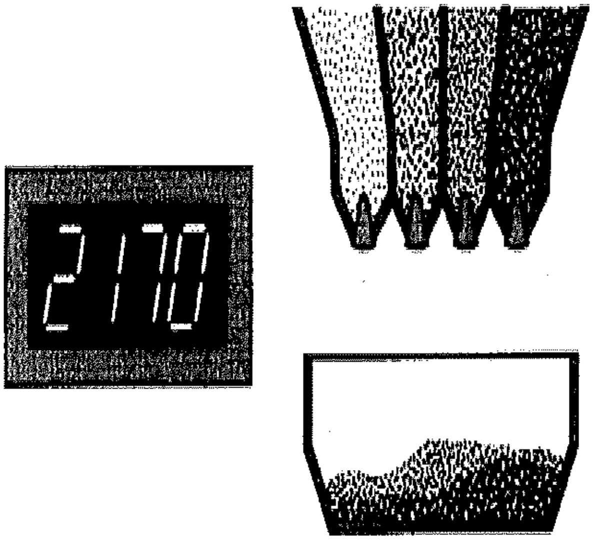
1. The discharge gate of an aggregate bin is opened and the aggregate pours into the weigh box.



2. When the scale reading reaches a preset weight, the discharge gate is closed.

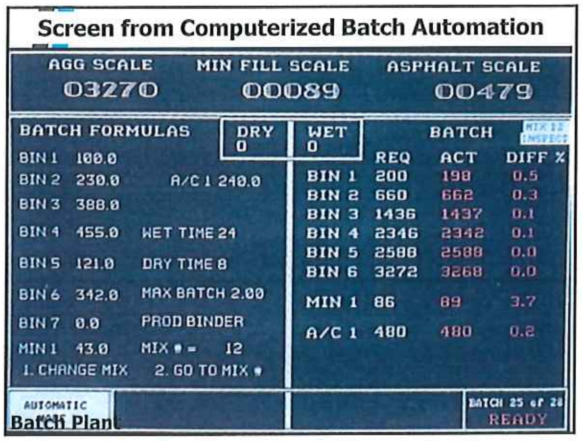


3. The dicharge gate of the next aggregate bin is opened.



4. When the scale reading reaches a preset weight, the discharge gate is closed.

5. These steps are repeated for the remaining aggregate sizes and the mineral filler.



Screen from Computerized Batch Automation

```
   AGG SCALE      MIN FILL SCALE     ASPHALT SCALE
     03270            00089              00479

BATCH FORMULAS    DRY    WET              BATCH         MIX 12
                  0      0                              INSPECT
BIN 1  100.0                      REQ     ACT     DIFF %
BIN 2  230.0        A/C 1 240.0   BIN 1  200     198     0.5
                                  BIN 2  660     662     0.3
BIN 3  388.0                      BIN 3  1436    1437    0.1
BIN 4  455.0   WET TIME 24        BIN 4  2346    2342    0.1
                                  BIN 5  2588    2588    0.0
BIN 5  121.0   DRY TIME 8         BIN 6  3272    3268    0.0
BIN 6  342.0   MAX BATCH 2.00     MIN 1  86      89      3.7
BIN 7  0.0     PROD BINDER        A/C 1  480     480     0.2
MIN 1  43.0    MIX # =    12
 1. CHANGE MIX   2. GO TO MIX #

AUTOMATIC                                       BATCH 25 of 28
                                                READY
```

Batch Plant

Pug Mill

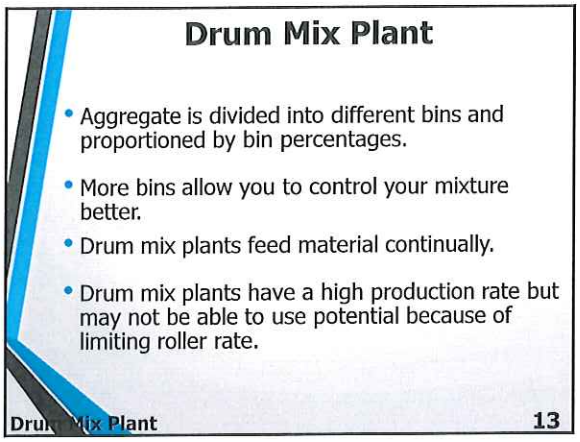
Dry cycle: say 15 sec
Wet cycle: say 20 sec

Inspect paddle wear tolerance weekly, more if traprock

Batch Plant

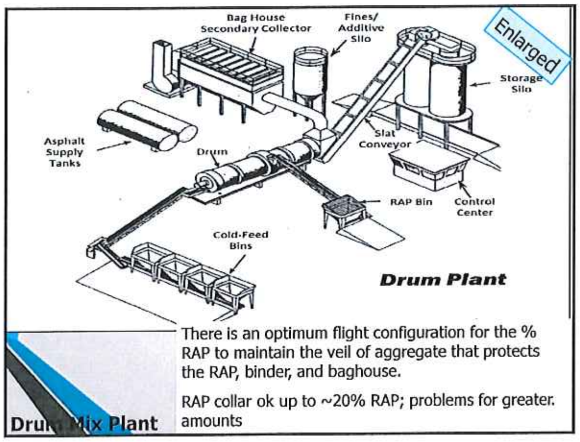
Drum Mix Plant

Drum Mix Plant



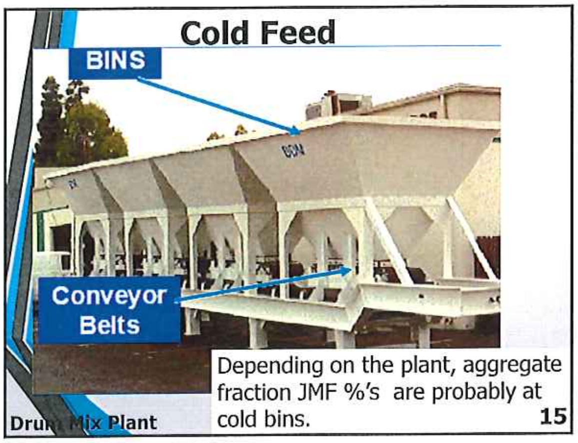
Drum Mix Plant

- Aggregate is divided into different bins and proportioned by bin percentages.
- More bins allow you to control your mixture better.
- Drum mix plants feed material continually.
- Drum mix plants have a high production rate but may not be able to use potential because of limiting roller rate.



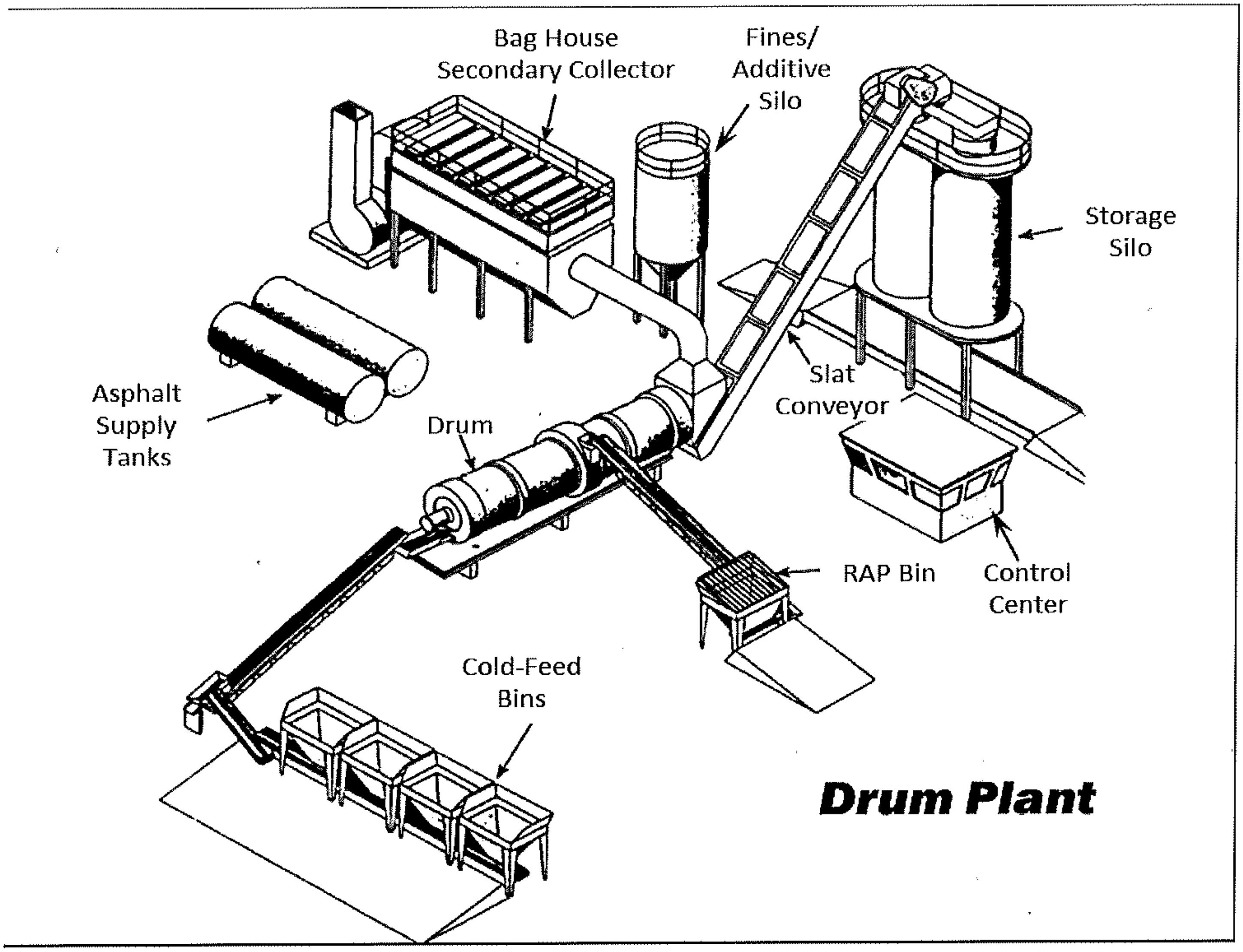
There is an optimum flight configuration for the % RAP to maintain the veil of aggregate that protects the RAP, binder, and baghouse.

RAP collar ok up to ~20% RAP; problems for greater amounts



Cold Feed

Depending on the plant, aggregate fraction JMF %'s are probably at cold bins.



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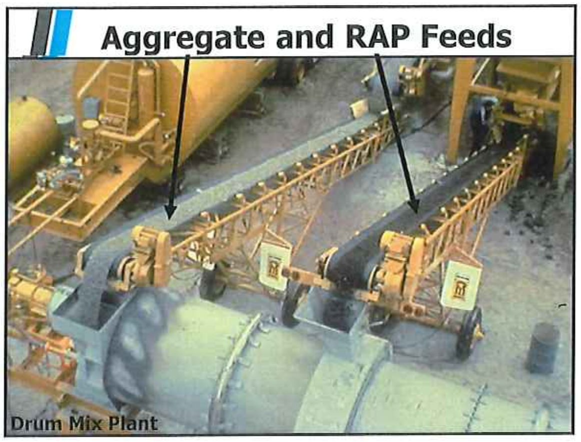

Aggregate and RAP Feeds

Drum Mix Plant

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Dryer For Drum Dryer Mix Plant

End of day: shut off oil, run aggregate through to clean out mix to prevent chunks breaking loose

Drum Mix Plant

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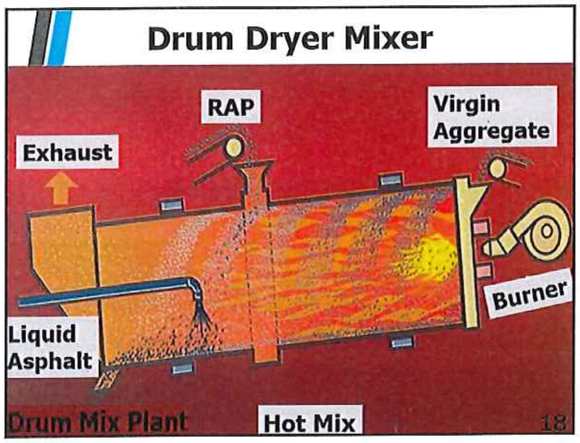

Drum Dryer Mixer

Drum Mix Plant

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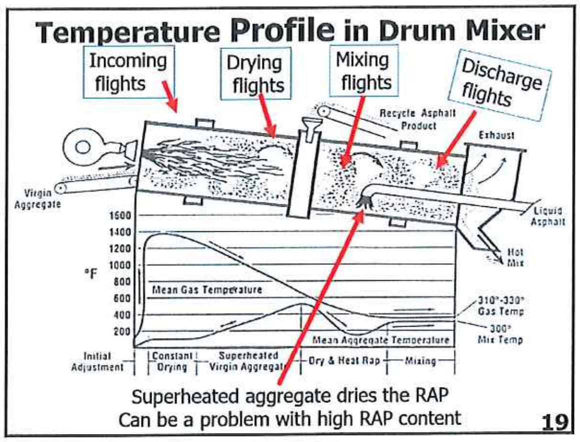
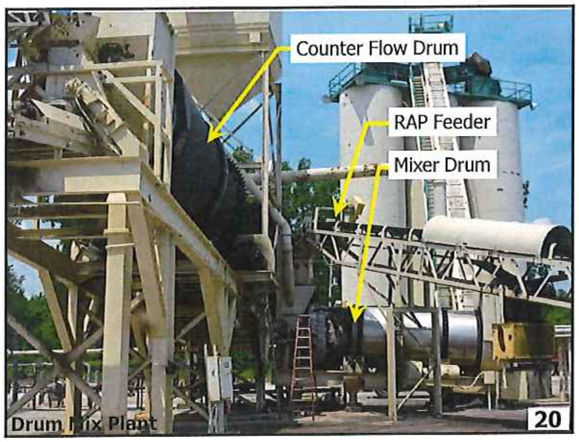
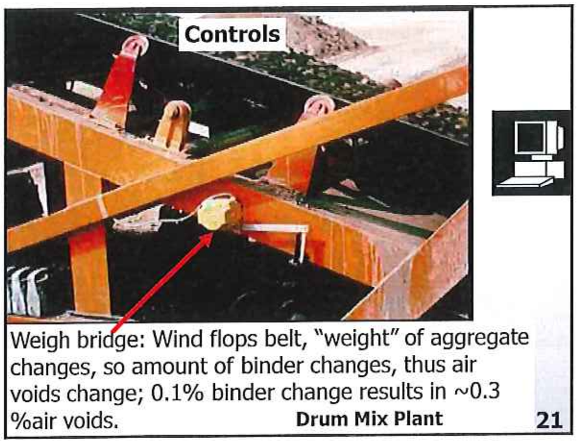


Temperature Profile in Drum Mixer

Superheated aggregate dries the RAP
Can be a problem with high RAP content

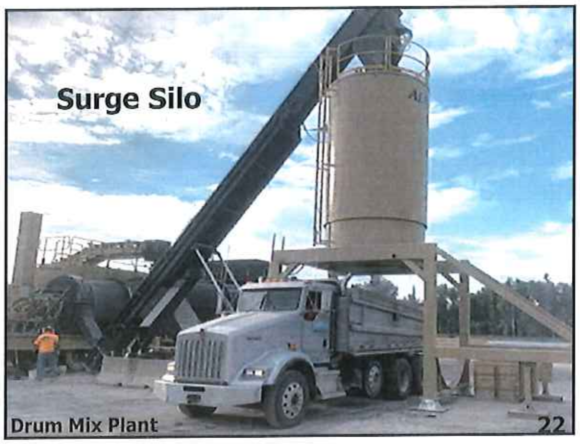


Drum Mix Plant



Controls

Weigh bridge: Wind flops belt, "weight" of aggregate changes, so amount of binder changes, thus air voids change; 0.1% binder change results in ~0.3 %air voids. **Drum Mix Plant**



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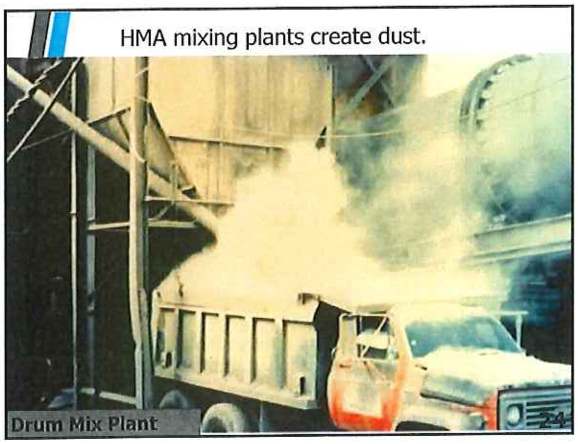
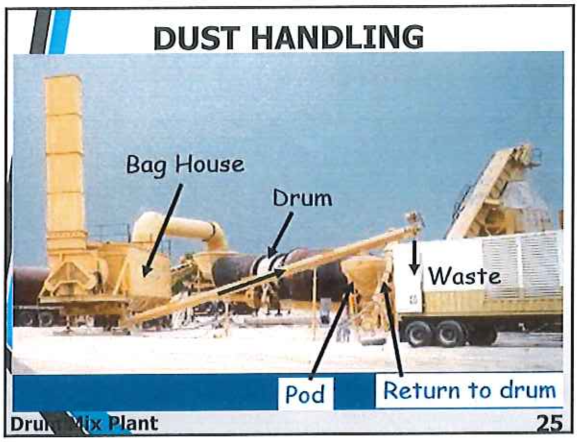

HMA mixing plants create dust.

24



DUST HANDLING

Drum Mix Plant

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Dust Handling

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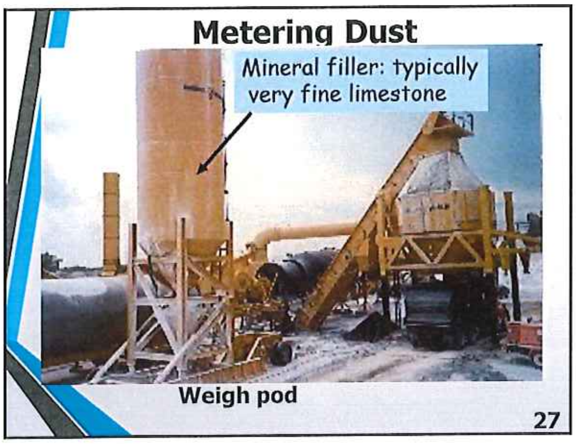

Metering Dust

Weigh pod

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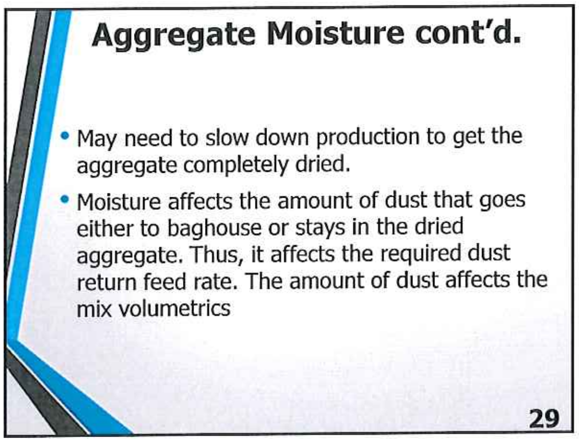
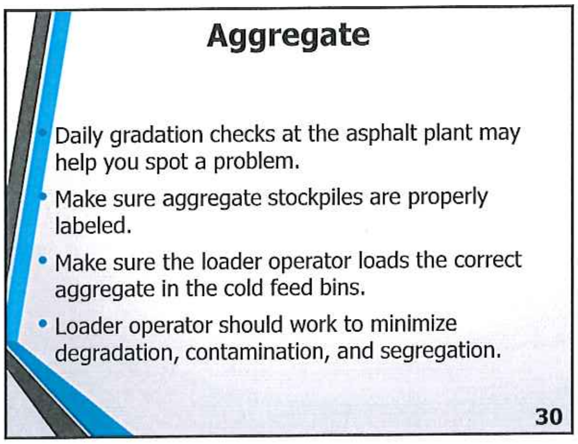
Aggregate Moisture Content

- Daily moisture contents are needed for every aggregate bin for drum mix plants.
- Wet fine aggregate will stick to conveyor belts. This may cause over-asphalting & low voids.
- Moisture may cause tender mix behavior.



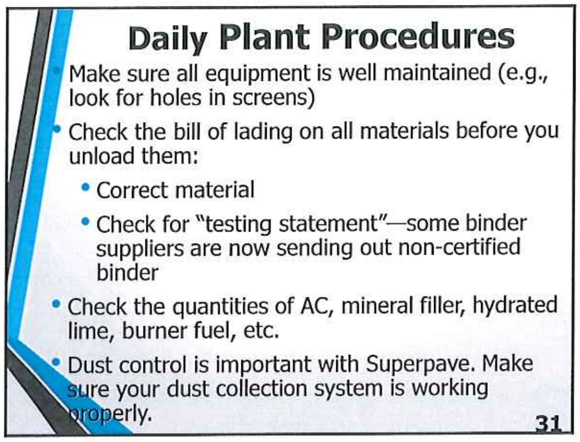
Aggregate Moisture cont'd.

- May need to slow down production to get the aggregate completely dried.
- Moisture affects the amount of dust that goes either to baghouse or stays in the dried aggregate. Thus, it affects the required dust return feed rate. The amount of dust affects the mix volumetrics



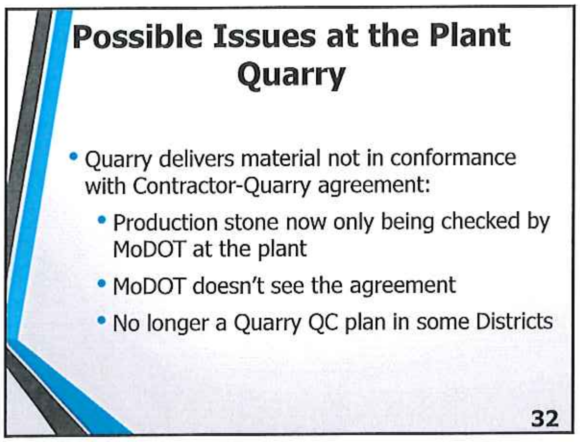
Aggregate

- Daily gradation checks at the asphalt plant may help you spot a problem.
- Make sure aggregate stockpiles are properly labeled.
- Make sure the loader operator loads the correct aggregate in the cold feed bins.
- Loader operator should work to minimize degradation, contamination, and segregation.



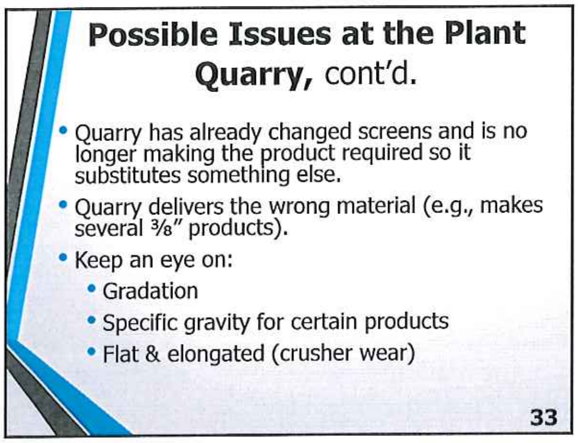
Daily Plant Procedures

- Make sure all equipment is well maintained (e.g., look for holes in screens)
- Check the bill of lading on all materials before you unload them:
  - Correct material
  - Check for "testing statement"—some binder suppliers are now sending out non-certified binder
- Check the quantities of AC, mineral filler, hydrated lime, burner fuel, etc.
- Dust control is important with Superpave. Make sure your dust collection system is working properly.



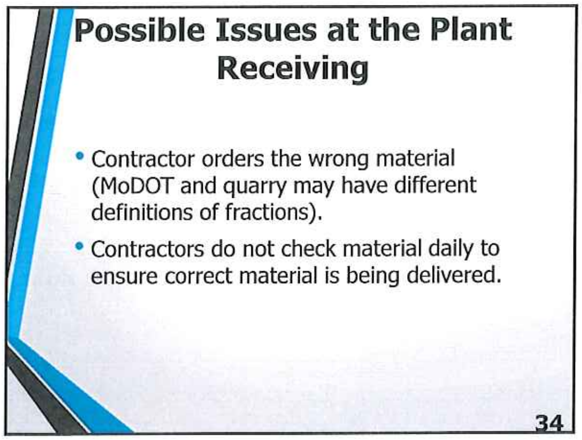
Possible Issues at the Plant
Quarry

- Quarry delivers material not in conformance with Contractor-Quarry agreement:
  - Production stone now only being checked by MoDOT at the plant
  - MoDOT doesn't see the agreement
  - No longer a Quarry QC plan in some Districts



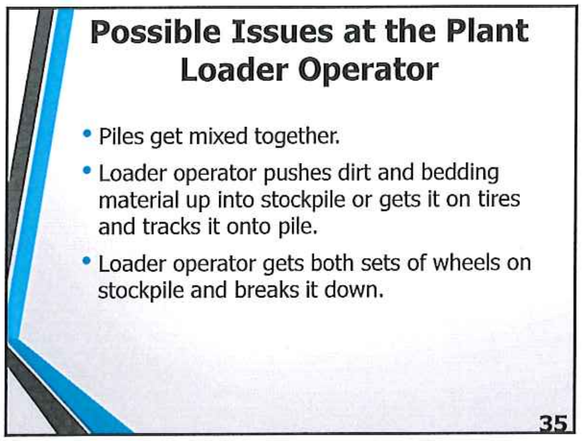
Possible Issues at the Plant
Quarry, cont'd.

- Quarry has already changed screens and is no longer making the product required so it substitutes something else.
- Quarry delivers the wrong material (e.g., makes several ⅜" products).
- Keep an eye on:
  - Gradation
  - Specific gravity for certain products
  - Flat & elongated (crusher wear)



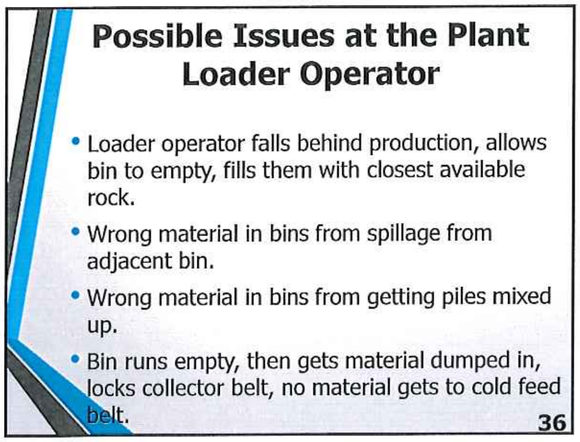
Possible Issues at the Plant
Receiving

- Contractor orders the wrong material (MoDOT and quarry may have different definitions of fractions).
- Contractors do not check material daily to ensure correct material is being delivered.



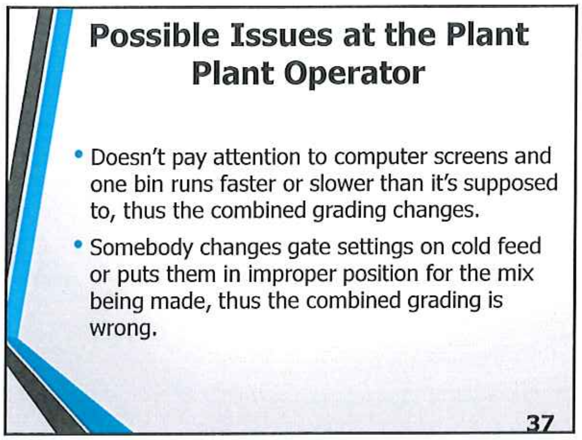
Possible Issues at the Plant
Loader Operator

- Piles get mixed together.
- Loader operator pushes dirt and bedding material up into stockpile or gets it on tires and tracks it onto pile.
- Loader operator gets both sets of wheels on stockpile and breaks it down.



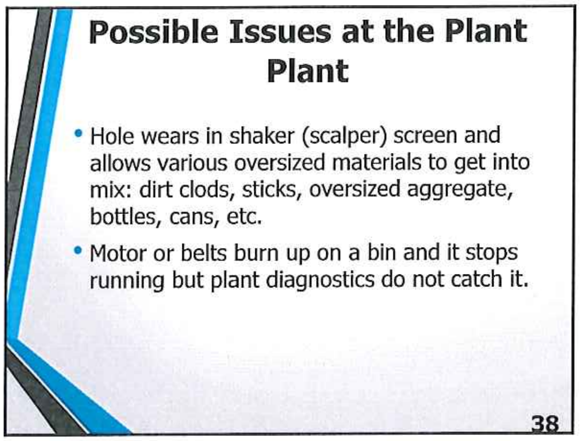
Possible Issues at the Plant
Loader Operator

- Loader operator falls behind production, allows bin to empty, fills them with closest available rock.
- Wrong material in bins from spillage from adjacent bin.
- Wrong material in bins from getting piles mixed up.
- Bin runs empty, then gets material dumped in, locks collector belt, no material gets to cold feed belt.



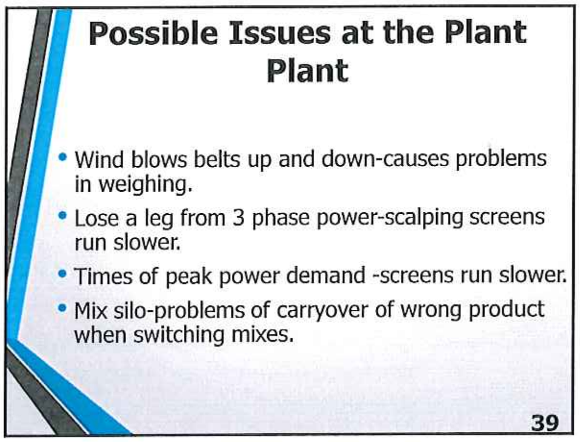
Possible Issues at the Plant
Plant Operator

- Doesn't pay attention to computer screens and one bin runs faster or slower than it's supposed to, thus the combined grading changes.
- Somebody changes gate settings on cold feed or puts them in improper position for the mix being made, thus the combined grading is wrong.



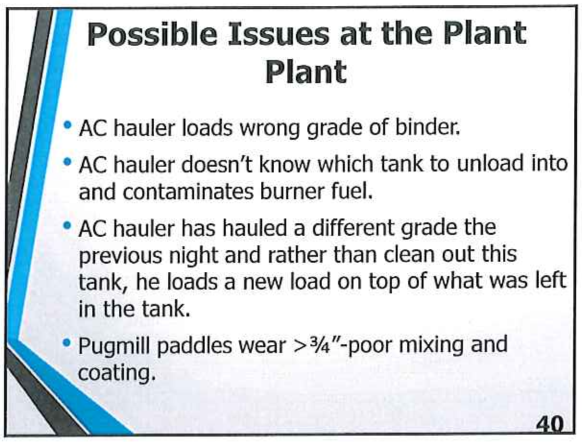
Possible Issues at the Plant
Plant

- Hole wears in shaker (scalper) screen and allows various oversized materials to get into mix: dirt clods, sticks, oversized aggregate, bottles, cans, etc.
- Motor or belts burn up on a bin and it stops running but plant diagnostics do not catch it.



Possible Issues at the Plant
Plant

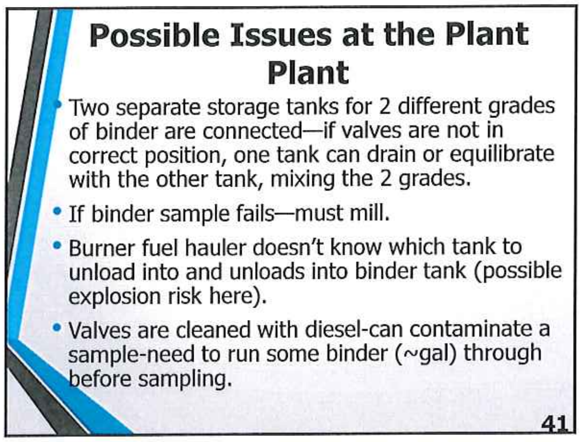
- Wind blows belts up and down-causes problems in weighing.
- Lose a leg from 3 phase power-scalping screens run slower.
- Times of peak power demand -screens run slower.
- Mix silo-problems of carryover of wrong product when switching mixes.



Possible Issues at the Plant Plant

- AC hauler loads wrong grade of binder.
- AC hauler doesn't know which tank to unload into and contaminates burner fuel.
- AC hauler has hauled a different grade the previous night and rather than clean out this tank, he loads a new load on top of what was left in the tank.
- Pugmill paddles wear >¾″-poor mixing and coating.

40



Possible Issues at the Plant Plant

- Two separate storage tanks for 2 different grades of binder are connected—if valves are not in correct position, one tank can drain or equilibrate with the other tank, mixing the 2 grades.
- If binder sample fails—must mill.
- Burner fuel hauler doesn't know which tank to unload into and unloads into binder tank (possible explosion risk here).
- Valves are cleaned with diesel-can contaminate a sample-need to run some binder (~gal) through before sampling.

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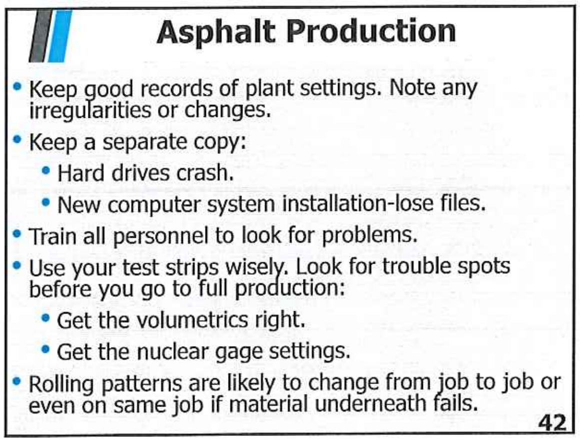

Asphalt Production

- Keep good records of plant settings. Note any irregularities or changes.
- Keep a separate copy:
  - Hard drives crash.
  - New computer system installation-lose files.
- Train all personnel to look for problems.
- Use your test strips wisely. Look for trouble spots before you go to full production:
  - Get the volumetrics right.
  - Get the nuclear gage settings.
- Rolling patterns are likely to change from job to job or even on same job if material underneath fails.

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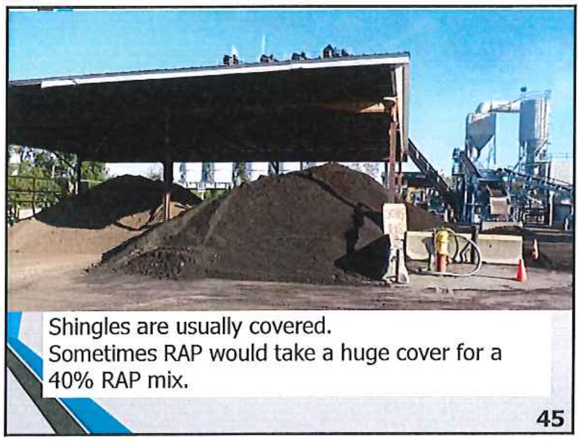
Coarse RAP (½ to 1 inch)

Fine RAP (minus ½ inch)



Shingles are usually covered.
Sometimes RAP would take a huge cover for a 40% RAP mix.

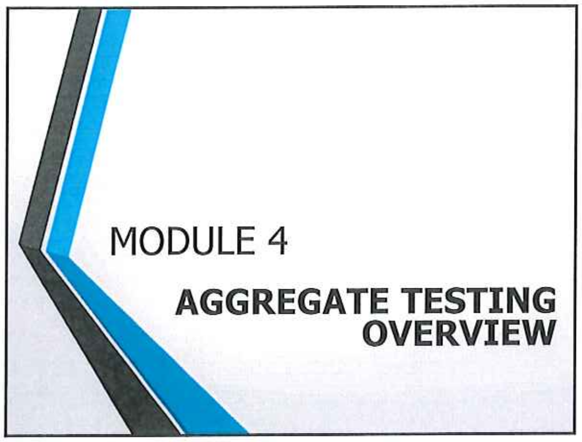
TAB

Module 4

Module 4

Aggregate Testing Overview

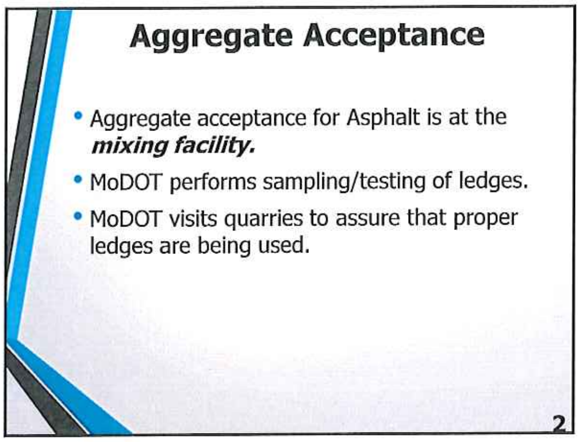
MoDOT



MODULE 4

AGGREGATE TESTING OVERVIEW

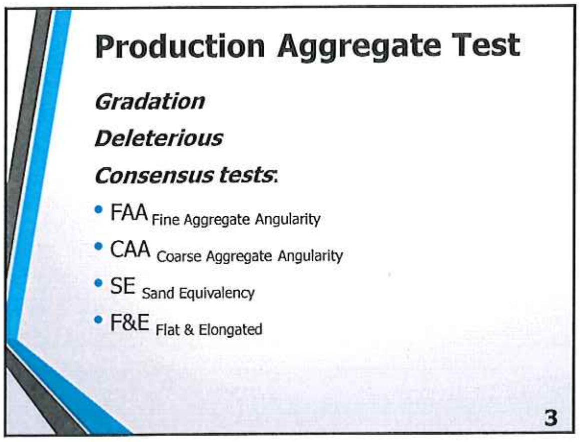
1



Aggregate Acceptance

- Aggregate acceptance for Asphalt is at the ***mixing facility.***
- MoDOT performs sampling/testing of ledges.
- MoDOT visits quarries to assure that proper ledges are being used.

2



Production Aggregate Test

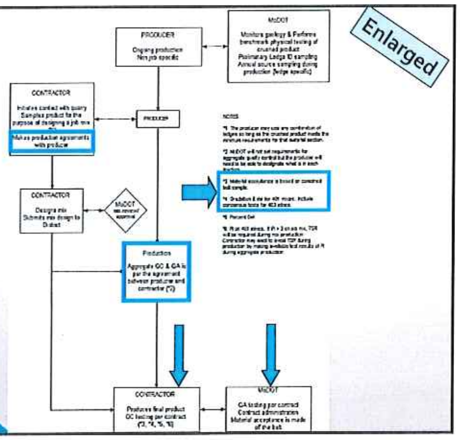
Gradation

Deleterious

Consensus tests:

- FAA Fine Aggregate Angularity
- CAA Coarse Aggregate Angularity
- SE Sand Equivalency
- F&E Flat & Elongated

3



Enlarged

PRODUCER
Ongoing production
Non job specific

MoDOT
Monitors geology & Performs benchmark physical testing of crushed product
Preliminary Ledge ID sampling
Annual source sampling during production (ledge specific)

CONTRACTOR
Initiates contact with quarry
Samples product for the purpose of designing a job mix
Makes production agreements with producer

PRODUCER

CONTRACTOR
Designs mix
Submits mix design to District

MoDOT
mix review/approval

Production
Aggregate QC & QA is per the agreement between producer and contractor (*2)

NOTES

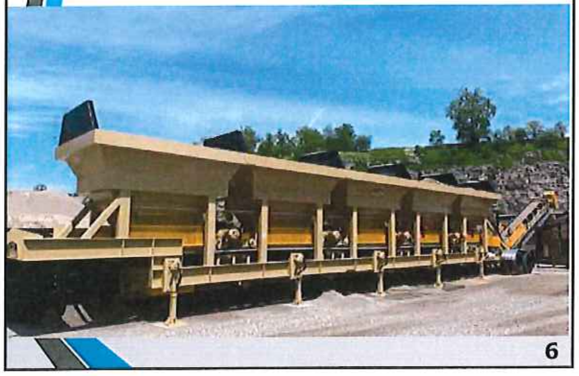
CONTRACTOR
Produces final product
QC testing per contract
(*3, *4, *5, *6)

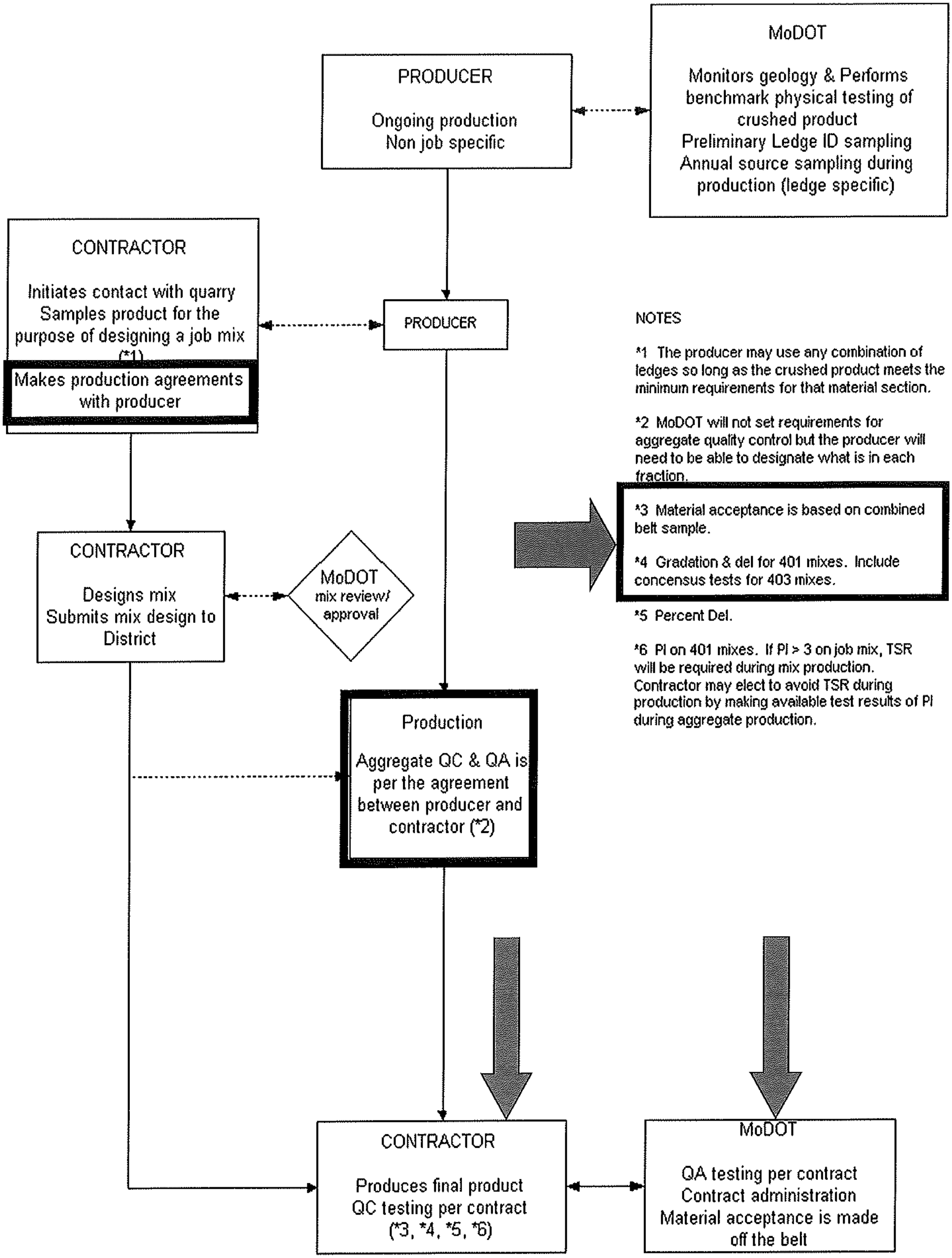
MoDOT
QA testing per contract
Contract administration
Material acceptance is made of the belt

SAMPLING: Aggregate

- **Gradation**:
  - Drum - Cold feed belt
  - Batch - Hot bins
  - Can use Asphalt sample - T308 residue (Not applicable for dolomite).
  - RAP - T308 residue; combine mathematically with virgin gradation. (Dolomite – will need to extract)
- **Deleterious:**
  - All plants - Cold feed belt
- **Consensus:**
  - All plants - Cold feed belt
- **QC** retains half their sample (after final split) for QA.

COLD BINS





NOTES

*1 The producer may use any combination of ledges so long as the crushed product meets the minimum requirements for that material section.

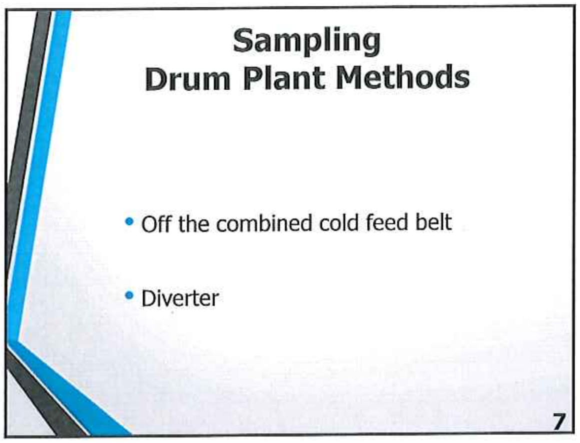
*2 MoDOT will not set requirements for aggregate quality control but the producer will need to be able to designate what is in each fraction.

*3 Material acceptance is based on combined belt sample.

*4 Gradation & del for 401 mixes. Include concensus tests for 403 mixes.

*5 Percent Del.

*6 PI on 401 mixes. If PI > 3 on job mix, TSR will be required during mix production. Contractor may elect to avoid TSR during production by making available test results of PI during aggregate production.

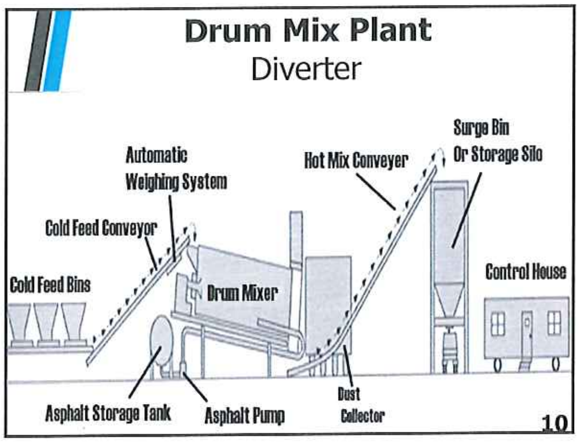


Sampling Drum Plant Methods

- Off the combined cold feed belt
- Diverter

Sampling Gradation

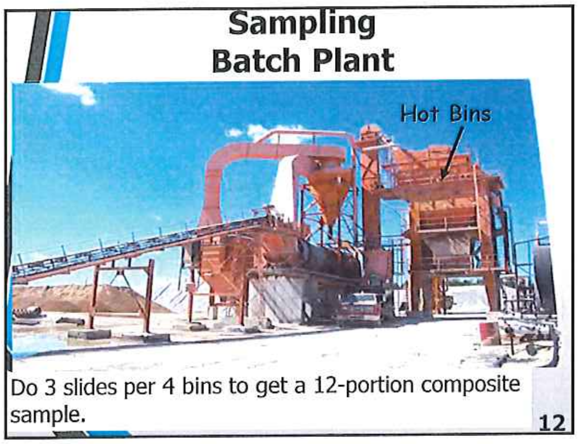
Sampling Cold Feed Belt



Drum Mix Plant
Diverter

Diverter Chute

Diverter chute: Get 3 grabs to combine.



Sampling
Batch Plant

Do 3 slides per 4 bins to get a 12-portion composite sample.

Sampling Hot Bins

QC Aggregate Sampling/Testing

- ***Gradation*** -1 per 2 sublots
- ***Consensus tests*** -1 per 10,000 tons mix (at least 1 per project per mix type)
- ***Deleterious*** - 1 per 2 sublots
- Save a retained sample of each.

QA Aggregate Sampling/Testing

- **Independent:**
  - ***Gradation*** -1 per 4 sublots minimum
  - ***Consensus*** -1 per project minimum (no matter how many mixes)
  - ***Deleterious*** -1 per 4 sublots
- **QC retained split:**
  - ***Gradation*** -1 per week minimum
  - ***Consensus*** -1 per project minimum (no matter how many mixes)
  - ***Deleterious*** -same as gradation

Sampling & Testing

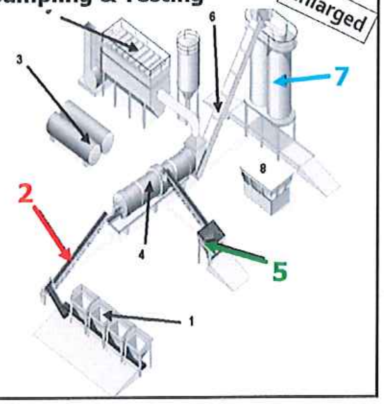
Enlarged

2: Aggregate Cold feed:
- Deleterious
- Consensus
- Gradation: if dolomite and maybe if limestone

5: RAP
- Binder content (T308/T164)
- Gradation-binder residue
- (Mathematically combined with cold feed gradation if not using roadway sample for gradation)
- Micro-Deval- maybe

7: Silo Discharge-Truck or HMA Mini-stockpile:
- Maybe TSR

Not Shown-Roadway sample:
- Binder content/moisture
- (Gradation-binder residue)
- Gyro pucks
- Rice Gravity



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Aggregate

Acceptance:
- ***Be within tolerance of JMF values (Gradation and Consensus tests)***
- ***Be within standard specs (Deleterious)***
- Compare "favorably" with QA results

17

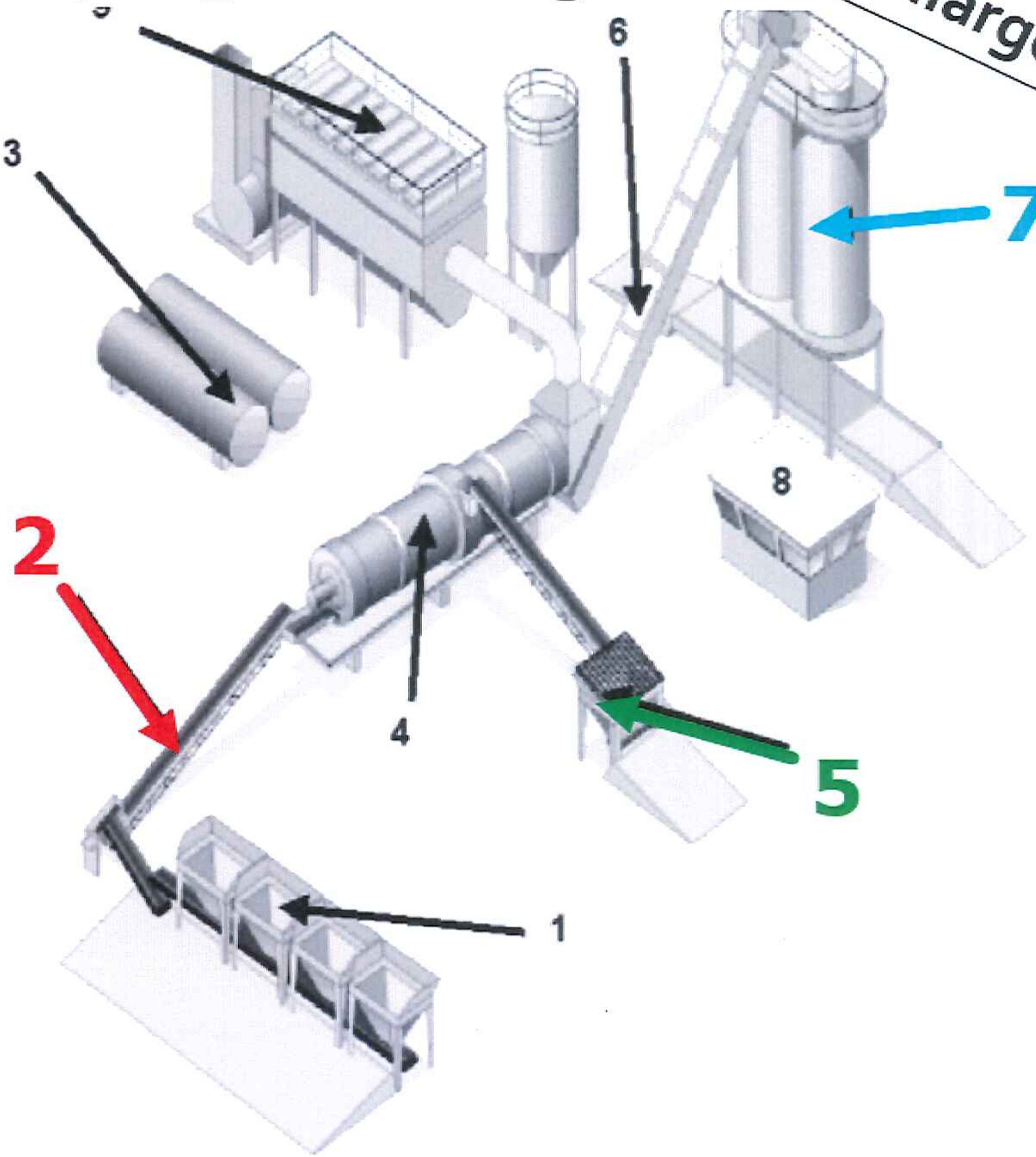
Unfavorable Comparison

- Has been traced to the splitting operation and equipment that each side was using.

18

Sampling & Testing

Enlarged



2: Aggregate Cold feed:

- Deleterious
- Consensus
- Gradation: if dolomite and maybe if limestone

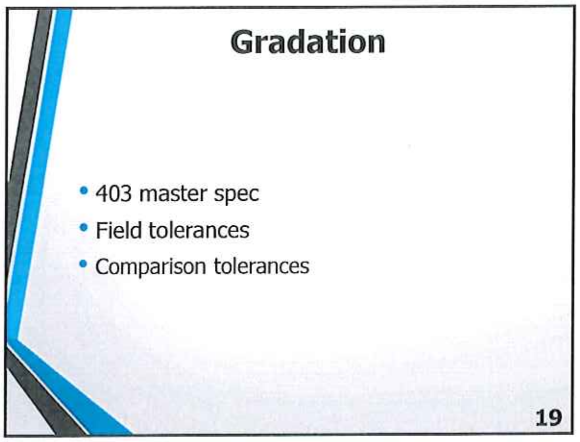
5: RAP

- Binder content (T308/T164)
- Gradation-binder residue
- (Mathematically combined with cold feed gradation if not using roadway sample for gradation)
- Micro-Deval- maybe

- **7: Silo Discharge-Truck or HMA Mini-stockpile:**
- Maybe TSR

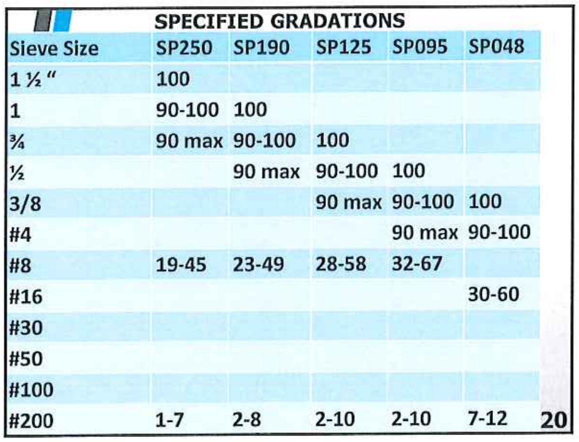
Not Shown-Roadway sample:

- Binder content/moisture
- (Gradation-binder residue)
- Gyro pucks
- Rice Gravity



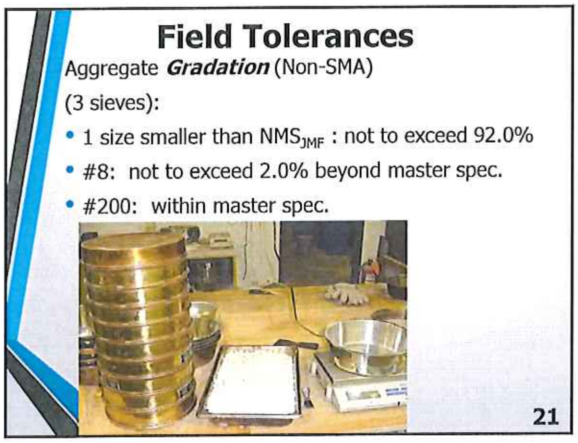
Gradation

- 403 master spec
- Field tolerances
- Comparison tolerances



SPECIFIED GRADATIONS

Sieve Size	SP250	SP190	SP125	SP095	SP048
1 ½ "	100				
1	90-100	100			
¾	90 max	90-100	100		
½		90 max	90-100	100	
3/8			90 max	90-100	100
#4				90 max	90-100
#8	19-45	23-49	28-58	32-67	
#16					30-60
#30					
#50					
#100					
#200	1-7	2-8	2-10	2-10	7-12

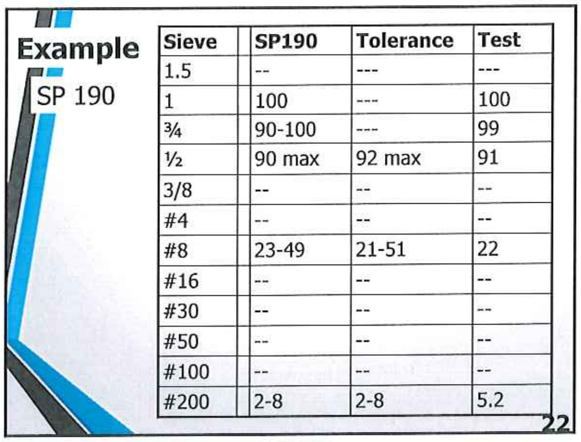


Field Tolerances

Aggregate ***Gradation*** (Non-SMA)

(3 sieves):

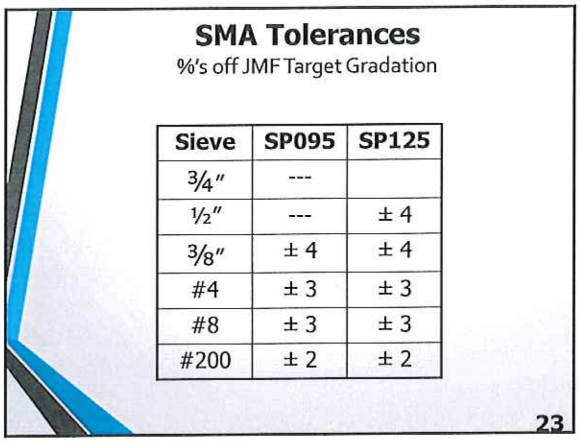
- 1 size smaller than NMS_{JMF} : not to exceed 92.0%
- #8: not to exceed 2.0% beyond master spec.
- #200: within master spec.



Example

SP 190

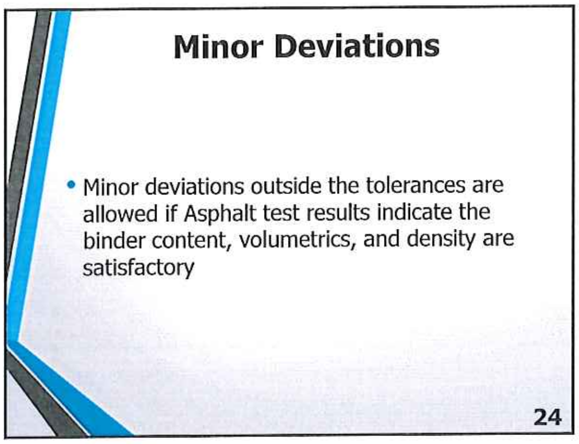
Sieve	SP190	Tolerance	Test
1.5	--	---	---
1	100	---	100
¾	90-100	---	99
½	90 max	92 max	91
3/8	--	--	--
#4	--	--	--
#8	23-49	21-51	22
#16	--	--	--
#30	--	--	--
#50	--	--	--
#100	--	--	--
#200	2-8	2-8	5.2



SMA Tolerances

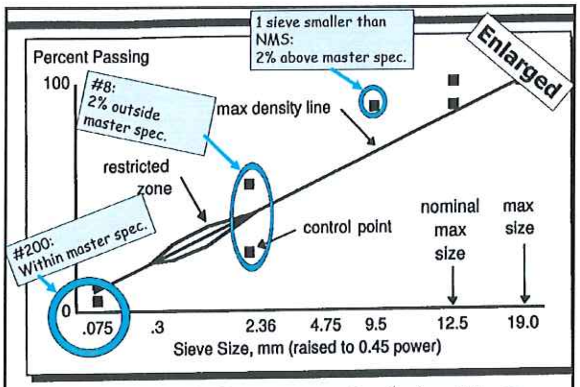
%'s off JMF Target Gradation

Sieve	SP095	SP125
¾"	---	
½"	---	± 4
⅜"	± 4	± 4
#4	± 3	± 3
#8	± 3	± 3
#200	± 2	± 2



Minor Deviations

- Minor deviations outside the tolerances are allowed if Asphalt test results indicate the binder content, volumetrics, and density are satisfactory



1 sieve smaller than NMS: 2% above master spec.

#8: 2% outside master spec.

#200: Within master spec.

Figure 3.10 Superpave Gradation Limits

Aggregate

Acceptance:

- Be within tolerance of JMF values (***Gradation*** and ***Consensus tests***)
- Be within standard specs (***Deleterious***)
- ***Compare "favorably" with QA results***

Comparing QA to QC

(QC Retained Sample)

- *Consensus* Tests:
  - CAA: QC ± 5%
  - FAA: QC ± 2%
  - SE: QC ± 8%
  - T& E: QC ± 1%
- ***Gradation***: see table
- If QC meets spec and QA compares favorably (Verifies QC) but QA is out of spec, the sample passes.

1 sieve smaller than NMS:
2% above master spec

#8:
2% outside master spec

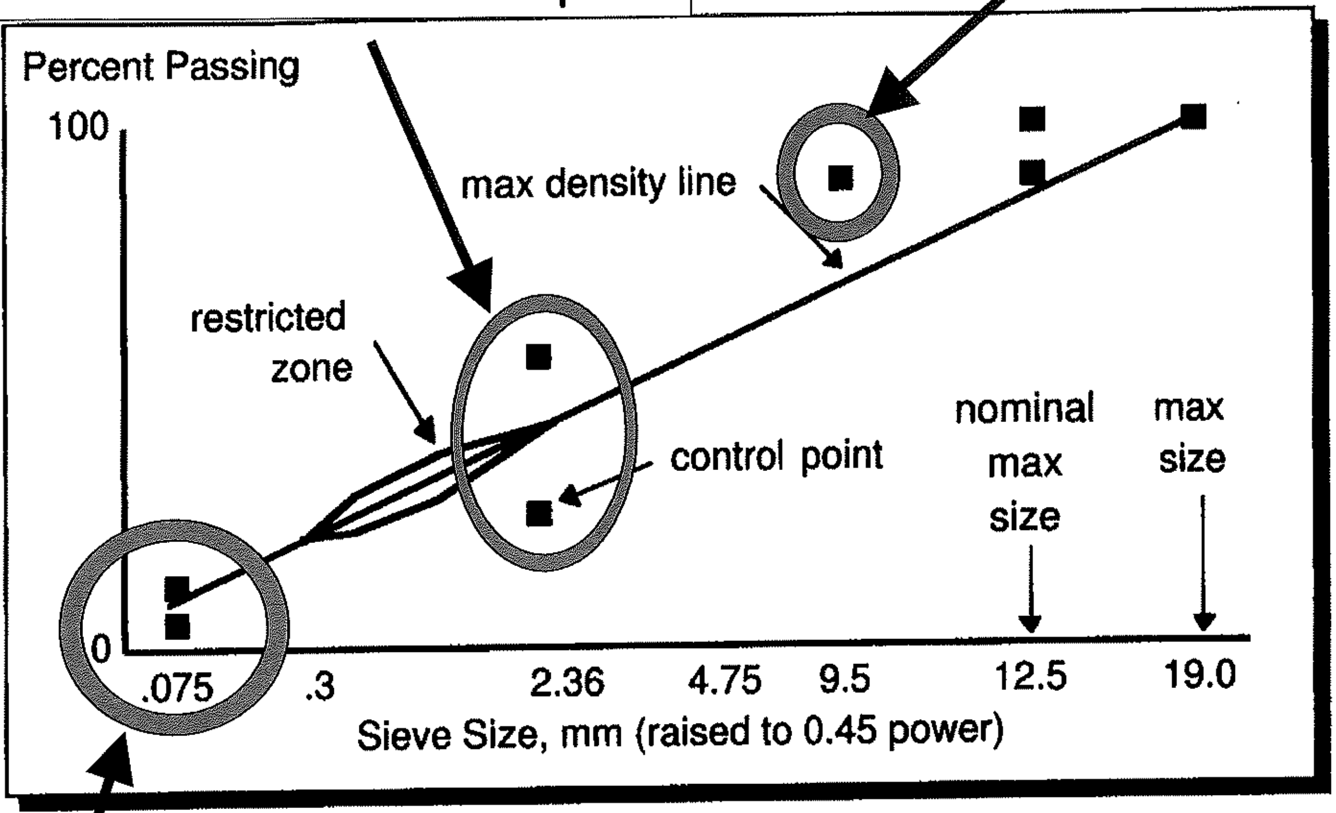
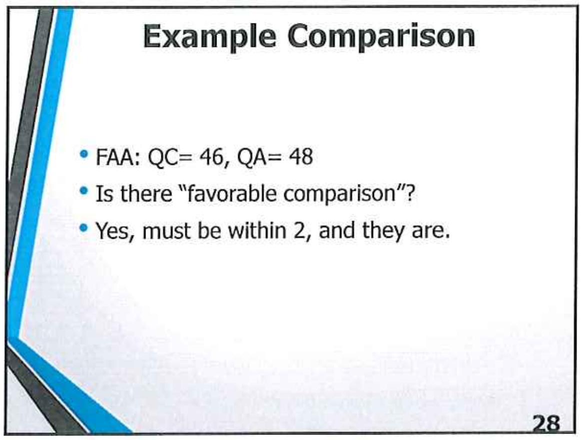


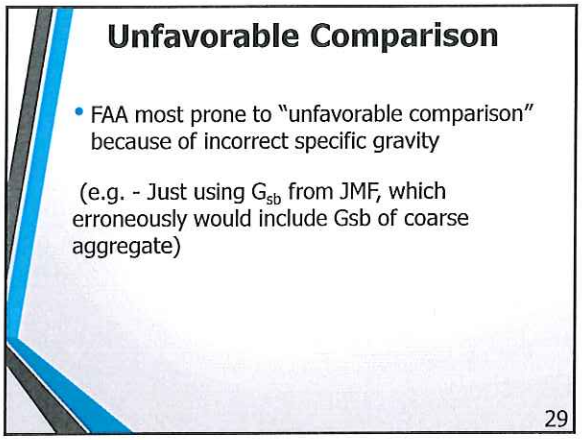
Figure 3.10 Superpave Gradation Limits

#200:
within master spec



Example Comparison

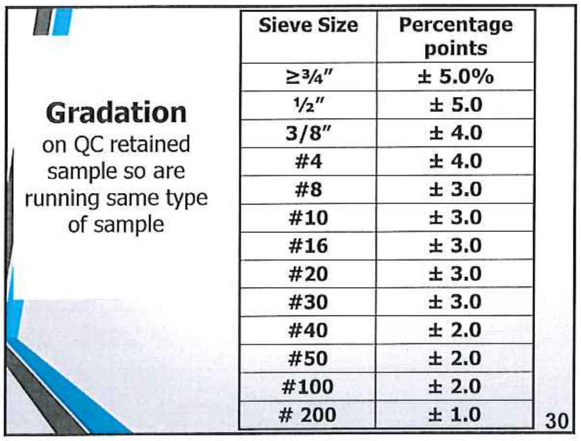
- FAA: QC= 46, QA= 48
- Is there "favorable comparison"?
- Yes, must be within 2, and they are.



Unfavorable Comparison

- FAA most prone to "unfavorable comparison" because of incorrect specific gravity

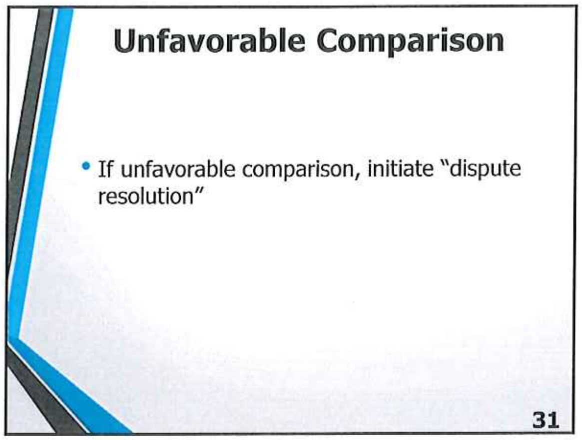
(e.g. - Just using G_{sb} from JMF, which erroneously would include Gsb of coarse aggregate)



Gradation

on QC retained sample so are running same type of sample

Sieve Size	Percentage points
≥¾"	± 5.0%
½"	± 5.0
3/8"	± 4.0
#4	± 4.0
#8	± 3.0
#10	± 3.0
#16	± 3.0
#20	± 3.0
#30	± 3.0
#40	± 2.0
#50	± 2.0
#100	± 2.0
# 200	± 1.0



Unfavorable Comparison

- If unfavorable comparison, initiate "dispute resolution"

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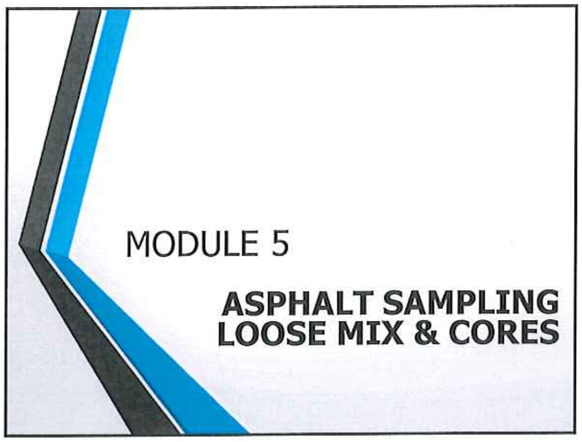
TAB

Module 5

Module 5

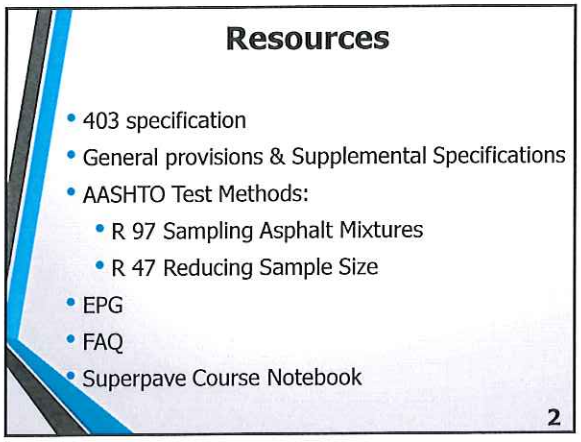
Asphalt Sampling
Loose Mix & Cores

MoDOT



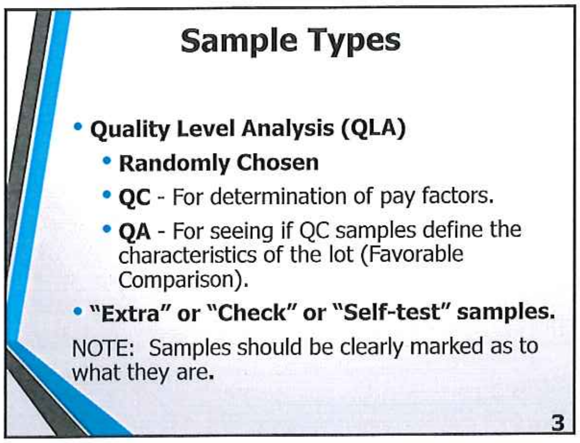
MODULE 5

ASPHALT SAMPLING LOOSE MIX & CORES



Resources

- 403 specification
- General provisions & Supplemental Specifications
- AASHTO Test Methods:
  - R 97 Sampling Asphalt Mixtures
  - R 47 Reducing Sample Size
- EPG
- FAQ
- Superpave Course Notebook



Sample Types

- **Quality Level Analysis (QLA)**
  - **Randomly Chosen**
  - **QC** - For determination of pay factors.
  - **QA** - For seeing if QC samples define the characteristics of the lot (Favorable Comparison).
- **"Extra" or "Check" or "Self-test" samples.**

NOTE: Samples should be clearly marked as to what they are.

Extra or Check Samples

Extra sampling done by MoDOT or contractor to:

- Check how the mix is doing.
- Investigate problem areas *e.g.,* does a problem exist?
- Determine limits of the problem.

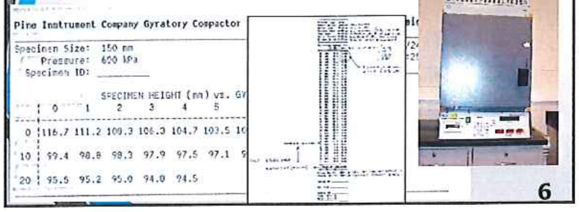
- Can be from truck, plant, mat.
- Not random – and cannot be used for QLA.

EXTRA or CHECK SAMPLES

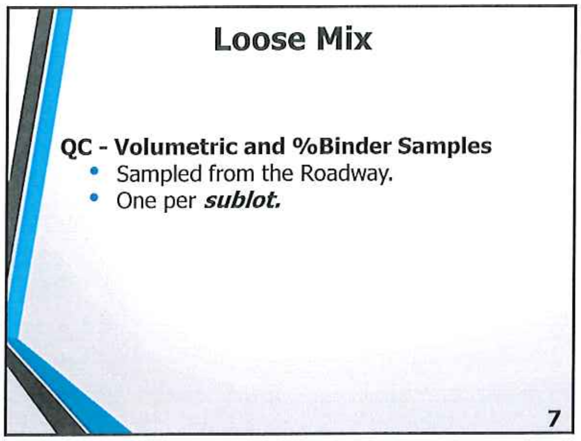
- Can be used to define removal limits, but must be "Well - Documented"

"Well - Documented"
The Following are Available:

- Gyro pucks
- Gyration/height printouts
- Binder content printouts



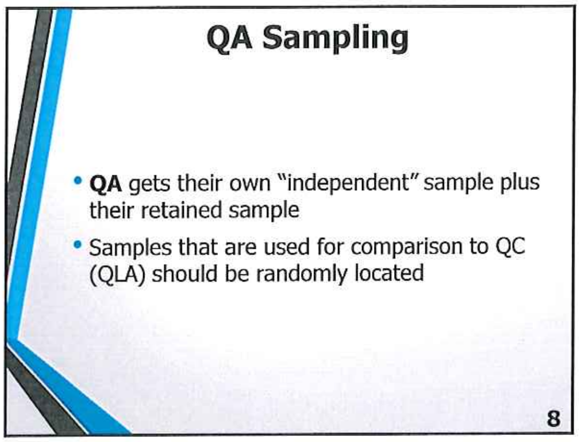
```
Pine Instrument Company Gyratory Compactor

Specimen Size:   150 mm
     Pressure:   600 kPa
  Specimen ID:   __________

              SPECIMEN HEIGHT (mm) vs. GY
      |  0     1     2     3     4     5
------+----------------------------------------
    0 |116.7 111.2 109.3 106.3 104.7 103.5 10
   10 | 99.4  98.8  98.3  97.9  97.5  97.1  9
   20 | 95.5  95.2  95.0  94.0  94.5
```



Loose Mix

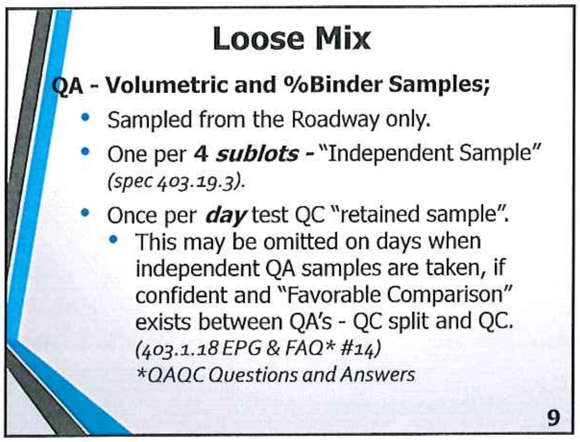
QC - Volumetric and %Binder Samples

- Sampled from the Roadway.
- One per ***sublot.***



QA Sampling

- **QA** gets their own "independent" sample plus their retained sample
- Samples that are used for comparison to QC (QLA) should be randomly located



Loose Mix

QA - Volumetric and %Binder Samples;

- Sampled from the Roadway only.
- One per **4 *sublots* -** "Independent Sample" *(spec 403.19.3).*
- Once per ***day*** test QC "retained sample".
  - This may be omitted on days when independent QA samples are taken, if confident and "Favorable Comparison" exists between QA's - QC split and QC. *(403.1.18 EPG & FAQ* #14)*
    **QAQC Questions and Answers*

Retained Samples

403.17.2.3:

Retained samples should be clearly labeled and not discarded until all QC/QA comparison issues are resolved. If the lab becomes crowded, the RE should store the samples in the project office.

The retained sample is a contract requirement and belongs to the Commission.

The contractor can keep ADDITIONAL mix for internal use.

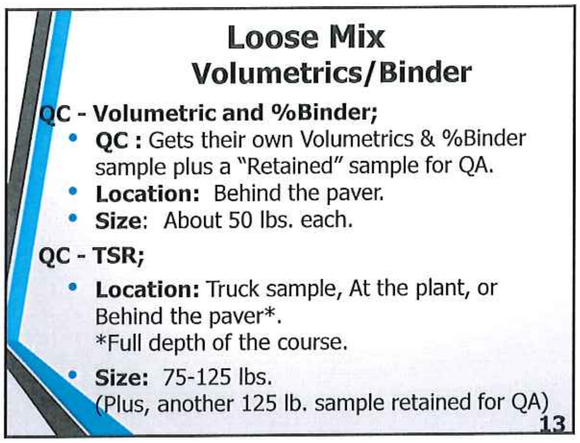
Loose Mix - TSR Sample

- **QC**: 1 per 10,000 tons or fraction thereof.
- **QA**: 1 per 50,000 tons or minimum 1 per combination of projects.
- **Random locations:**
  - Required by spec.
  - Not enforced (EPG)
    - *FAQ* #23*

Loose Mix
Sampling Location

- **Volumetric/Binder Content samples;**
  - Sampled from the ***Roadway.***

    Use of spray paver or trackless tack may contaminate sample; consider an alternate sample location.
- **TSR Samples;**
  - Sampled from a ***Truck, Plant Discharge or Roadway.***
  - **QA** samples same place as **QC**, but at a different time.



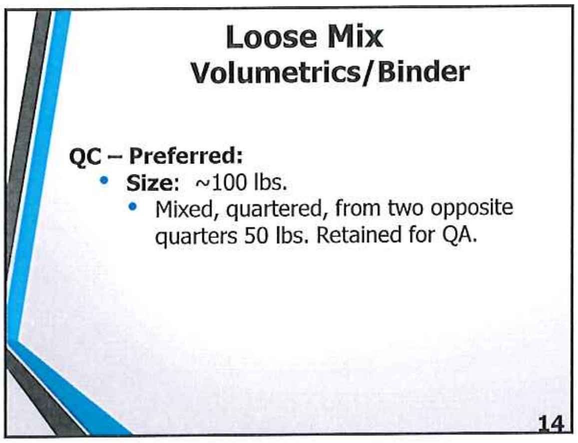
Loose Mix
Volumetrics/Binder

QC - Volumetric and %Binder;

- **QC :** Gets their own Volumetrics & %Binder sample plus a "Retained" sample for QA.
- **Location:** Behind the paver.
- **Size:** About 50 lbs. each.

QC - TSR;

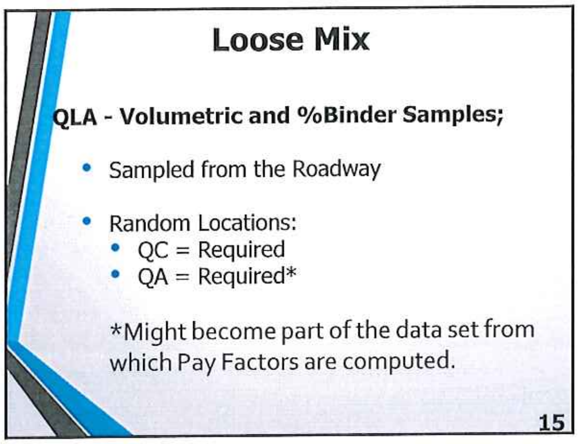
- **Location:** Truck sample, At the plant, or Behind the paver*.
  *Full depth of the course.
- **Size:** 75-125 lbs.
  (Plus, another 125 lb. sample retained for QA)



Loose Mix
Volumetrics/Binder

QC – Preferred:

- **Size:** ~100 lbs.
  - Mixed, quartered, from two opposite quarters 50 lbs. Retained for QA.

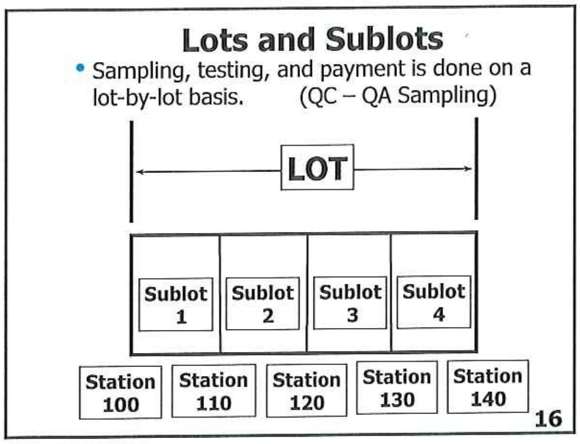


Loose Mix

QLA - Volumetric and %Binder Samples;

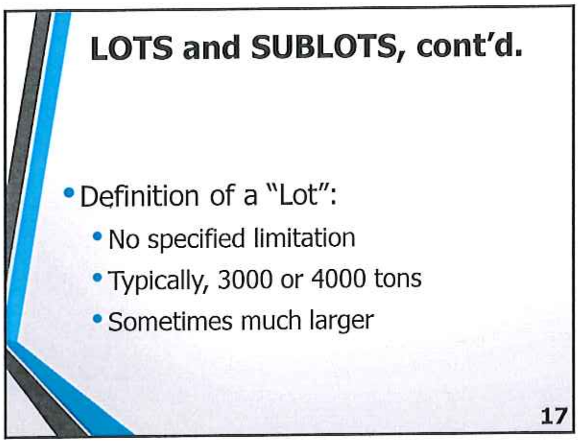
- Sampled from the Roadway
- Random Locations:
  - QC = Required
  - QA = Required*

*Might become part of the data set from which Pay Factors are computed.



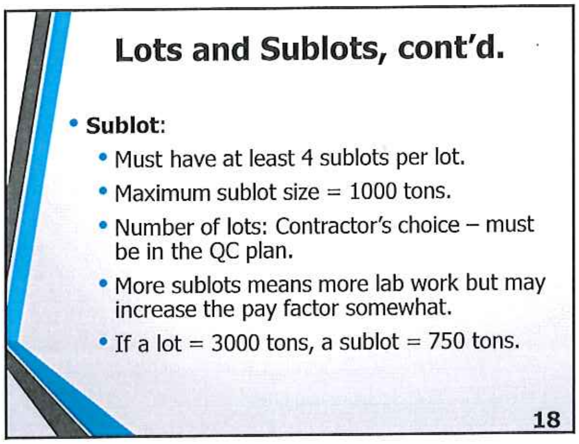
Lots and Sublots

- Sampling, testing, and payment is done on a lot-by-lot basis. (QC – QA Sampling)



LOTS and SUBLOTS, cont'd.

- Definition of a "Lot":
  - No specified limitation
  - Typically, 3000 or 4000 tons
  - Sometimes much larger



Lots and Sublots, cont'd.

- **Sublot**:
  - Must have at least 4 sublots per lot.
  - Maximum sublot size = 1000 tons.
  - Number of lots: Contractor's choice – must be in the QC plan.
  - More sublots means more lab work but may increase the pay factor somewhat.
  - If a lot = 3000 tons, a sublot = 750 tons.

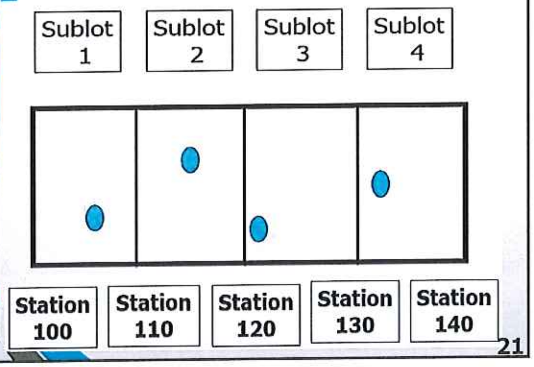
Lot Routines
403 Mixes

- Traveled way + integral shoulders.
- Non-integral shoulders (If Superpave).
- If not Superpave (e.g., BP-1), random. numbers not required- see "Non-traveled area" notes.

Sample Location

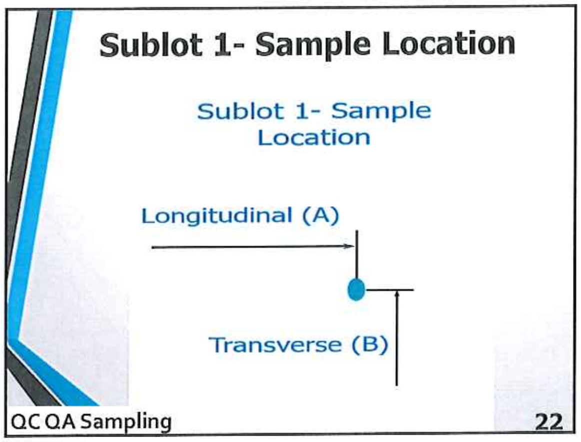
- ***Longitudinal*** position in terms of tons of mix from the start of the lot.
- ***Transverse*** position in terms of distance from edge of mat.

Stratified Random Sampling



Sublot 1 | Sublot 2 | Sublot 3 | Sublot 4

Station 100 | **Station 110** | **Station 120** | **Station 130** | **Station 140**



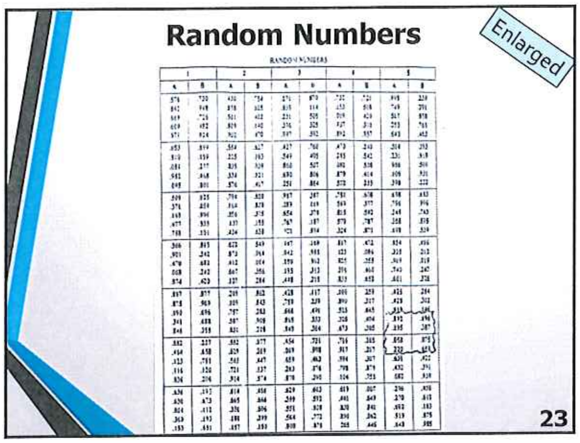
Sublot 1- Sample Location

Sublot 1- Sample Location

Longitudinal (A)

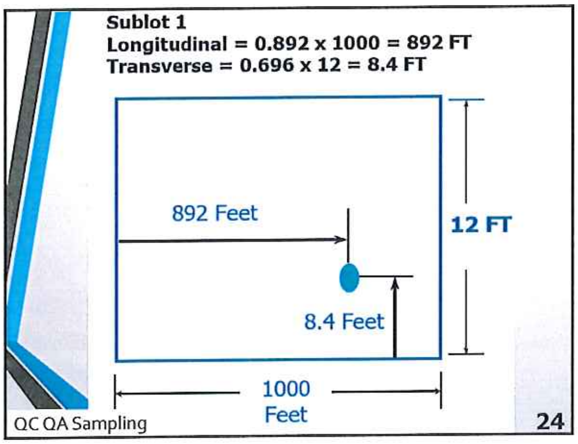
Transverse (B)

QC QA Sampling



Random Numbers

Enlarged



Sublot 1

Longitudinal = 0.892 x 1000 = 892 FT

Transverse = 0.696 x 12 = 8.4 FT

892 Feet

8.4 Feet

12 FT

1000 Feet

QC QA Sampling

Random Numbers

RANDOM NUMBERS

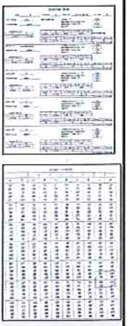
1		2		3		4		5	
A	B	A	B	A	B	A	B	A	B
.576	.730	.430	.754	.271	.870	.732	.721	.998	.239
.892	.948	.858	.025	.935	.114	.153	.508	.749	.291
.669	.726	.501	.402	.231	.505	.009	.420	.517	.858
.609	.482	.809	.140	.396	.325	.937	.310	.253	.761
.971	.824	.902	.470	.997	.392	.892	.957	.640	.463
.053	.899	.554	.627	.427	.760	.470	.240	.304	.393
.810	.159	.225	.163	.549	.405	.285	.542	.231	.919
.081	.277	.035	.039	.860	.507	.081	.538	.986	.501
.982	.468	.334	.921	.690	.806	.879	.414	.106	.931
.095	.801	.576	.417	.251	.884	.522	.235	.398	.222
.509	.025	.794	.850	.917	.387	.751	.608	.698	.683
.371	.059	.164	.838	.289	.169	.569	.377	.796	.996
.165	.996	.356	.375	.654	.379	.815	.592	.348	.743
.477	.535	.137	.155	.767	.187	.579	.787	.358	.595
.788	.101	.434	.638	.021	.894	.324	.871	.698	.539
.566	.815	.622	.549	.947	.169	.817	.472	.854	.466
.901	.342	.873	.964	.942	.985	.123	.086	.335	.212
.470	.682	.412	.064	.150	.962	.925	.355	.909	.019
.068	.242	.667	.356	.195	.313	.396	.460	.740	.247
.874	.420	.127	.284	.448	.215	.833	.652	.601	.326
.897	.877	.209	.862	.428	.117	.100	.259	.425	.284
.875	.969	.109	.843	.759	.239	.890	.317	.428	.302
.190	.696	.757	.283	.666	.491	.523	.665	.919	.146
.341	.688	.587	.908	.865	.333	.328	.404	.892	.696
.846	.355	.831	.218	.945	.364	.673	.305	.195	.387
.882	.227	.552	.077	.454	.731	.716	.265	.058	.075
.464	.658	.629	.269	.069	.998	.917	.217	.220	.659
.123	.791	.503	.447	.659	.463	.994	.307	.631	.422
.116	.120	.721	.137	.263	.176	.798	.879	.432	.391
.836	.206	.914	.574	.870	.390	.104	.755	.082	.939
.636	.193	.614	.486	.629	.663	.619	.007	.296	.456
.630	.673	.665	.666	.399	.592	.441	.649	.270	.612
.804	.112	.331	.606	.551	.928	.830	.841	.602	.183
.360	.193	.181	.399	.564	.772	.890	.062	.919	.875
.183	.651	.157	.150	.800	.875	.205	.446	.648	.985

Random Numbers

- Position of loose mix: longitudinal tonnage and a transverse distance generated by random number.
- Position of core: a transverse distance and a longitudinal distance.
- Distances are determined by random numbers-one for longitudinal (A), one for transverse (B).
- The pair of random numbers are different for each sample location (core or loose mix) QC, or QA.

Random Numbers

- Random Numbers are generated by QA.
- Methods of generating random numbers;
    - By compute (Routines, websites, MoDOT spreadsheet, etc.).
    - Use of random number tables.



Random Numbers

- **Object**: to produce unbiased samples-sample bias occurs either during construction or during sampling.
- **QC** should provide contingencies in QC Plan to handle random numbers in weird locations (does not apply to early tonnage e.g., first 50 tons).

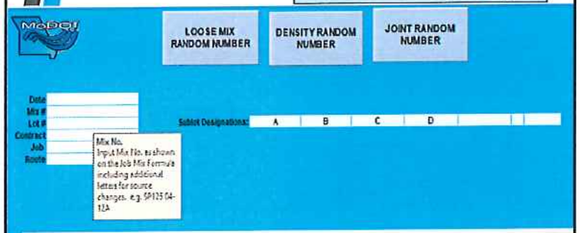
Random Number Generation

- MoDOT spreadsheet is the preferred method.
- Use the "Asphalt Random Location spreadsheet" (FAQ #5).
- MoDOT internal site:

http://eprojects/Template/Forms/AllItems.aspx

MoDOT Spreadsheet

Slides 29 to 33 Enlarged

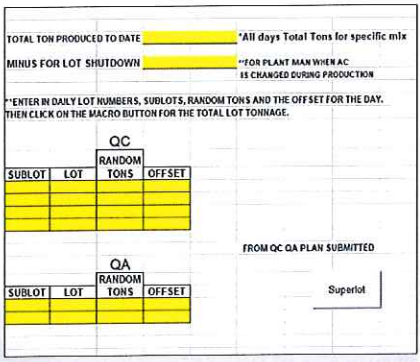


Date
Mix #
Lot #
Contract
Job
Route

Sublot Designations: A B C D

Mix No.
Input Mix No. as shown on the Job Mix Formula including additional letters for source changes. e.g. SP125 04-12A

Set-up Sheet



TOTAL TON PRODUCED TO DATE *All days Total Tons for specific mix

MINUS FOR LOT SHUTDOWN **FOR PLANT MAN WHEN AC IS CHANGED DURING PRODUCTION

**ENTER IN DAILY LOT NUMBERS, SUBLOTS, RANDOM TONS AND THE OFFSET FOR THE DAY. THEN CLICK ON THE MACRO BUTTON FOR THE TOTAL LOT TONNAGE.

QC

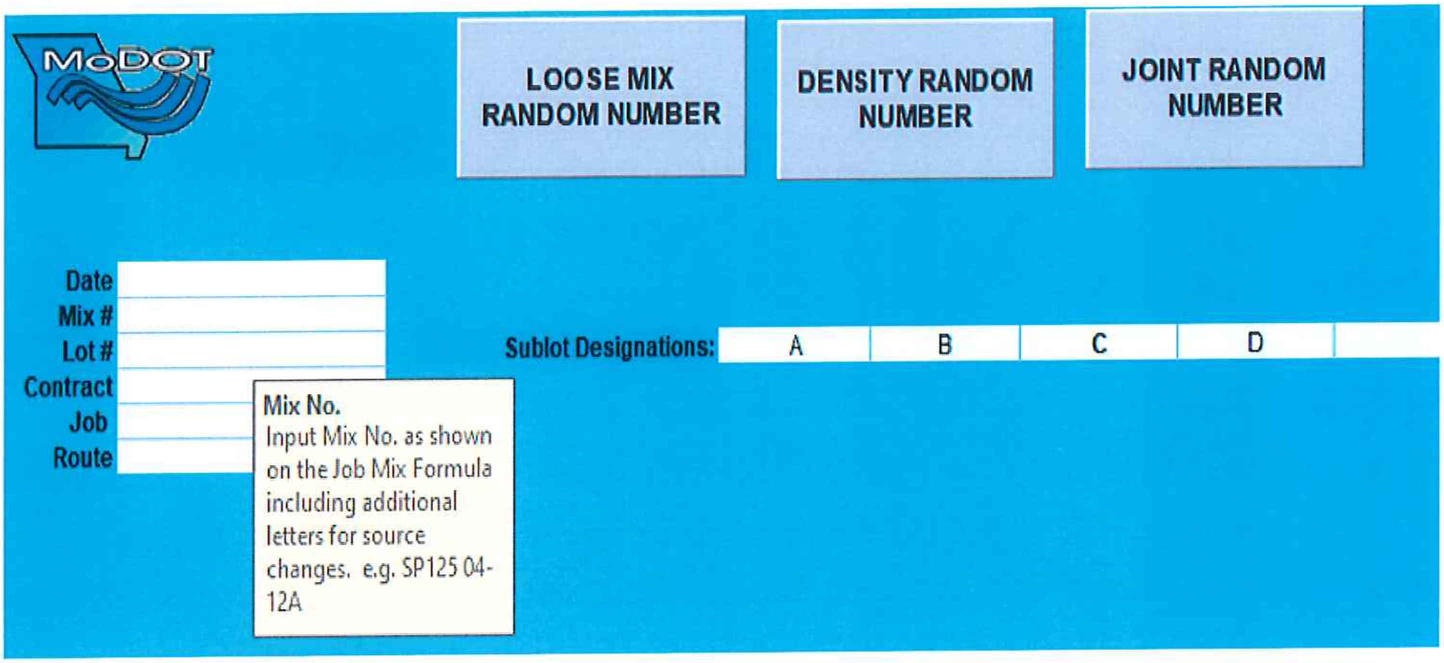
SUBLOT	LOT	RANDOM TONS	OFFSET

FROM QC QA PLAN SUBMITTED

QA

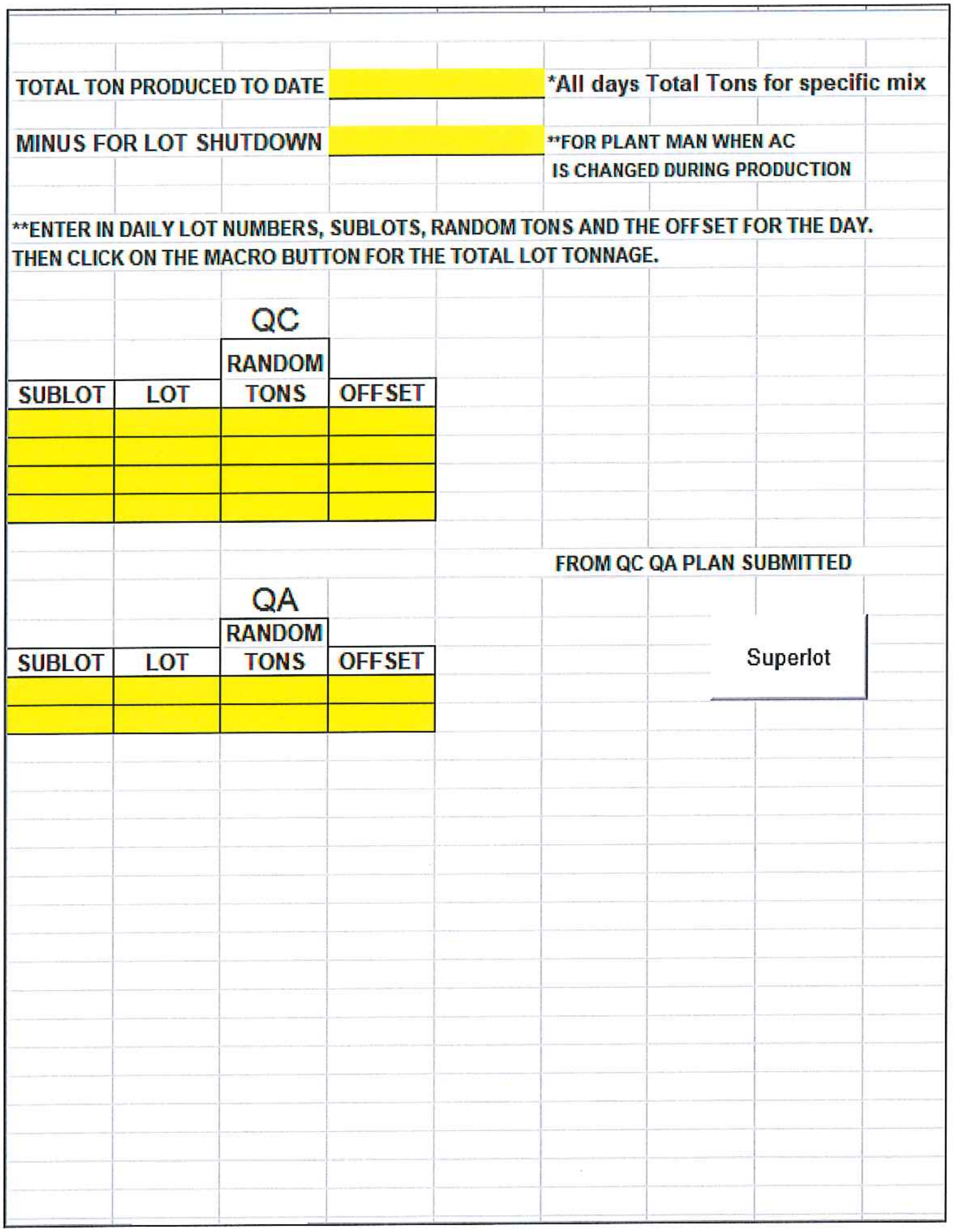
SUBLOT	LOT	RANDOM TONS	OFFSET

MoDOT Spreadsheet



Mix No.
Input Mix No. as shown on the Job Mix Formula including additional letters for source changes. e.g. SP125 04-12A

Set-Up Sheet



TOTAL TON PRODUCED TO DATE *All days Total Tons for specific mix

MINUS FOR LOT SHUTDOWN **FOR PLANT MAN WHEN AC IS CHANGED DURING PRODUCTION

**ENTER IN DAILY LOT NUMBERS, SUBLOTS, RANDOM TONS AND THE OFFSET FOR THE DAY. THEN CLICK ON THE MACRO BUTTON FOR THE TOTAL LOT TONNAGE.

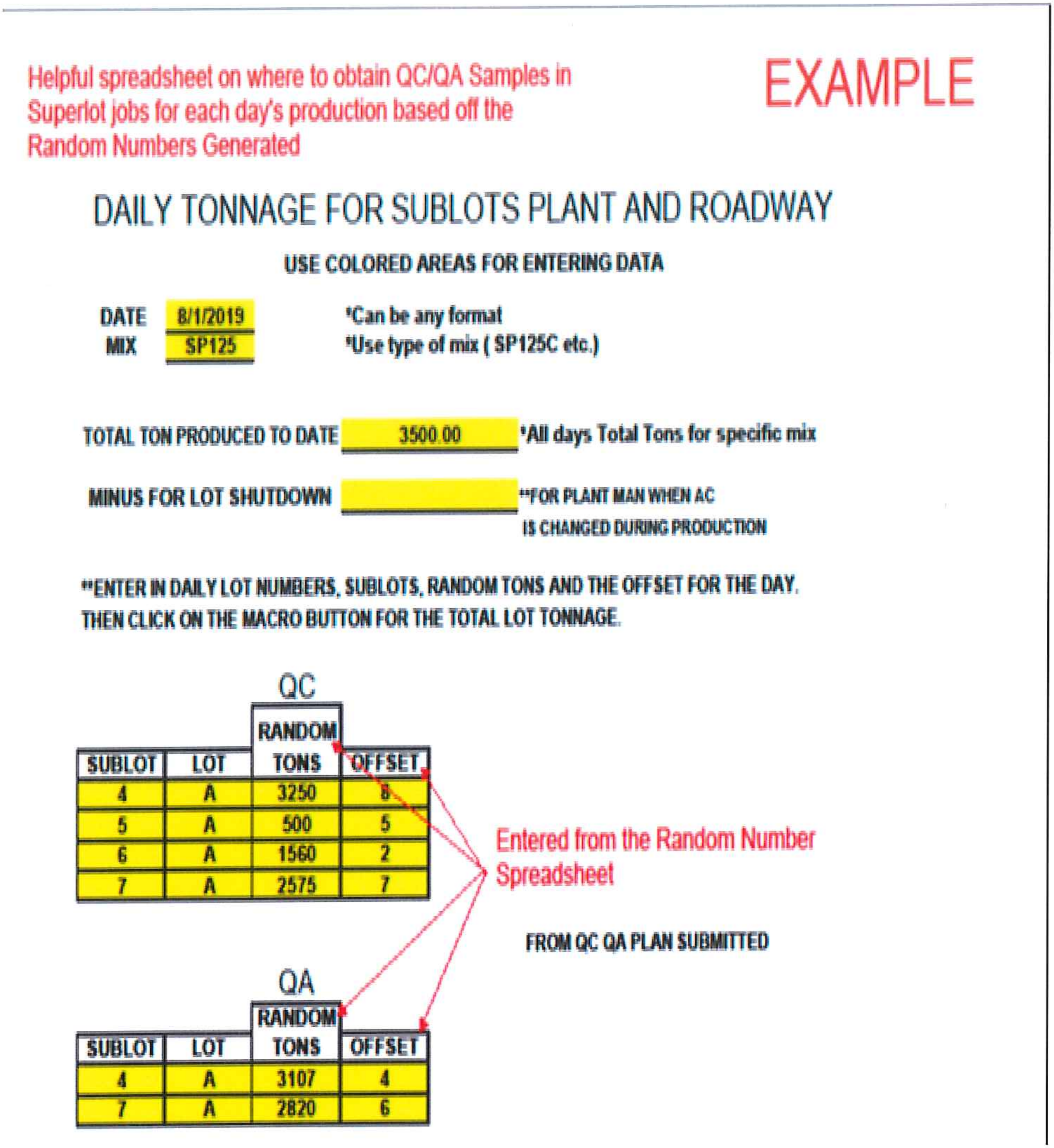
QC

SUBLOT	LOT	RANDOM TONS	OFFSET

FROM QC QA PLAN SUBMITTED

QA

SUBLOT	LOT	RANDOM TONS	OFFSET



Helpful spreadsheet on where to obtain QC/QA Samples in Superlot jobs for each day's production based off the Random Numbers Generated

EXAMPLE

DAILY TONNAGE FOR SUBLOTS PLANT AND ROADWAY

USE COLORED AREAS FOR ENTERING DATA

DATE 8/1/2019 *Can be any format

MIX SP125 *Use type of mix (SP125C etc.)

TOTAL TON PRODUCED TO DATE 3500.00 *All days Total Tons for specific mix

MINUS FOR LOT SHUTDOWN **FOR PLANT MAN WHEN AC IS CHANGED DURING PRODUCTION

**ENTER IN DAILY LOT NUMBERS, SUBLOTS, RANDOM TONS AND THE OFFSET FOR THE DAY. THEN CLICK ON THE MACRO BUTTON FOR THE TOTAL LOT TONNAGE.

QC

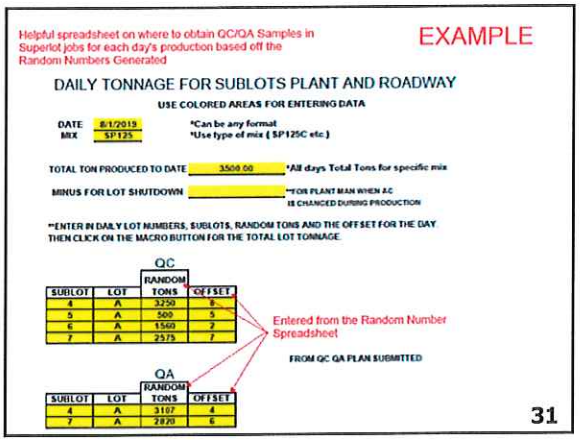
SUBLOT	LOT	RANDOM TONS	OFFSET
4	A	3250	8
5	A	500	5
6	A	1560	2
7	A	2575	7

Entered from the Random Number Spreadsheet

FROM QC QA PLAN SUBMITTED

QA

SUBLOT	LOT	RANDOM TONS	OFFSET
4	A	3107	4
7	A	2820	6



Helpful spreadsheet on where to obtain QC/QA Samples in Superlot jobs for each day's production based off the Random Numbers Generated

EXAMPLE

DAILY TONNAGE FOR SUBLOTS PLANT AND ROADWAY

USE COLORED AREAS FOR ENTERING DATA

DATE 8/1/2019 *Can be any format
MIX SP125 *Use type of mix (SP125C etc)

TOTAL TON PRODUCED TO DATE 3500.00 *All days Total Tons for specific mix

MINUS FOR LOT SHUTDOWN **FOR PLANT MAN WHEN AC IS CHANGED DURING PRODUCTION

**ENTER IN DAILY LOT NUMBERS, SUBLOTS, RANDOM TONS AND THE OFFSET FOR THE DAY THEN CLICK ON THE MACRO BUTTON FOR THE TOTAL LOT TONNAGE

QC

SUBLOT	LOT	RANDOM TONS	OFFSET
4	A	3250	8
5	A	500	5
6	A	1560	2
7	A	2575	7

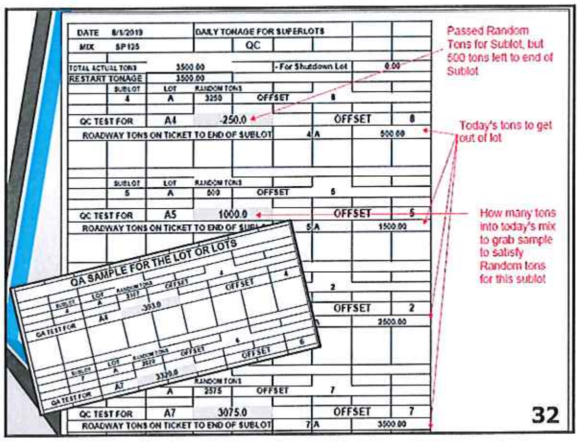
Entered from the Random Number Spreadsheet

FROM QC QA PLAN SUBMITTED

QA

SUBLOT	LOT	RANDOM TONS	OFFSET
4	A	3107	4
7	A	2820	6

31



DATE 8/1/2019 DAILY TONAGE FOR SUPERLOTS
MIX SP125 QC
TOTAL ACTUAL TONS 3500.00 - For Shutdown Lot 0.00
RESTART TONAGE 3500.00

SUBLOT 4 LOT A RANDOM TONS 3250 OFFSET 8
QC TEST FOR A4 -250.0 OFFSET 8
ROADWAY TONS ON TICKET TO END OF SUBLOT 4 A 500.00

SUBLOT 5 LOT A RANDOM TONS 500 OFFSET 5
QC TEST FOR A5 1000.0 OFFSET 5
ROADWAY TONS ON TICKET TO END OF SUBLOT 5 A 1500.00

2
OFFSET 2
2500.00

RANDOM TONS A 2575 OFFSET 7
QC TEST FOR A7 3075.0 OFFSET 7
ROADWAY TONS ON TICKET TO END OF SUBLOT 7 A 3500.00

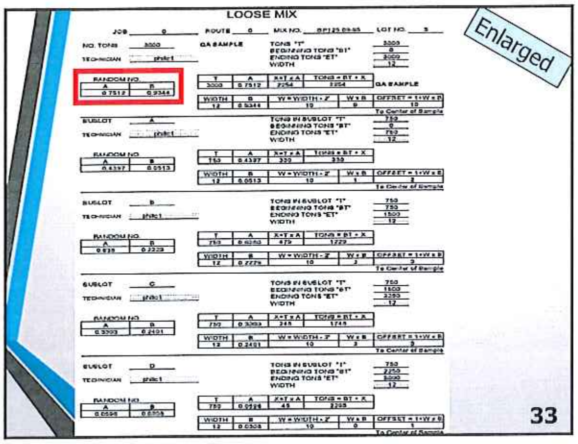
QA SAMPLE FOR THE LOT OR LOTS
SUBLOT 4 LOT A RANDOM TONS 3107 OFFSET 4 OFFSET 4
QA TEST FOR A4 -393.0
SUBLOT 7 LOT A RANDOM TONS 2820 OFFSET 6 OFFSET 6
QA TEST FOR A7 3320.0

Passed Random Tons for Sublot, but 500 tons left to end of Sublot

Today's tons to get out of lot

How many tons into today's mix to grab sample to satisfy Random tons for this sublot

32



Enlarged

LOOSE MIX

JOB 0 ROUTE 0 MIX NO. SP125 09-65 LOT NO. 5
NO. TONS 3000 QA SAMPLE
TECHNICIAN philc1
TONS "T" 3000
BEGINNING TONS "BT" 0
ENDING TONS "ET" 3000
WIDTH 12

RANDOM NO. A 0.7512 B 0.9344

T	A	X=T x A	TONS = BT + X
3000	0.7512	2254	2254

QA SAMPLE

WIDTH	B	W = WIDTH - 2'	W x B	OFFSET = 1+W x B
12	0.9344	10	9	10

To Center of Sample

SUBLOT A
TECHNICIAN philc1
TONS IN SUBLOT "T" 750
BEGINNING TONS "BT" 0
ENDING TONS "ET" 750
WIDTH 12

RANDOM NO. A 0.4397 B 0.0513

T	A	X=T x A	TONS = BT + X
750	0.4397	330	330

WIDTH	B	W = WIDTH - 2'	W x B	OFFSET = 1+W x B
12	0.0513	10	1	2

To Center of Sample

SUBLOT B
TECHNICIAN philc1
TONS IN SUBLOT "T" 750
BEGINNING TONS "BT" 750
ENDING TONS "ET" 1500
WIDTH 12

RANDOM NO. A 0.639 B 0.2229

T	A	X=T x A	TONS = BT + X
750	[illegible]	479	1229

WIDTH	B	W = WIDTH - 2'	W x B	OFFSET = 1+W x B
12	0.2229	10	2	3

To Center of Sample

SUBLOT C
TECHNICIAN philc1
TONS IN SUBLOT "T" 750
BEGINNING TONS "BT" 1500
ENDING TONS "ET" 2250
WIDTH 12

RANDOM NO. A 0.3303 B 0.2401

T	A	X=T x A	TONS = BT + X
750	0.3303	248	1748

WIDTH	B	W = WIDTH - 2'	W x B	OFFSET = 1+W x B
12	0.2401	10	2	3

To Center of Sample

SUBLOT D
TECHNICIAN philc1
TONS IN SUBLOT "T" 750
BEGINNING TONS "BT" 2250
ENDING TONS "ET" 3000
WIDTH 12

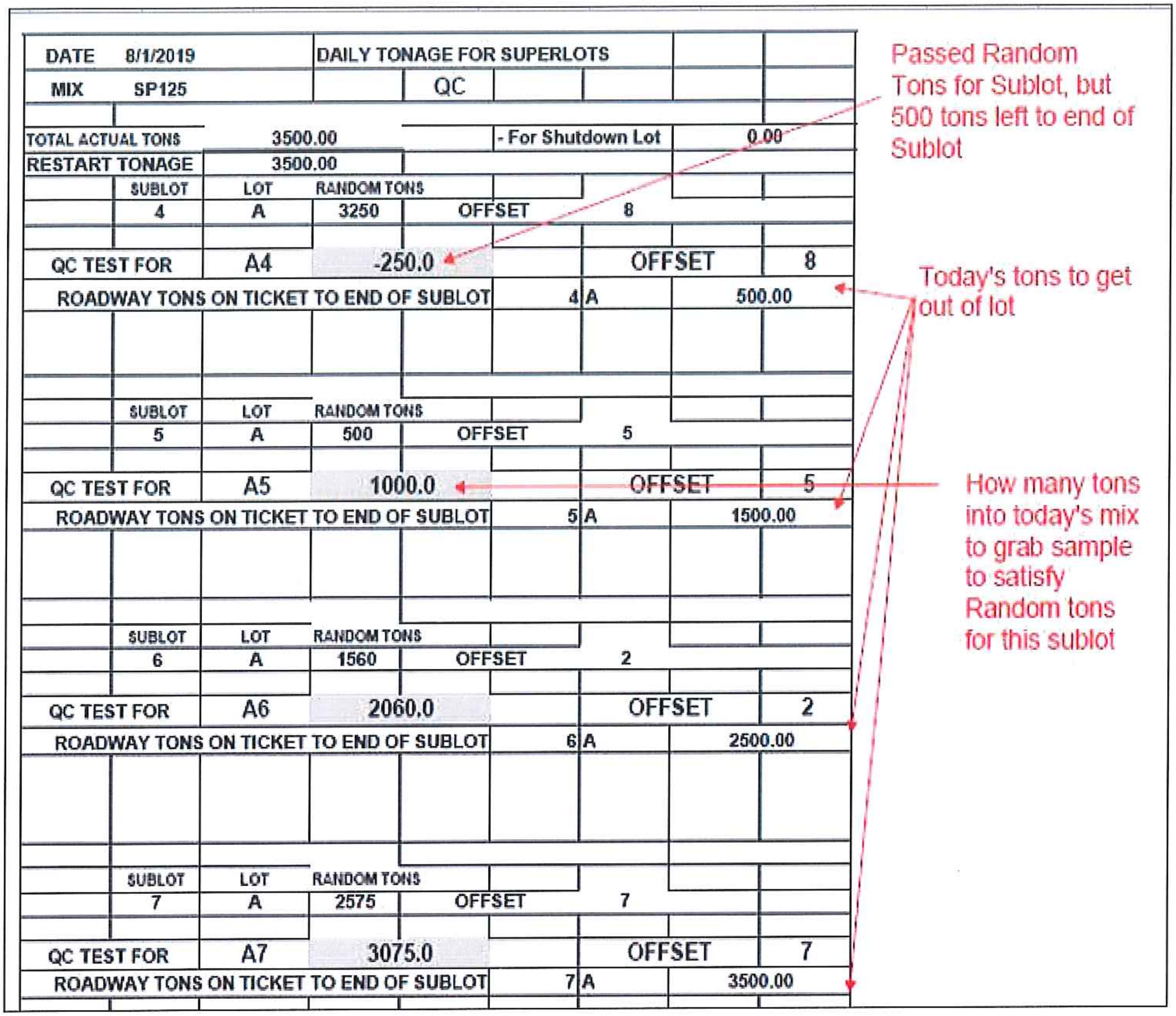
RANDOM NO. A 0.0596 B 0.0308

T	A	X=T x A	TONS = BT + X
750	0.0596	45	2295

WIDTH	B	W = WIDTH - 2'	W x B	OFFSET = 1+W x B
12	0.0308	10	0	1

To Center of Sample

33

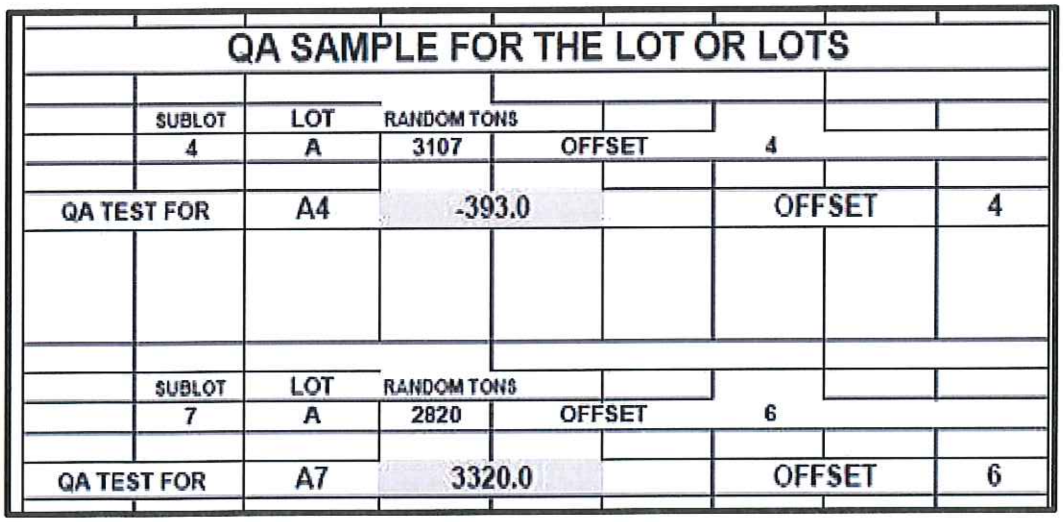


DATE 8/1/2019			DAILY TONAGE FOR SUPERLOTS		
MIX SP125			QC		
TOTAL ACTUAL TONS		3500.00	- For Shutdown Lot		0.00
RESTART TONAGE		3500.00			
	SUBLOT	LOT	RANDOM TONS		
	4	A	3250	OFFSET	8
QC TEST FOR		A4	-250.0	OFFSET	8
ROADWAY TONS ON TICKET TO END OF SUBLOT			4 A		500.00
	SUBLOT	LOT	RANDOM TONS		
	5	A	500	OFFSET	5
QC TEST FOR		A5	1000.0	OFFSET	5
ROADWAY TONS ON TICKET TO END OF SUBLOT			5 A		1500.00
	SUBLOT	LOT	RANDOM TONS		
	6	A	1560	OFFSET	2
QC TEST FOR		A6	2060.0	OFFSET	2
ROADWAY TONS ON TICKET TO END OF SUBLOT			6 A		2500.00
	SUBLOT	LOT	RANDOM TONS		
	7	A	2575	OFFSET	7
QC TEST FOR		A7	3075.0	OFFSET	7
ROADWAY TONS ON TICKET TO END OF SUBLOT			7 A		3500.00

Passed Random Tons for Sublot, but 500 tons left to end of Sublot

Today's tons to get out of lot

How many tons into today's mix to grab sample to satisfy Random tons for this sublot



QA SAMPLE FOR THE LOT OR LOTS

	SUBLOT	LOT	RANDOM TONS		
	4	A	3107	OFFSET	4
QA TEST FOR		A4	-393.0	OFFSET	4
	SUBLOT	LOT	RANDOM TONS		
	7	A	2820	OFFSET	6
QA TEST FOR		A7	3320.0	OFFSET	6

LOOSE MIX

JOB 0 ROUTE 0 MIX NO. SP125 09-95 LOT NO. 5

NO. TONS 3000

TECHNICIAN phillc1

QA SAMPLE

TONS "T" 3000
BEGINNING TONS "BT" 0
ENDING TONS "ET" 3000
WIDTH 12

RANDOM NO.

A	B
0.7512	0.9344

T	A	X=T x A	TONS = BT + X
3000	0.7512	2254	2254

QA SAMPLE

WIDTH	B	W = WIDTH - 2'	W x B	OFFSET = 1+W x B
12	0.9344	10	9	10

To Center of Sample

SUBLOT A

TECHNICIAN phillc1

TONS IN SUBLOT "T" 750
BEGINNING TONS "BT" 0
ENDING TONS "ET" 750
WIDTH 12

RANDOM NO.

A	B
0.4397	0.0513

T	A	X=T x A	TONS = BT + X
750	0.4397	330	330

WIDTH	B	W = WIDTH - 2'	W x B	OFFSET = 1+W x B
12	0.0513	10	1	2

To Center of Sample

SUBLOT B

TECHNICIAN phillc1

TONS IN SUBLOT "T" 750
BEGINNING TONS "BT" 750
ENDING TONS "ET" 1500
WIDTH 12

RANDOM NO.

A	B
0.638	0.2229

T	A	X=T x A	TONS = BT + X
750	0.6380	479	1229

WIDTH	B	W = WIDTH - 2'	W x B	OFFSET = 1+W x B
12	0.2229	10	2	3

To Center of Sample

SUBLOT C

TECHNICIAN phillc1

TONS IN SUBLOT "T" 750
BEGINNING TONS "BT" 1500
ENDING TONS "ET" 2250
WIDTH 12

RANDOM NO.

A	B
0.3303	0.2401

T	A	X=T x A	TONS = BT + X
750	0.3303	248	1748

WIDTH	B	W = WIDTH - 2'	W x B	OFFSET = 1+W x B
12	0.2401	10	2	3

To Center of Sample

SUBLOT D

TECHNICIAN phillc1

TONS IN SUBLOT "T" 750
BEGINNING TONS "BT" 2250
ENDING TONS "ET" 3000
WIDTH 12

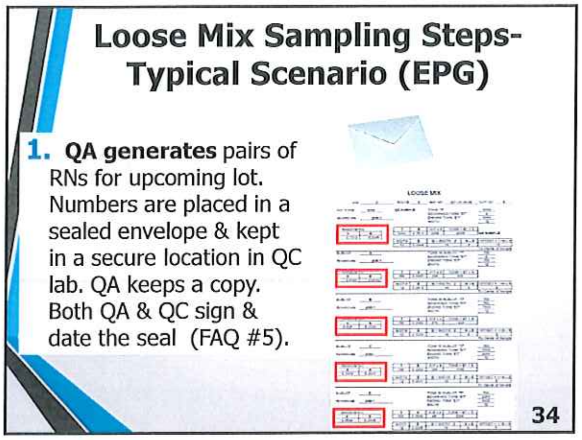
RANDOM NO.

A	B
0.0596	0.0308

T	A	X=T x A	TONS = BT + X
750	0.0596	45	2295

WIDTH	B	W = WIDTH - 2'	W x B	OFFSET = 1+W x B
12	0.0308	10	0	1

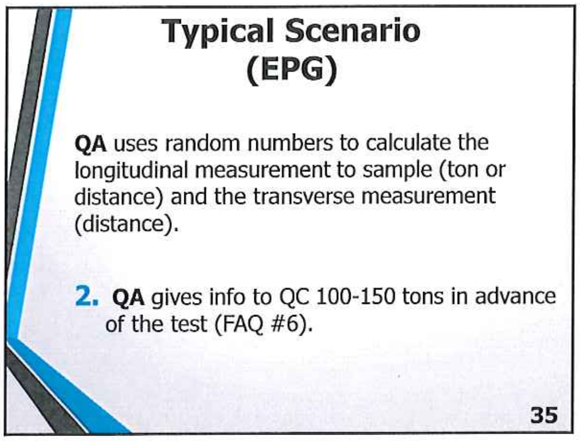
To Center of Sample



Loose Mix Sampling Steps- Typical Scenario (EPG)

1. **QA generates** pairs of RNs for upcoming lot. Numbers are placed in a sealed envelope & kept in a secure location in QC lab. QA keeps a copy. Both QA & QC sign & date the seal (FAQ #5).

34

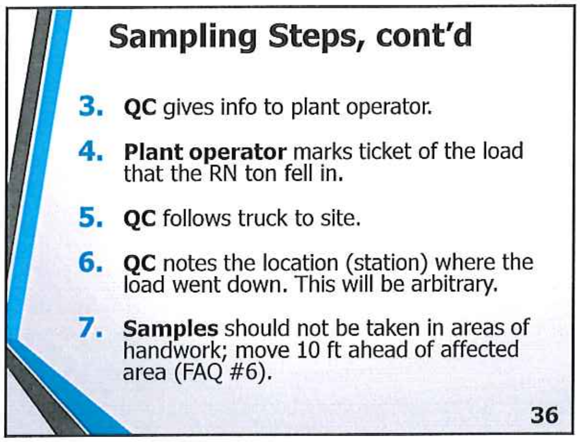


Typical Scenario (EPG)

QA uses random numbers to calculate the longitudinal measurement to sample (ton or distance) and the transverse measurement (distance).

2. **QA** gives info to QC 100-150 tons in advance of the test (FAQ #6).

35



Sampling Steps, cont'd

3. **QC** gives info to plant operator.
4. **Plant operator** marks ticket of the load that the RN ton fell in.
5. **QC** follows truck to site.
6. **QC** notes the location (station) where the load went down. This will be arbitrary.
7. **Samples** should not be taken in areas of handwork; move 10 ft ahead of affected area (FAQ #6).

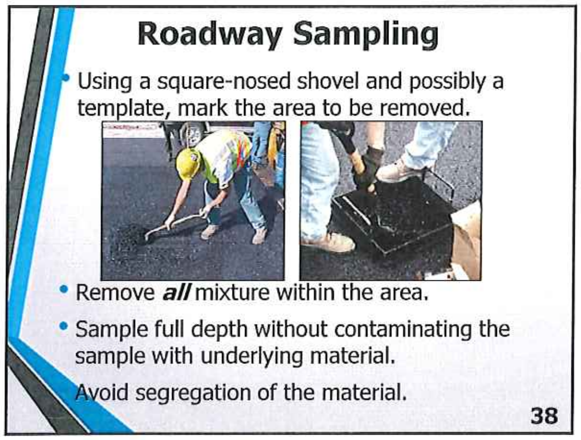
36

Sampling Steps, cont'd

8. **QC** measures transversely from edge of mat to the sampling location, if possible, away from traffic, once defined keep consistent.

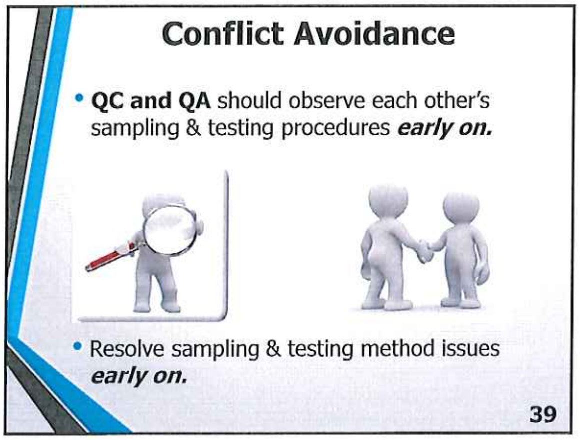
9. **Loose mix** is removed from roadway.

10. **QC** places sample in insulated container and transports it to mobile lab.



Roadway Sampling

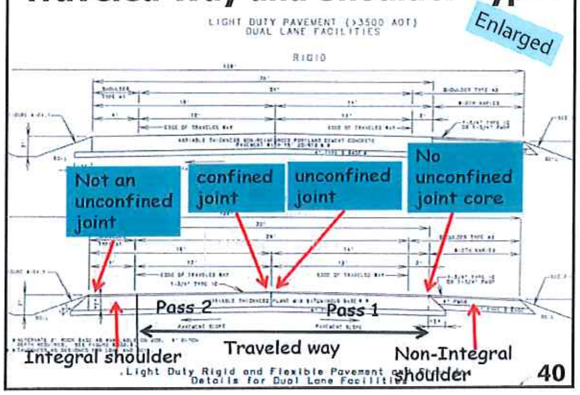
- Using a square-nosed shovel and possibly a template, mark the area to be removed.
- Remove *all* mixture within the area.
- Sample full depth without contaminating the sample with underlying material.
- Avoid segregation of the material.



Conflict Avoidance

- **QC and QA** should observe each other's sampling & testing procedures ***early on.***
- Resolve sampling & testing method issues ***early on.***

Traveled Way and Shoulder Types



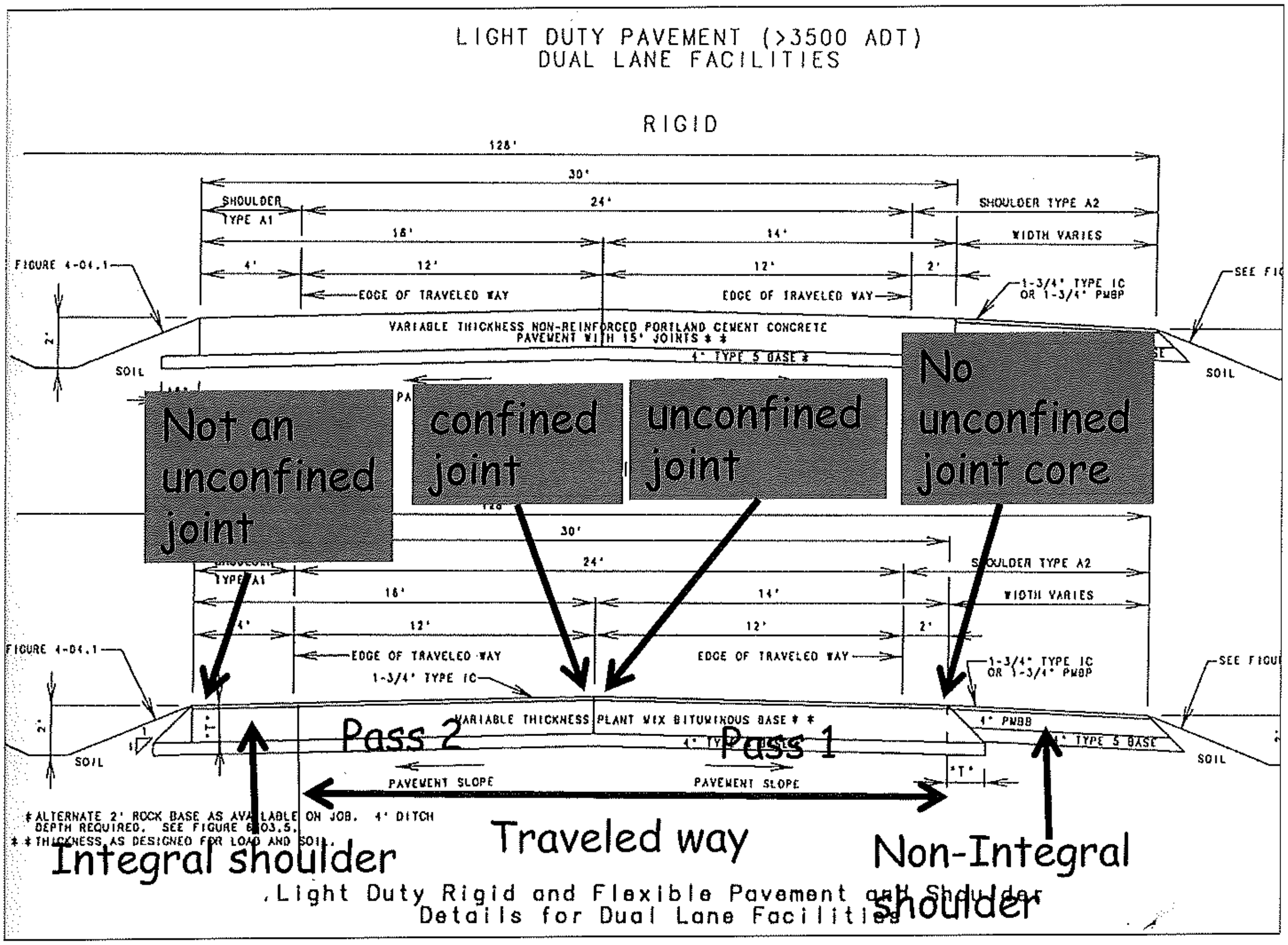
Types of Cores

- **QLA cores**----QLA Pay Factor.
- **Longitudinal unconfined joint density cores**----Pay Adjustment Factor.
- **Non-integral shoulder cores**---Pay Adjustment Factor.

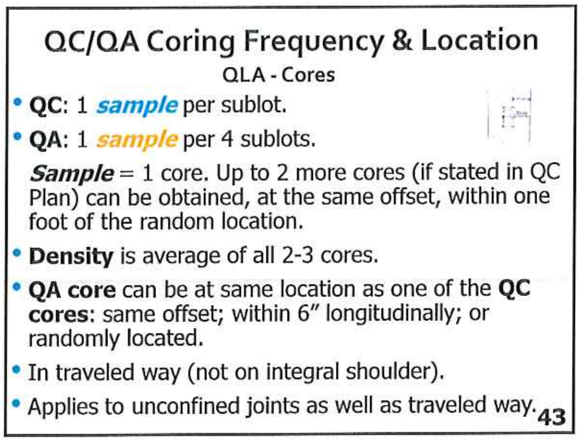
Types of Cores

- **QLA**
- **Non-integral shoulders**
- **Unconfined joints**

Traveled Way and Shoulder Types



Light Duty Rigid and Flexible Pavement and Shoulder Details for Dual Lane Facilities



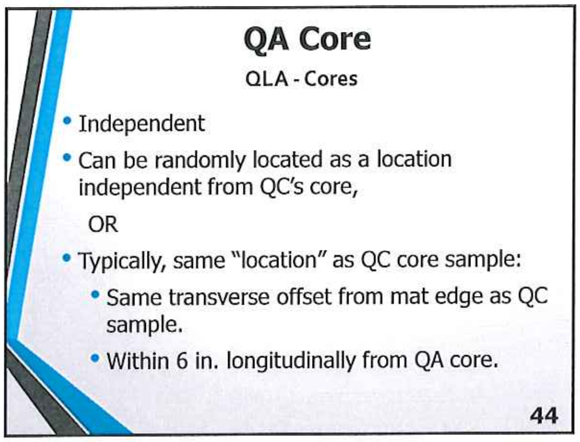
QC/QA Coring Frequency & Location

QLA - Cores

- **QC**: 1 ***sample*** per sublot.
- **QA**: 1 ***sample*** per 4 sublots.

Sample = 1 core. Up to 2 more cores (if stated in QC Plan) can be obtained, at the same offset, within one foot of the random location.

- **Density** is average of all 2-3 cores.
- **QA core** can be at same location as one of the **QC cores**: same offset; within 6″ longitudinally; or randomly located.
- In traveled way (not on integral shoulder).
- Applies to unconfined joints as well as traveled way.



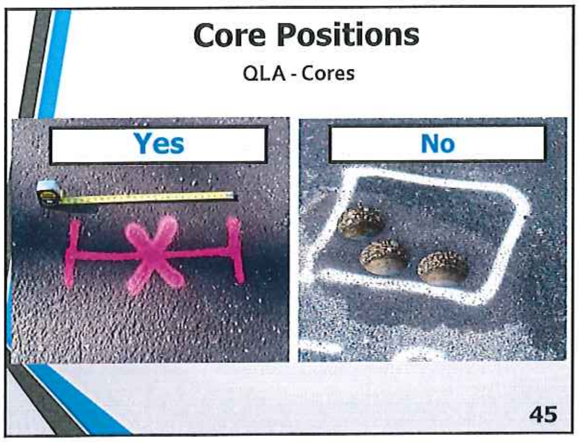
QA Core

QLA - Cores

- Independent
- Can be randomly located as a location independent from QC's core,

OR

- Typically, same "location" as QC core sample:
  - Same transverse offset from mat edge as QC sample.
  - Within 6 in. longitudinally from QA core.



Core Positions

QLA - Cores

Yes

No

Coring

QLA - Cores

403.22.4.2 – Density core holes should be patched promptly to prevent moisture intrusion and damage to the pavement.

Extra QC Cores

QLA - Cores

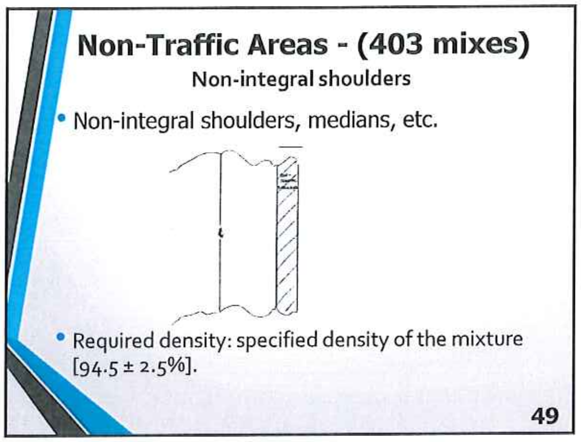
- Recommended that QA witness extra coring to avoid questions about unidentified holes.

Thick Lifts

QLA - Cores

- If mix is placed in lifts ≥ 6 x NMS, cores should be cut in half & density determined separately
- **Example**:SP250 NMS= 1", 6" mat

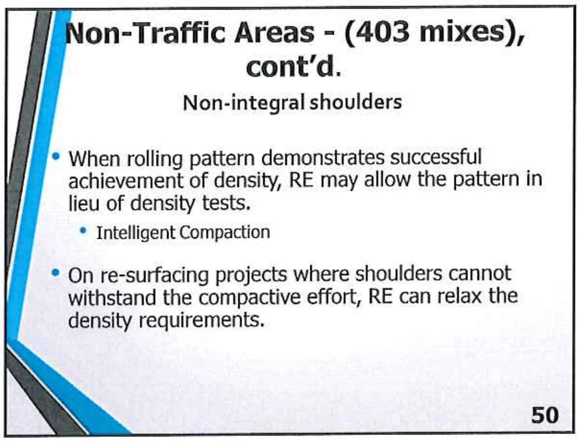
- **PF density** will be based on N = 8, not N = 4



Non-Traffic Areas - (403 mixes)

Non-integral shoulders

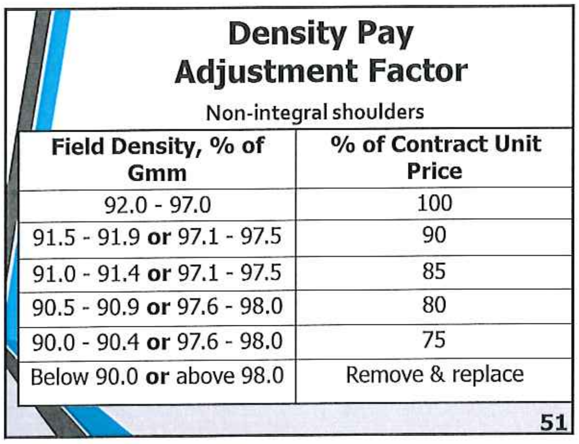
- Non-integral shoulders, medians, etc.
- Required density: specified density of the mixture [94.5 ± 2.5%].



Non-Traffic Areas - (403 mixes), cont'd.

Non-integral shoulders

- When rolling pattern demonstrates successful achievement of density, RE may allow the pattern in lieu of density tests.
  - Intelligent Compaction
- On re-surfacing projects where shoulders cannot withstand the compactive effort, RE can relax the density requirements.



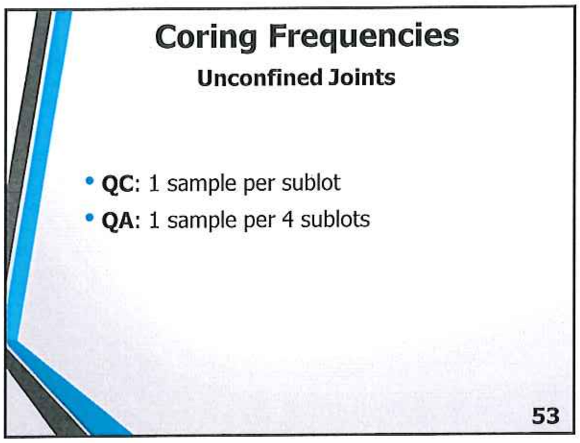
Density Pay Adjustment Factor

Non-integral shoulders

Field Density, % of Gmm	% of Contract Unit Price
92.0 - 97.0	100
91.5 - 91.9 **or** 97.1 - 97.5	90
91.0 - 91.4 **or** 97.1 - 97.5	85
90.5 - 90.9 **or** 97.6 - 98.0	80
90.0 - 90.4 **or** 97.6 - 98.0	75
Below 90.0 **or** above 98.0	Remove & replace

LONGITUDINAL JOINT

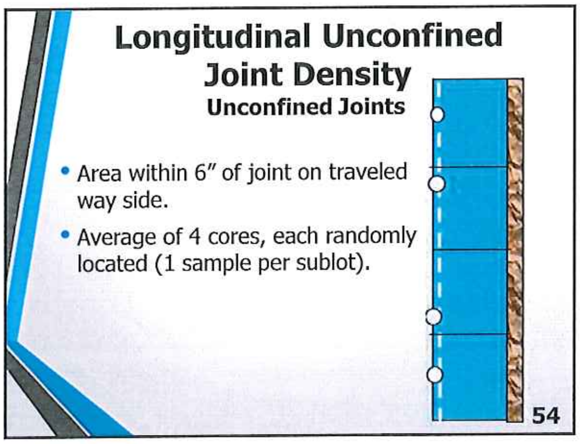
Unconfined Joints



Coring Frequencies

Unconfined Joints

- **QC**: 1 sample per sublot
- **QA**: 1 sample per 4 sublots



Longitudinal Unconfined Joint Density

Unconfined Joints

- Area within 6″ of joint on traveled way side.
- Average of 4 cores, each randomly located (1 sample per sublot).

Longitudinal Unconfined Joint Density

Unconfined Joints

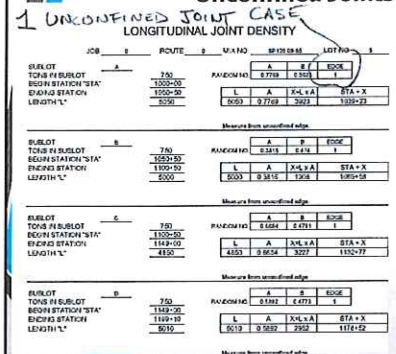
- Typically use the same longitudinal location as the mat density cores or can generate new random locations.

Longitudinal Joint Density

Unconfined Joints

Enlarged

1 UNCONFINED JOINT CASE



LONGITUDINAL JOINT DENSITY

JOB [illegible] ROUTE [illegible] MIX NO [illegible] LOT NO [illegible]

SUBLOT A
TONS IN SUBLOT 750
BEGIN STATION "STA" 1000+00
ENDING STATION 1050+50
LENGTH "L" 5050

	A	B	EDGE
RANDOM NO	0.7769	[illegible]	1

L	A	X=L x A	STA + X
5050	0.7769	3923	1039+23

Measure from unconfined edge.

SUBLOT B
TONS IN SUBLOT 750
BEGIN STATION "STA" 1050+50
ENDING STATION 1100+50
LENGTH "L" 5000

	A	B	EDGE
RANDOM NO	0.3815	[illegible]	1

L	A	X=L x A	STA + X
5000	0.3815	1908	1069+58

Measure from unconfined edge.

SUBLOT C
TONS IN SUBLOT 750
BEGIN STATION "STA" 1100+50
ENDING STATION 1149+00
LENGTH "L" 4850

	A	B	EDGE
RANDOM NO	0.6654	[illegible]	1

L	A	X=L x A	STA + X
4850	0.6654	3227	1132+77

Measure from unconfined edge.

SUBLOT D
TONS IN SUBLOT 750
BEGIN STATION "STA" 1149+00
ENDING STATION 1199+10
LENGTH "L" 5010

	A	B	EDGE
RANDOM NO	0.5892	[illegible]	1

L	A	X=L x A	STA + X
5010	0.5892	2952	1178+52

Measure from unconfined edge.

NOTE:
Must alternate sides if have 2 unconfined joints.

Confined Joints

- Density on confined joints is handled with the traveled way coring. Required density is same as for the traveled way.
- 94.5 ± 2.5% for non-SMA.
- 94.0% minimum for SMA.

LONGITUDINAL JOINT DENSITY

1 UNCONFINED JOINT CASE

LONGITUDINAL JOINT DENSITY

JOB 0 ROUTE 0 MIX NO. SP125 09-95 LOT NO. 5

SUBLOT A
TONS IN SUBLOT 750
BEGIN STATION "STA" 1000+00
ENDING STATION 1050+50
LENGTH "L" 5050

	A	B	EDGE
RANDOM NO.	0.7769	0.5033	1

L	A	X=L x A	STA + X
5050	0.7769	3923	1039+23

Measure from unconfined edge.

SUBLOT B
TONS IN SUBLOT 750
BEGIN STATION "STA" 1050+50
ENDING STATION 1100+50
LENGTH "L" 5000

	A	B	EDGE
RANDOM NO.	0.3816	0.474	1

L	A	X=L x A	STA + X
5000	0.3816	1908	1069+58

Measure from unconfined edge.

SUBLOT C
TONS IN SUBLOT 750
BEGIN STATION "STA" 1100+50
ENDING STATION 1149+00
LENGTH "L" 4850

	A	B	EDGE
RANDOM NO.	0.6654	0.4791	1

L	A	X=L x A	STA + X
4850	0.6654	3227	1132+77

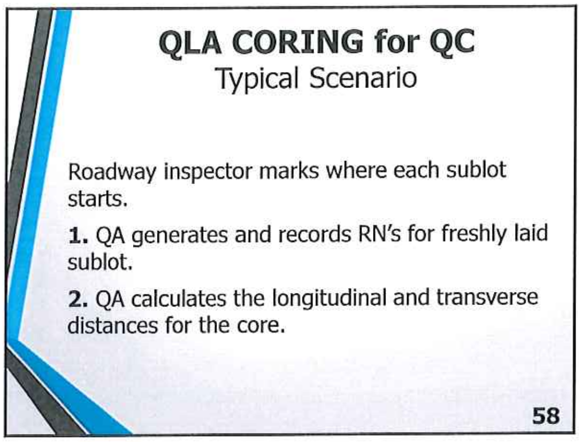
Measure from unconfined edge.

SUBLOT D
TONS IN SUBLOT 750
BEGIN STATION "STA" 1149+00
ENDING STATION 1199+10
LENGTH "L" 5010

	A	B	EDGE
RANDOM NO.	0.5892	0.4773	1

L	A	X=L x A	STA + X
5010	0.5892	2952	1178+52

Measure from unconfined edge



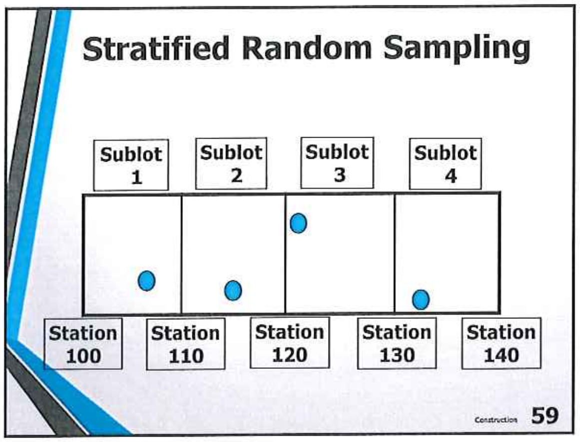
QLA CORING for QC

Typical Scenario

Roadway inspector marks where each sublot starts.

1. QA generates and records RN's for freshly laid sublot.

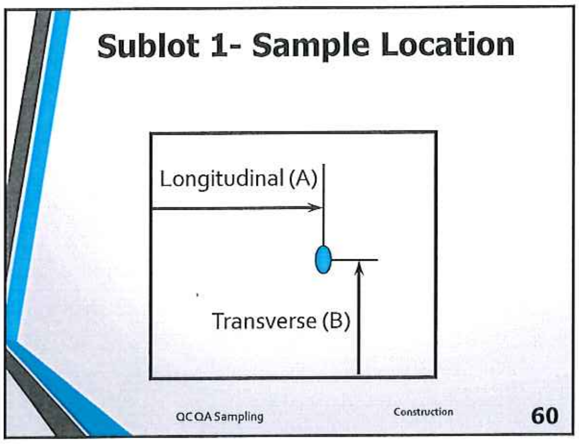
2. QA calculates the longitudinal and transverse distances for the core.



Stratified Random Sampling

Sublot 1
Sublot 2
Sublot 3
Sublot 4

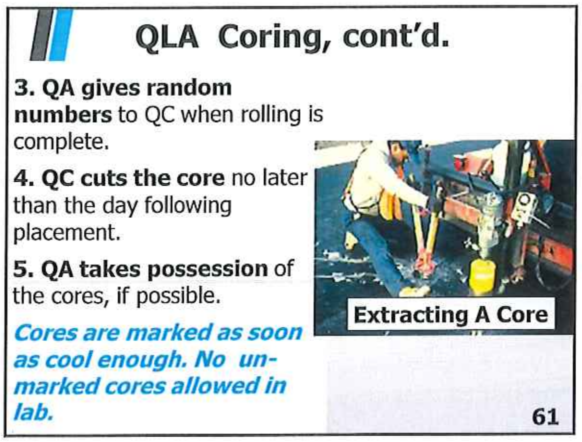
Station 100
Station 110
Station 120
Station 130
Station 140



Sublot 1- Sample Location

Longitudinal (A)

Transverse (B)



QLA Coring, cont'd.

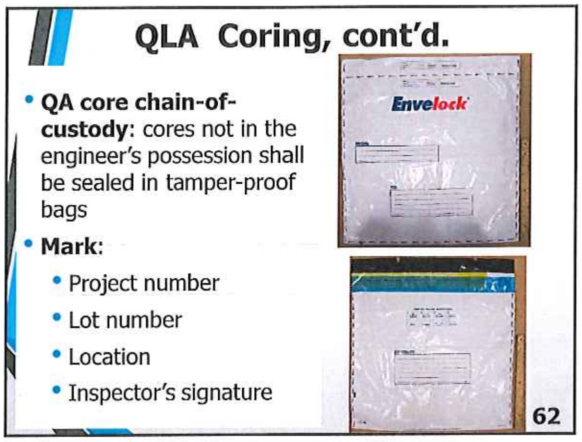
3. QA gives random numbers to QC when rolling is complete.

4. QC cuts the core no later than the day following placement.

5. QA takes possession of the cores, if possible.

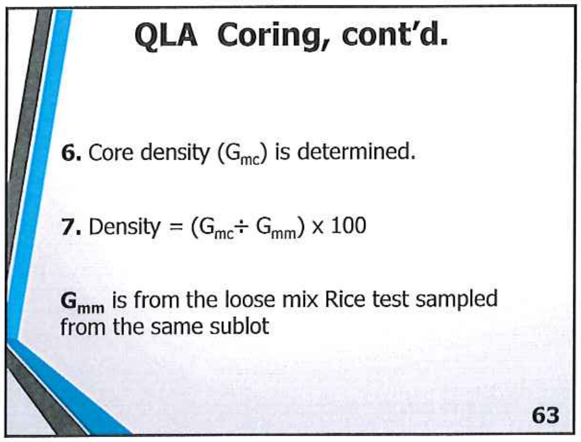
Cores are marked as soon as cool enough. No un-marked cores allowed in lab.

Extracting A Core



QLA Coring, cont'd.

- **QA core chain-of-custody**: cores not in the engineer's possession shall be sealed in tamper-proof bags
- **Mark:**
  - Project number
  - Lot number
  - Location
  - Inspector's signature



QLA Coring, cont'd.

6. Core density (G_{mc}) is determined.

7. Density = ($G_{mc} \div G_{mm}$) x 100

G_{mm} is from the loose mix Rice test sampled from the same sublot

Stations

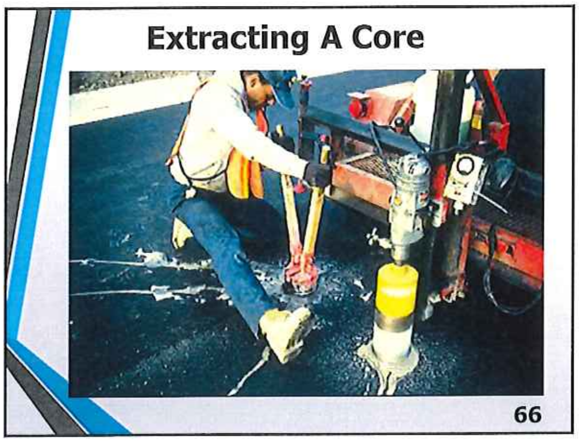
- Longitudinal distance may be in "stations" = 100 ft.
- 5010 ft= 50 stations+ 10 ft or " station 50+10".

Stationing Example

- Beginning station = 1200+00
- Add 5238 ft= 52+38
- Ending station:

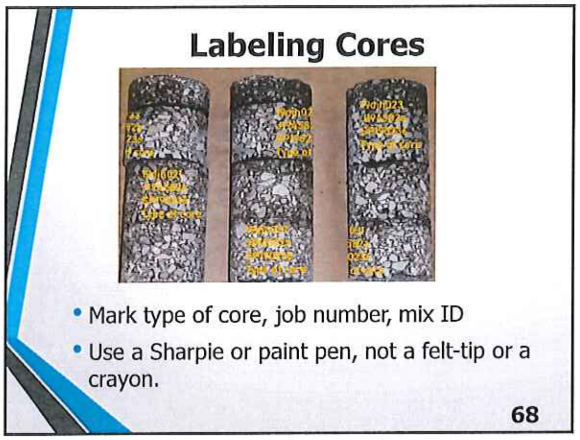
1200+00
52+38
1252+38

Extracting A Core



Procedure

- Avoid distorting or cracking of the cores during and after removal from pavement.
- Cores should be free from seal coats, soil, paper, paint, any other foreign materials.
- Cores may be separated from other pavement lifts by sawing or other appropriate methods.
- Cores should be allowed to air dry overnight (12 hr minimum) to a constant weight (checking at 2 hr intervals) as per T 166.
- Some contractors report less variability with 6" diameter cores.

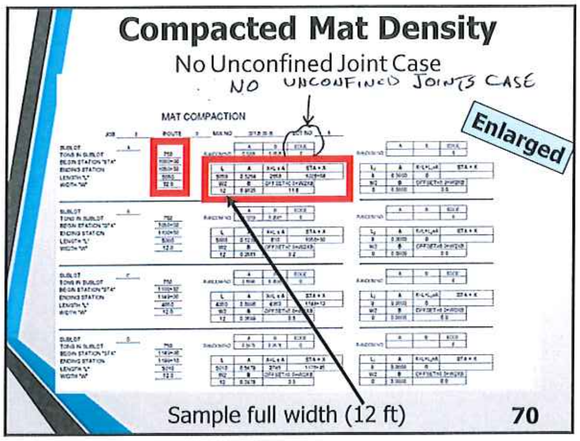


Labeling Cores

- Mark type of core, job number, mix ID
- Use a Sharpie or paint pen, not a felt-tip or a crayon.

Coring Examples

- No unconfined joints
- One unconfined joint
- Two unconfined joints

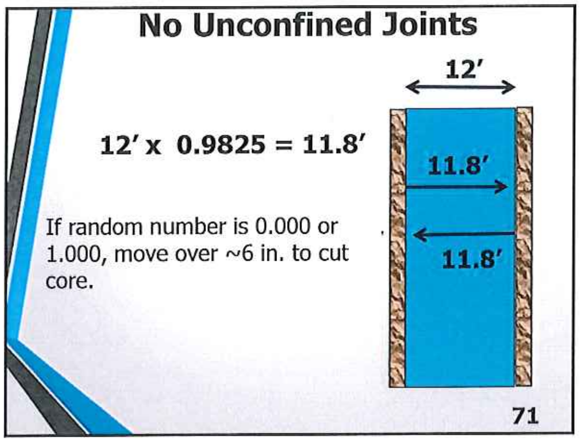


Compacted Mat Density

No Unconfined Joint Case

NO UNCONFINED JOINTS CASE

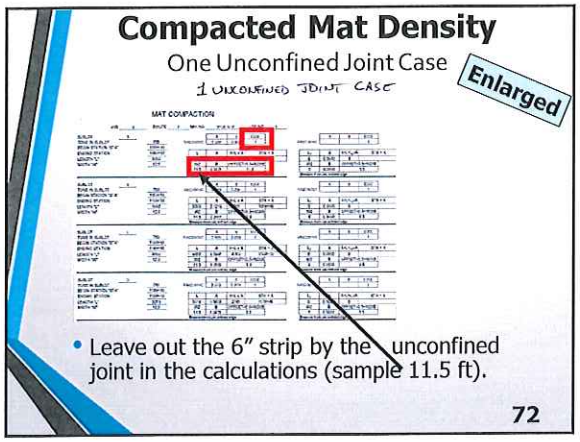
Sample full width (12 ft)



No Unconfined Joints

$12' \times 0.9825 = 11.8'$

If random number is 0.000 or 1.000, move over ~6 in. to cut core.



Compacted Mat Density

One Unconfined Joint Case

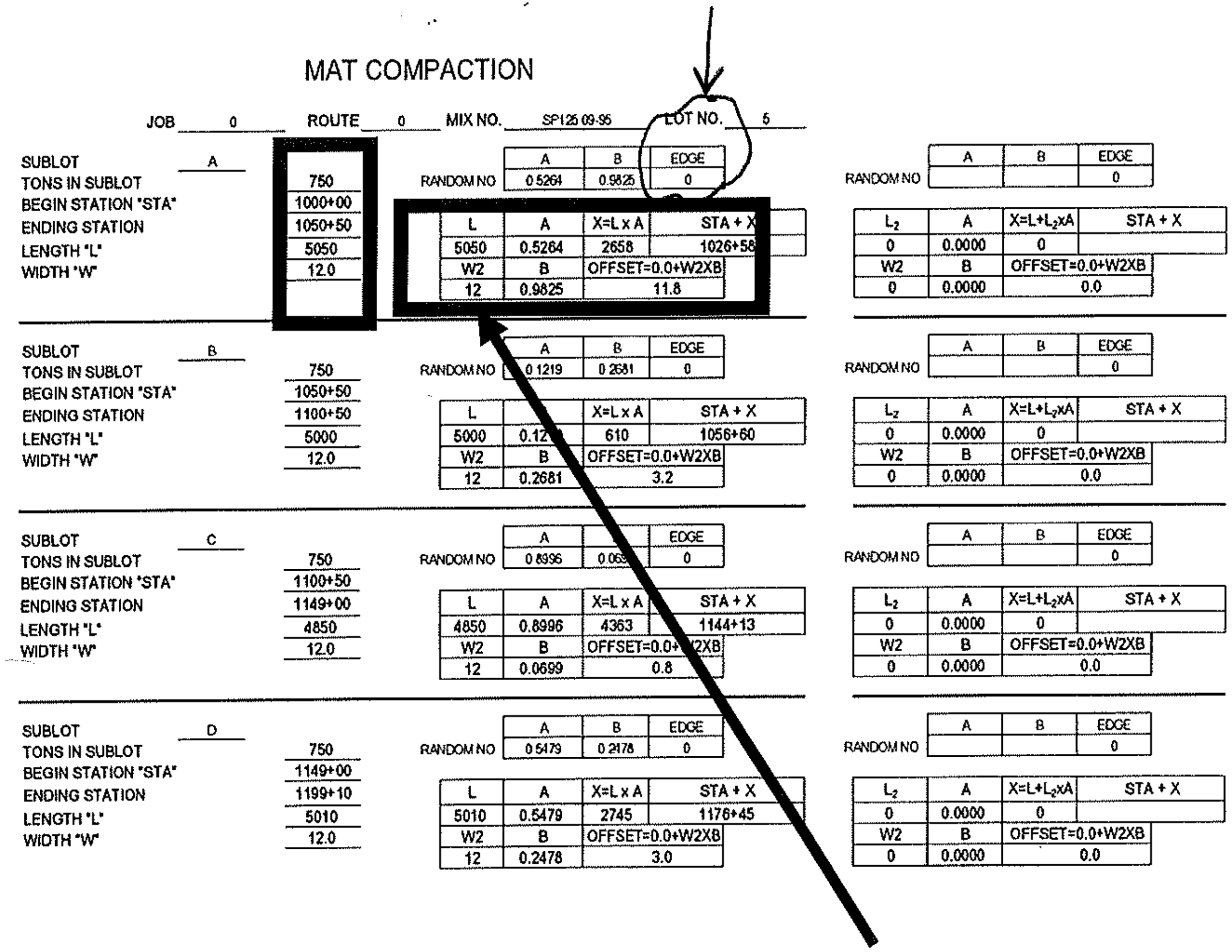
1 UNCONFINED JOINT CASE

- Leave out the 6″ strip by the unconfined joint in the calculations (sample 11.5 ft).

COMPACTED MAT DENSITY

No Unconfined Joint Case

NO UNCONFINED JOINTS CASE



MAT COMPACTION

JOB 0 ROUTE 0 MIX NO. SP125 09-95 LOT NO. 5

SUBLOT A
TONS IN SUBLOT 750
BEGIN STATION "STA" 1000+00
ENDING STATION 1050+50
LENGTH "L" 5050
WIDTH "W" 12.0

	A	B	EDGE
RANDOM NO	0.5264	0.9825	0

L	A	X=L x A	STA + X
5050	0.5264	2658	1026+58
W2	B	OFFSET=0.0+W2XB	
12	0.9825	11.8	

	A	B	EDGE
RANDOM NO			0

L_2	A	X=L+L_2xA	STA + X
0	0.0000	0	
W2	B	OFFSET=0.0+W2XB	
0	0.0000	0.0	

SUBLOT B
TONS IN SUBLOT 750
BEGIN STATION "STA" 1050+50
ENDING STATION 1100+50
LENGTH "L" 5000
WIDTH "W" 12.0

	A	B	EDGE
RANDOM NO	0.1219	0.2681	0

L		X=L x A	STA + X
5000	0.12	610	1056+60
W2	B	OFFSET=0.0+W2XB	
12	0.2681	3.2	

	A	B	EDGE
RANDOM NO			0

L_2	A	X=L+L_2xA	STA + X
0	0.0000	0	
W2	B	OFFSET=0.0+W2XB	
0	0.0000	0.0	

SUBLOT C
TONS IN SUBLOT 750
BEGIN STATION "STA" 1100+50
ENDING STATION 1149+00
LENGTH "L" 4850
WIDTH "W" 12.0

	A		EDGE
RANDOM NO	0.8996	0.06	0

L	A	X=L x A	STA + X
4850	0.8996	4363	1144+13
W2	B	OFFSET=0.0+ 2XB	
12	0.0699	0.8	

	A	B	EDGE
RANDOM NO			0

L_2	A	X=L+L_2xA	STA + X
0	0.0000	0	
W2	B	OFFSET=0.0+W2XB	
0	0.0000	0.0	

SUBLOT D
TONS IN SUBLOT 750
BEGIN STATION "STA" 1149+00
ENDING STATION 1199+10
LENGTH "L" 5010
WIDTH "W" 12.0

	A	B	EDGE
RANDOM NO	0.5479	0.2178	0

L	A	X=L x A	STA + X
5010	0.5479	2745	1176+45
W2	B	OFFSET=0.0+W2XB	
12	0.2478	3.0	

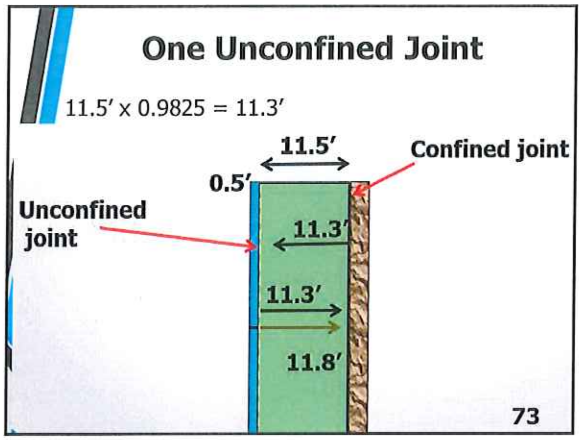
	A	B	EDGE
RANDOM NO			0

L_2	A	X=L+L_2xA	STA + X
0	0.0000	0	
W2	B	OFFSET=0.0+W2XB	
0	0.0000	0.0	

- Sample full width (12 ft)

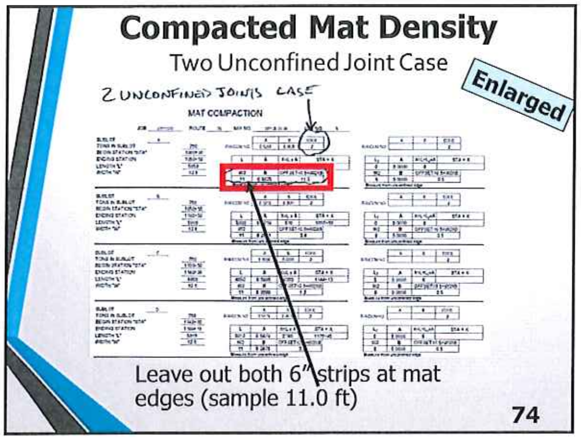
One Unconfined Joint

11.5′ x 0.9825 = 11.3′

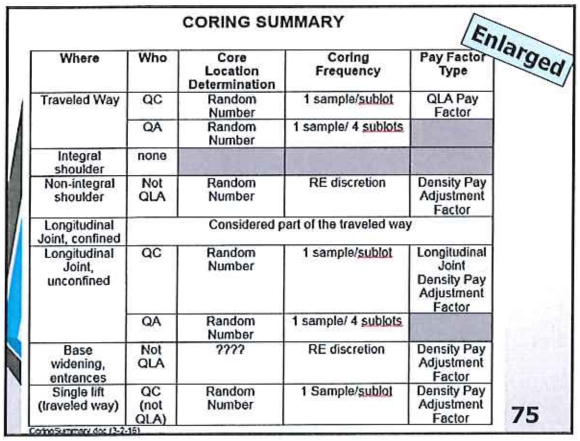


Compacted Mat Density

Two Unconfined Joint Case



Leave out both 6″ strips at mat edges (sample 11.0 ft)



CORING SUMMARY

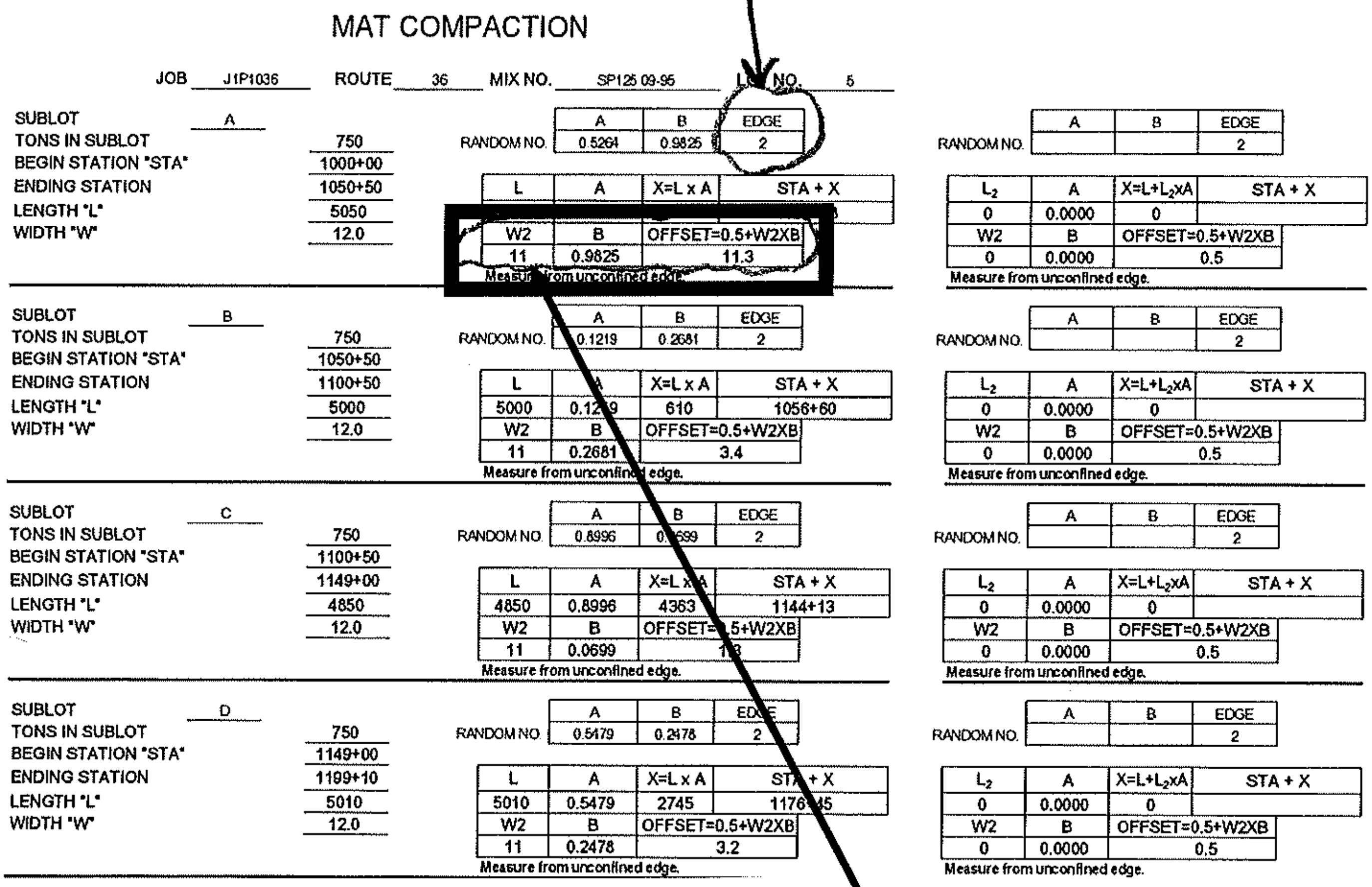
Where	Who	Core Location Determination	Coring Frequency	Pay Factor Type
Traveled Way	QC	Random Number	1 sample/sublot	QLA Pay Factor
	QA	Random Number	1 sample/ 4 sublots	
Integral shoulder	none			
Non-integral shoulder	Not QLA	Random Number	RE discretion	Density Pay Adjustment Factor
Longitudinal Joint, confined	Considered part of the traveled way			
Longitudinal Joint, unconfined	QC	Random Number	1 sample/sublot	Longitudinal Joint Density Pay Adjustment Factor
	QA	Random Number	1 sample/ 4 sublots	
Base widening, entrances	Not QLA	????	RE discretion	Density Pay Adjustment Factor
Single lift (traveled way)	QC (not QLA)	Random Number	1 Sample/sublot	Density Pay Adjustment Factor

CoringSummary.doc (3-2-16)

COMPACTED MAT DENSITY

Two Unconfined Joints Case

2 UNCONFINED JOINTS CASE



MAT COMPACTION

JOB J1P1036 ROUTE 36 MIX NO. SP125 09-95 LOT NO. 5

SUBLOT A
TONS IN SUBLOT 750
BEGIN STATION "STA" 1000+00
ENDING STATION 1050+50
LENGTH "L" 5050
WIDTH "W" 12.0

	A	B	EDGE
RANDOM NO.	0.5264	0.9825	2

L	A	X=L x A	STA + X
[illegible]	[illegible]	[illegible]	[illegible]
W2	B	OFFSET=0.5+W2XB	
11	0.9825	11.3	

Measure from unconfined edge.

	A	B	EDGE
RANDOM NO.			2

L_2	A	$X=L+L_2xA$	STA + X
0	0.0000	0	
W2	B	OFFSET=0.5+W2XB	
0	0.0000	0.5	

Measure from unconfined edge.

SUBLOT B
TONS IN SUBLOT 750
BEGIN STATION "STA" 1050+50
ENDING STATION 1100+50
LENGTH "L" 5000
WIDTH "W" 12.0

	A	B	EDGE
RANDOM NO.	0.1219	0.2681	2

L	A	X=L x A	STA + X
5000	0.1219	610	1056+60
W2	B	OFFSET=0.5+W2XB	
11	0.2681	3.4	

Measure from unconfined edge.

	A	B	EDGE
RANDOM NO.			2

L_2	A	$X=L+L_2xA$	STA + X
0	0.0000	0	
W2	B	OFFSET=0.5+W2XB	
0	0.0000	0.5	

Measure from unconfined edge.

SUBLOT C
TONS IN SUBLOT 750
BEGIN STATION "STA" 1100+50
ENDING STATION 1149+00
LENGTH "L" 4850
WIDTH "W" 12.0

	A	B	EDGE
RANDOM NO.	0.8996	0.0699	2

L	A	X=L x A	STA + X
4850	0.8996	4363	1144+13
W2	B	OFFSET=0.5+W2XB	
11	0.0699	1.3	

Measure from unconfined edge.

	A	B	EDGE
RANDOM NO.			2

L_2	A	$X=L+L_2xA$	STA + X
0	0.0000	0	
W2	B	OFFSET=0.5+W2XB	
0	0.0000	0.5	

Measure from unconfined edge.

SUBLOT D
TONS IN SUBLOT 750
BEGIN STATION "STA" 1149+00
ENDING STATION 1199+10
LENGTH "L" 5010
WIDTH "W" 12.0

	A	B	EDGE
RANDOM NO.	0.5479	0.2478	2

L	A	X=L x A	STA + X
5010	0.5479	2745	1176+45
W2	B	OFFSET=0.5+W2XB	
11	0.2478	3.2	

Measure from unconfined edge.

	A	B	EDGE
RANDOM NO.			2

L_2	A	$X=L+L_2xA$	STA + X
0	0.0000	0	
W2	B	OFFSET=0.5+W2XB	
0	0.0000	0.5	

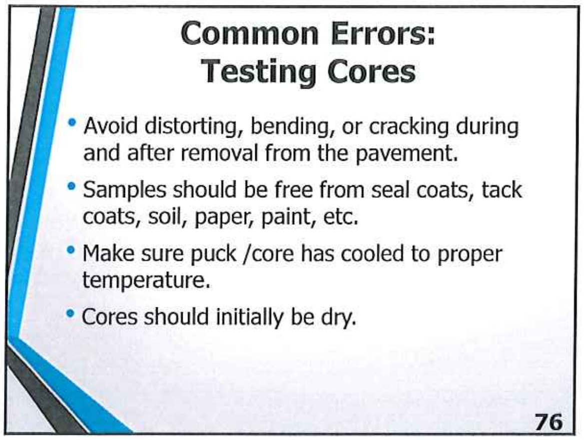
Measure from unconfined edge.

- Leave out both 6" strips at mat edges (sample 11.0 ft)

CORING SUMMARY

Where	Who	Core Location Determination	Coring Frequency	Pay Factor Type
Traveled Way	QC	Random Number	1 sample/sublot	QLA Pay Factor
	QA	Random Number	1 sample/ 4 sublots	
Integral shoulder	none			
Non-integral shoulder	Not QLA	Random Number	RE discretion	Density Pay Adjustment Factor
Longitudinal Joint, confined	Considered part of the traveled way			
Longitudinal Joint, unconfined	QC	Random Number	1 sample/sublot	Longitudinal Joint Density Pay Adjustment Factor
	QA	Random Number	1 sample/ 4 sublots	
Base widening, entrances	Not QLA	????	RE discretion	Density Pay Adjustment Factor
Single lift (traveled way)	QC (not QLA)	Random Number	1 Sample/sublot	Density Pay Adjustment Factor

CoringSummary.doc (3-2-16)



Common Errors: Testing Cores

- Avoid distorting, bending, or cracking during and after removal from the pavement.
- Samples should be free from seal coats, tack coats, soil, paper, paint, etc.
- Make sure puck /core has cooled to proper temperature.
- Cores should initially be dry.

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TAB

Module 6

Module 6

Sample Reduction and Aging

MODULE 6

SAMPLE REDUCTION AND AGING

Test Methods

- AASHTO **R 47** Reducing Sample Size
- AASHTO **R 30** Mixture Conditioning (Aging)

Quartering and Testing

- Specimen size for gyro & MoDOT nuclear samples are on JMF.
- Specimen size for Maximum Specific Gravity (Rice) & ignition oven samples are based on aggregate size.

AASHTO R47

Reducing Samples of HMA Testing Size

Riffle Splitter

Quartering

Mechanical Splitter Type A

Quartermaster

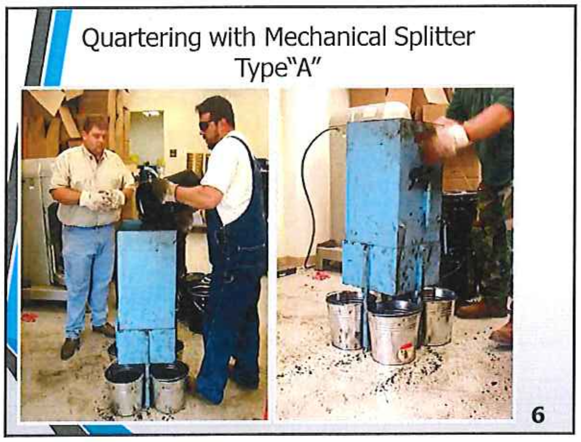
Incremental Loaf Method will **NOT** be covered in this Certification.

Quartering Templates

Incremental (loaf)

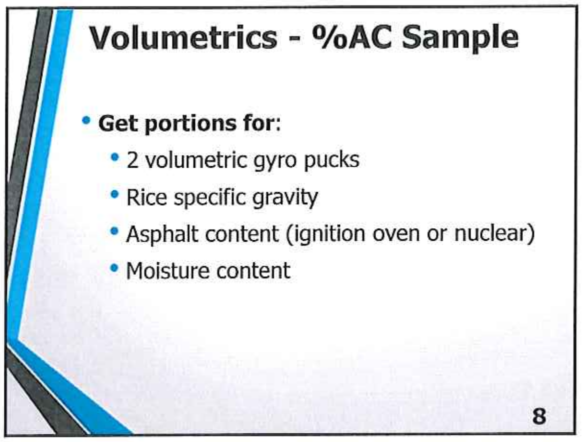
Splitting loose mix sample

Splitting the loose mix sample taken from the road - four samples.



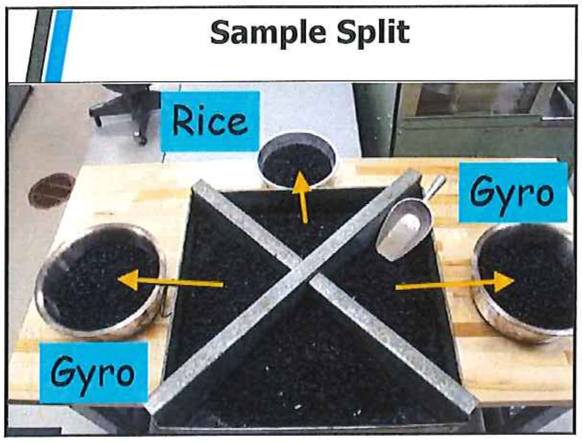
Quartering with Mechanical Splitter Type"A"

Quartering

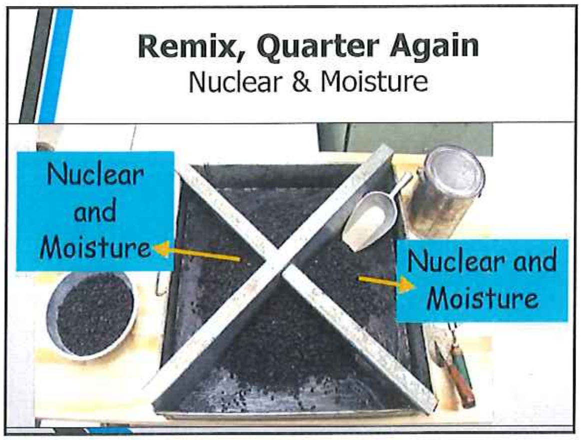


Volumetrics - %AC Sample

- **Get portions for:**
  - 2 volumetric gyro pucks
  - Rice specific gravity
  - Asphalt content (ignition oven or nuclear)
  - Moisture content

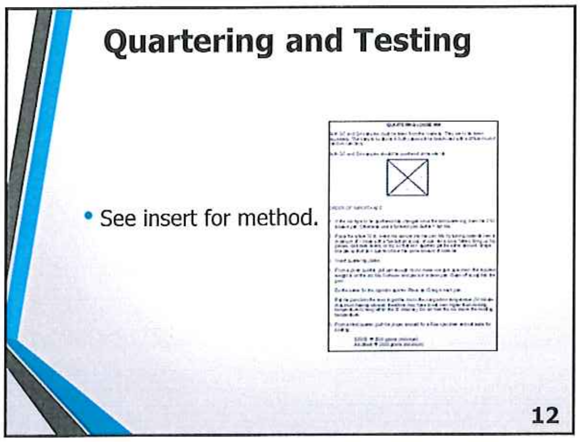


Sample Split



Remix, Quarter Again
Nuclear & Moisture

Remix, Quarter Again
Ignition Oven & Moisture



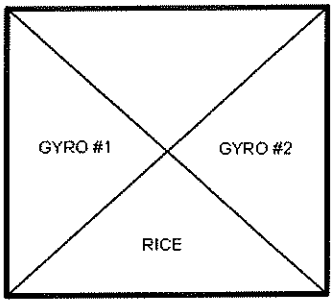
Quartering and Testing

- See insert for method.

QUARTERING LOOSE MIX

Both QC and QA samples must be taken from the roadway. They are to be taken separately. The sample locations in both cases will be determined with a different set of random numbers.

Both QC and QA samples should be quartered at the site lab.



ORDER OF IMPORTANCE

1. If the mix type to be quartered has changed since the last quartering, clean the 2'X2' square pan. Otherwise, use a buttered pan. Butter = hot mix.

2. Place the whole 50 lb. loose mix sample into the pan. Mix by turning material over a minimum of 4 times with a flat-bottom scoop, shape into a cone, flatten. Bring up big pieces, distribute evenly on top so that all 4 quarters get the same amount. Shape the pile so that all 4 quarters have the same amount of material.

3. Insert quartering plates.

4. From a given quarter, pull just enough mix to make one gyro specimen (the required weight is on the Job Mix Formula) and place in a clean pan. Clean off scoop into the pan.

   Do the same for the opposite quarter. Place an ID tag in each pan.

   Put the pans into the oven to get the mix to the compaction temperature ~~(30 minute maximum heating allowed, therefore, may have to set oven higher than molding temperature to keep within the 30 minutes)~~. Do not heat the mix above the molding temperature.

5. From a third quarter, pull the proper amount for a Rice specimen and set aside for cooling:

   SP250 → 2500 grams (minimum)
   All others → 2000 grams (minimum)

Scrape material stuck on the scoop into the appropriate pan. Place an ID tag in each pan.

6. Remove the quartering plates; remix the material, cone, flatten, quarter.

7. Remove sufficient material for the nuclear sample. The required amount is stated on the Job Mix Formula sheet. Scrape the scoop; place an ID tag in the pan.

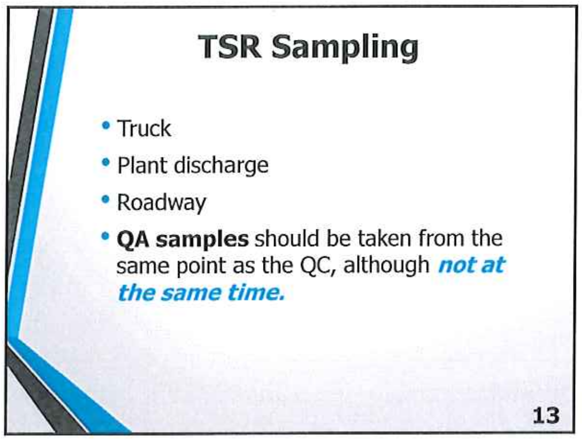
   Compact nuclear sample into the nuclear gage pan while mix is still warm (may have to re-warm).

   If running AC content by the ignition oven method, obtain the sample out of this quarter:

   SP250 → 3000 to 3500 grams
   SP190 → 2000 to 2500 grams
   SP125 → 1500 to 2000 grams
   SP095 and SP048 → 1200 to 1700 grams

8. Obtain moisture sample from same sample as the asphalt content sample. Treat the moisture sample the same as the mix sample in terms of the time interval between splitting and testing.

9. Leave the 2'X2' pan buttered if the type of mix will not change before the next 50 lb. is quartered.

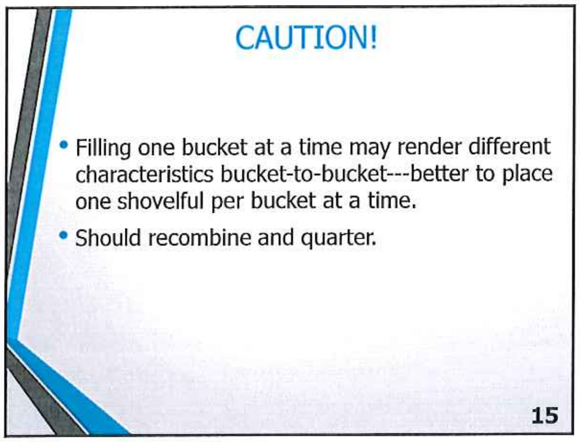


TSR Sampling

- Truck
- Plant discharge
- Roadway
- **QA samples** should be taken from the same point as the QC, although ***not at the same time.***

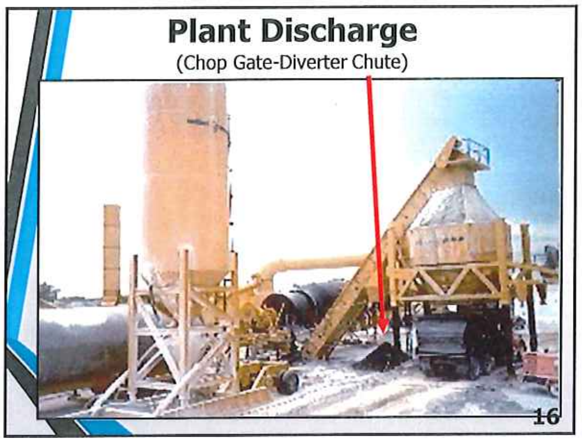
Truck Sampling

Hey Steve! You forgot your PPE!



CAUTION!

- Filling one bucket at a time may render different characteristics bucket-to-bucket---better to place one shovelful per bucket at a time.
- Should recombine and quarter.



Plant Discharge

(Chop Gate-Diverter Chute)

Plant Discharge

(Chop Gate-Diverter Chute)

- Divert entire production stream from drum to a loader bucket.
- Sample across the loader bucket, one shovel per box , all boxes.
- Repeat until boxes are full.
- Cool (beware of dust).
- Close boxes.

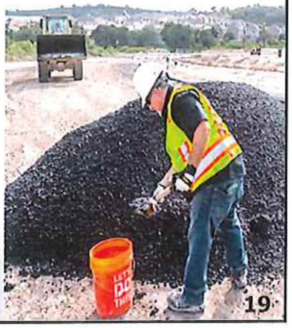
Plant Discharge

(Chop Gate-Diverter Chute)

- Re-heat material.
- Mix all boxes.
- Quarter with templates.
- Remove quarters to 4 buckets.
- Quarter each bucket.
- Pull one puck from each quarter.

Truck "Mini-stockpile"

- Need about **2** tons sampled from silo discharge into a truck.
- Dumped
- Back dragged
- Sampled into, **4** buckets or boxes.
- Back at lab; material is combined, mixed, quartered, and combined into **2** piles.
- Then **4** pucks are sampled from each pile.

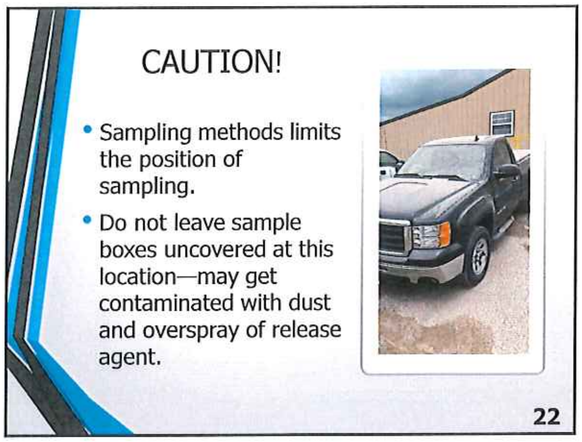


QA TSR Sample

QA inspector will box up 125 lbs. of loose mix sample and ship to Central Lab for testing, retaining another 125 lbs.

TSR Box Information

- AWP ID number
- Mix number
- G_{mm} from sublot taken (QC or QA)
- Specimen weight QC is using.



CAUTION!

- Sampling methods limits the position of sampling.
- Do not leave sample boxes uncovered at this location—may get contaminated with dust and overspray of release agent.

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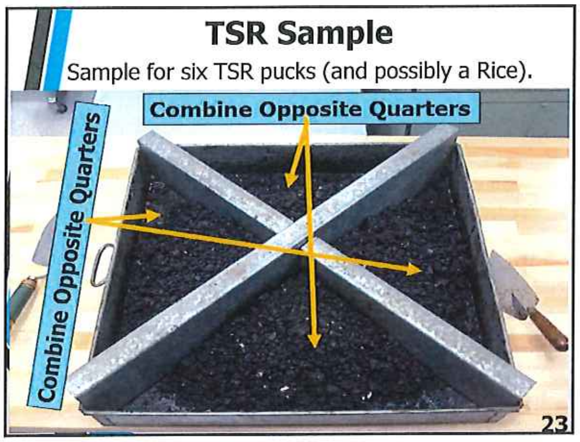

TSR Sample

Sample for six TSR pucks (and possibly a Rice).

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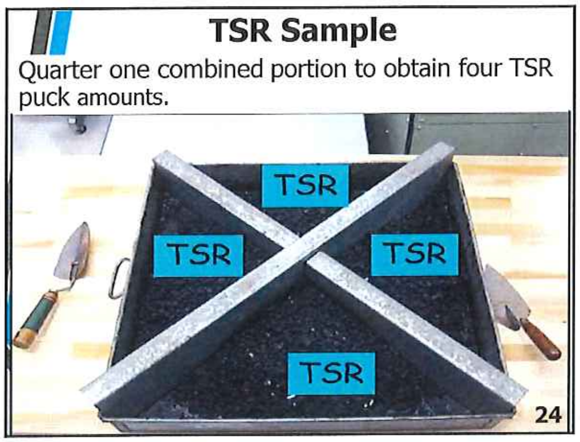
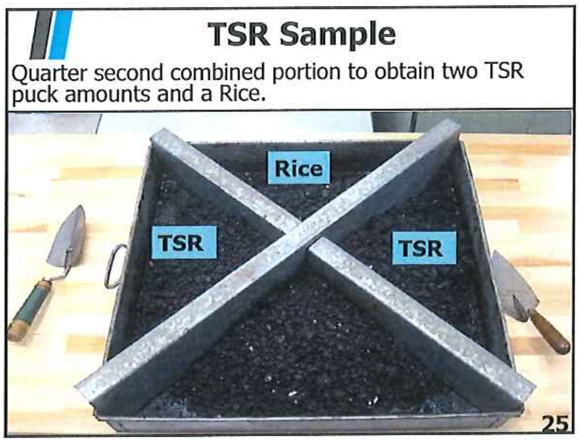


TSR Sample

Quarter one combined portion to obtain four TSR puck amounts.

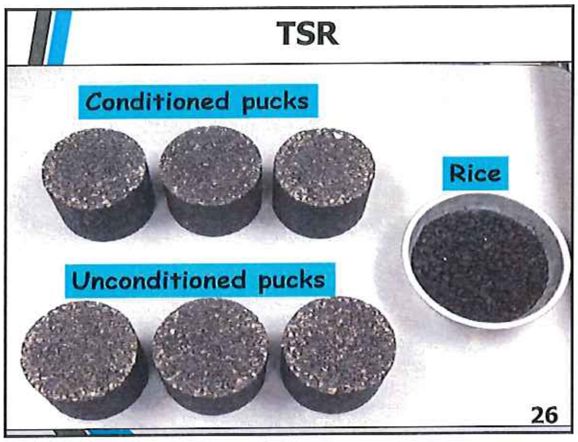
24



TSR Sample

Quarter second combined portion to obtain two TSR puck amounts and a Rice.

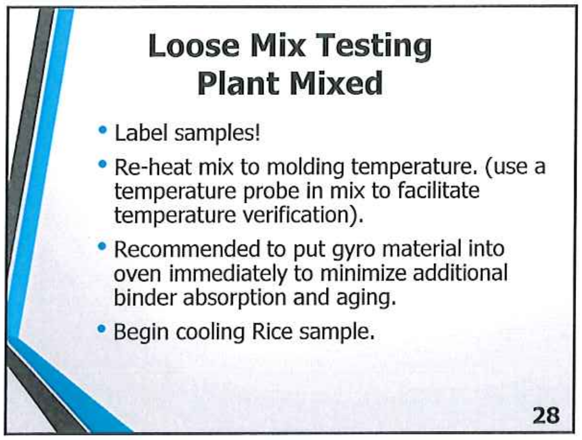
25



TSR

26

27



Loose Mix Testing
Plant Mixed

- Label samples!
- Re-heat mix to molding temperature. (use a temperature probe in mix to facilitate temperature verification).
- Recommended to put gyro material into oven immediately to minimize additional binder absorption and aging.
- Begin cooling Rice sample.

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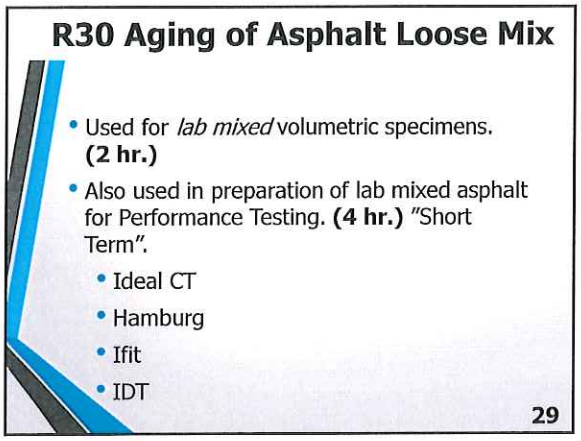
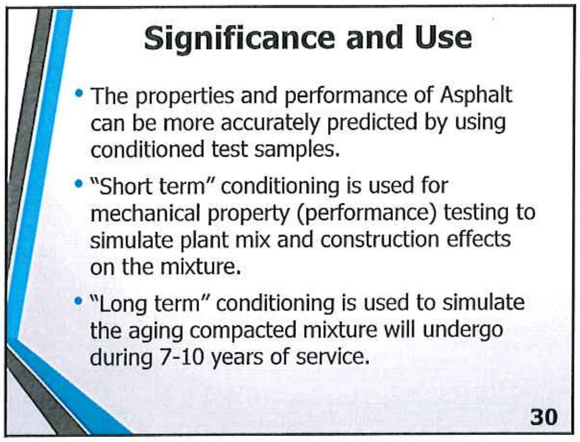


R30 Aging of Asphalt Loose Mix

- Used for *lab mixed* volumetric specimens. **(2 hr.)**
- Also used in preparation of lab mixed asphalt for Performance Testing. **(4 hr.)** "Short Term".
  - Ideal CT
  - Hamburg
  - Ifit
  - IDT

29



Significance and Use

- The properties and performance of Asphalt can be more accurately predicted by using conditioned test samples.
- "Short term" conditioning is used for mechanical property (performance) testing to simulate plant mix and construction effects on the mixture.
- "Long term" conditioning is used to simulate the aging compacted mixture will undergo during 7-10 years of service.

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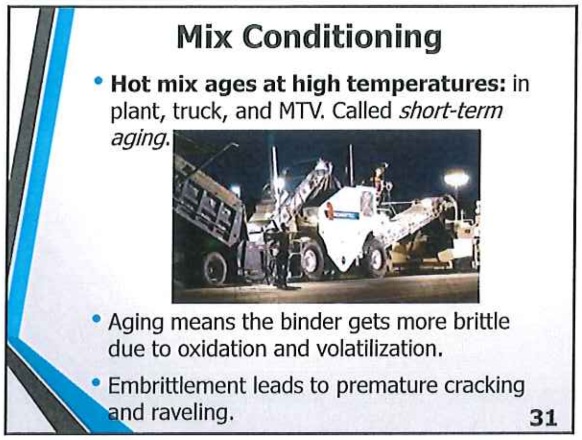
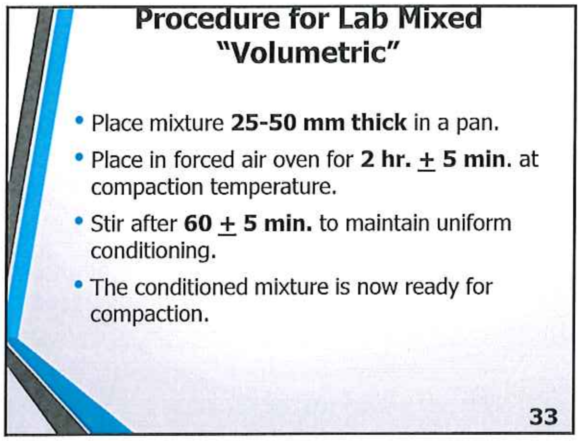


Mix Conditioning

- **Hot mix ages at high temperatures:** in plant, truck, and MTV. Called *short-term aging.*
- Aging means the binder gets more brittle due to oxidation and volatilization.
- Embrittlement leads to premature cracking and raveling.

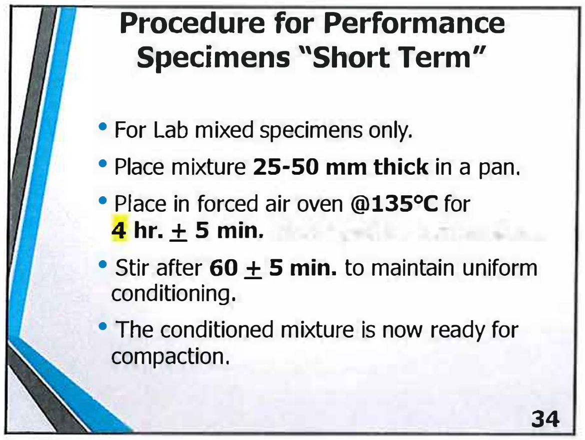
Mix Conditioning, cont'd.

- The binder will also be absorbed by the aggregate.
- **More absorption**, less effective binder left between the particles to function: less compactible, lower durability.
- ***Long-term aging,*** is the aging that occurs during the *service* life of the pavement.



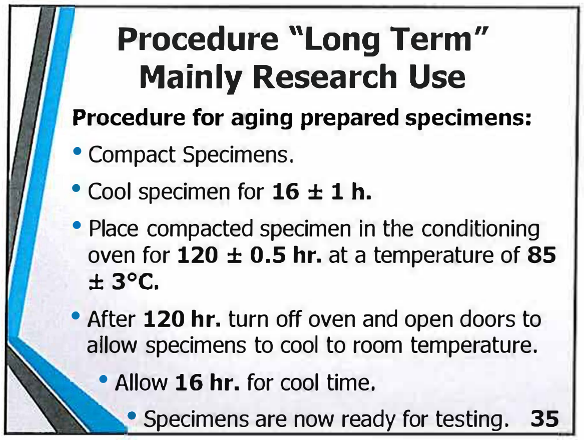
Procedure for Lab Mixed "Volumetric"

- Place mixture **25-50 mm thick** in a pan.
- Place in forced air oven for **2 hr. + 5 min**. at compaction temperature.
- Stir after **60 + 5 min.** to maintain uniform conditioning.
- The conditioned mixture is now ready for compaction.



Procedure for Performance Specimens "Short Term"

- For Lab mixed specimens only.
- Place mixture **25-50 mm thick** in a pan.
- Place in forced air oven **@135°C** for **4 hr. ± 5 min.**
- Stir after **60 ± 5 min.** to maintain uniform conditioning.
- The conditioned mixture is now ready for compaction.



Procedure "Long Term" Mainly Research Use

Procedure for aging prepared specimens:

- Compact Specimens.
- Cool specimen for **16 ± 1 h.**
- Place compacted specimen in the conditioning oven for **120 ± 0.5 hr.** at a temperature of **85 ± 3°C.**
- After **120 hr.** turn off oven and open doors to allow specimens to cool to room temperature.
  - Allow **16 hr.** for cool time.
    - Specimens are now ready for testing.

TAB

Module 7

Module 7

Gyratory Compactor
AASHTO T312

MoDOT

MODULE 7

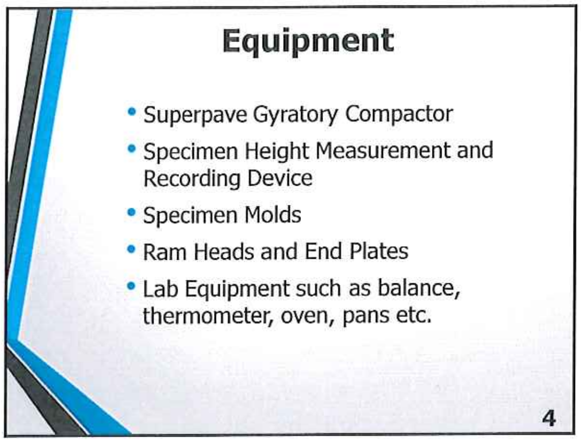
GYRATORY COMPACTOR

"GYRO"

Significance and Use

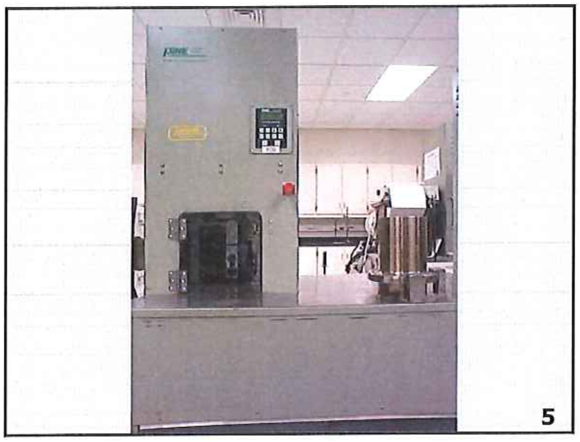
- To prepare specimens for determining mechanical and volumetric properties of asphalt mixtures. Specimens simulate the density, aggregate orientation, and structural characteristics of the actual roadway.
- May be used to monitor the density of test specimens during preparation.
- May be used for field control of mixture during the production process.

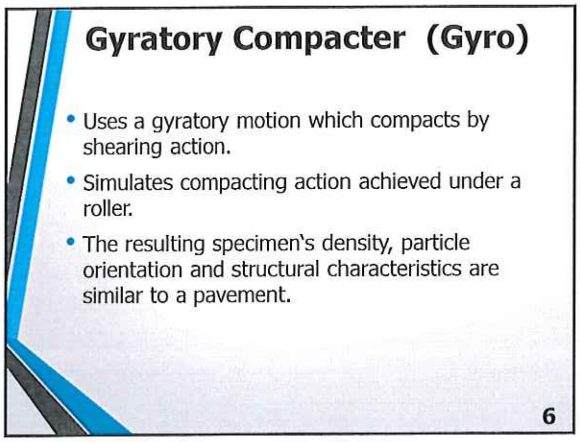
Gyratory Puck



Equipment

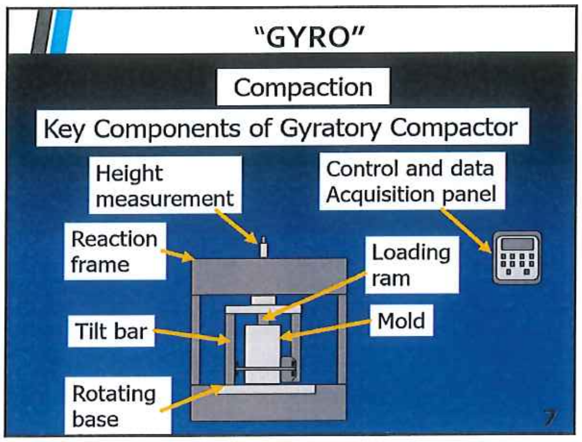
- Superpave Gyratory Compactor
- Specimen Height Measurement and Recording Device
- Specimen Molds
- Ram Heads and End Plates
- Lab Equipment such as balance, thermometer, oven, pans etc.





Gyratory Compacter (Gyro)

- Uses a gyratory motion which compacts by shearing action.
- Simulates compacting action achieved under a roller.
- The resulting specimen's density, particle orientation and structural characteristics are similar to a pavement.



"GYRO"

Compaction

Key Components of Gyratory Compactor

Height measurement

Control and data Acquisition panel

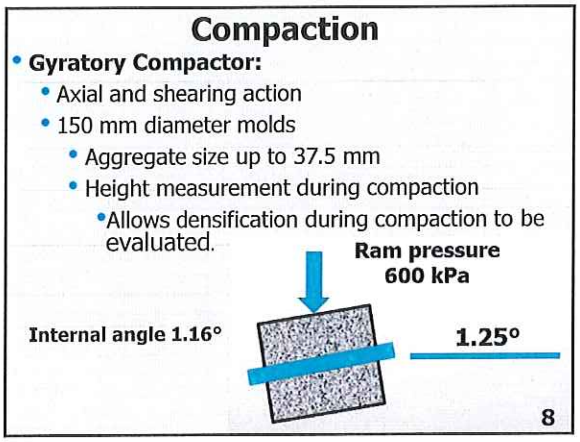
Reaction frame

Loading ram

Tilt bar

Mold

Rotating base



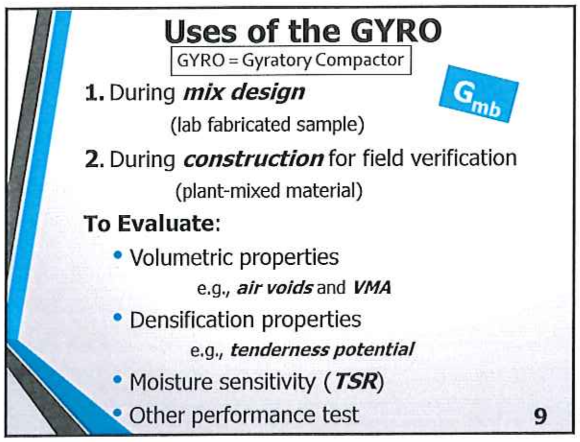
Compaction

- **Gyratory Compactor:**
  - Axial and shearing action
  - 150 mm diameter molds
    - Aggregate size up to 37.5 mm
    - Height measurement during compaction
      - Allows densification during compaction to be evaluated.

Ram pressure 600 kPa

Internal angle 1.16°

1.25°



Uses of the GYRO

GYRO = Gyratory Compactor

1. During ***mix design***

(lab fabricated sample)

2. During ***construction*** for field verification

(plant-mixed material)

G_{mb}

To Evaluate:

- Volumetric properties
  e.g., ***air voids*** and ***VMA***
- Densification properties
  e.g., ***tenderness potential***
- Moisture sensitivity (***TSR***)
- Other performance test

Gyratory Compactor

Gyratory Compactor = GYRO

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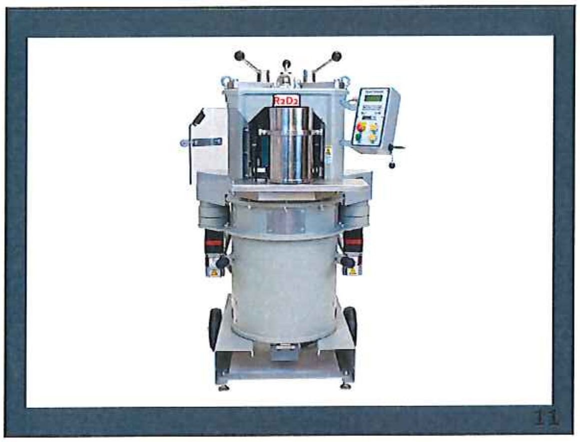

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AASHTO Test Methods & Specifications

- R35 Volumetric Design Practice
- M323 Volumetric Design Specs
- R30 Mix Conditioning
- ***T 312 Gyratory Compactor operation***
- ***T 166 Bulk Specific Gravity of gyro pucks***
- T 209 Max Specific Gravity of Voidless Mix (Rice)
- T 283 Moisture Sensitivity

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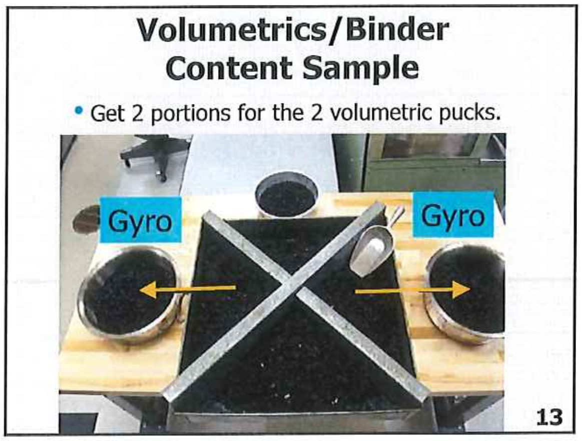
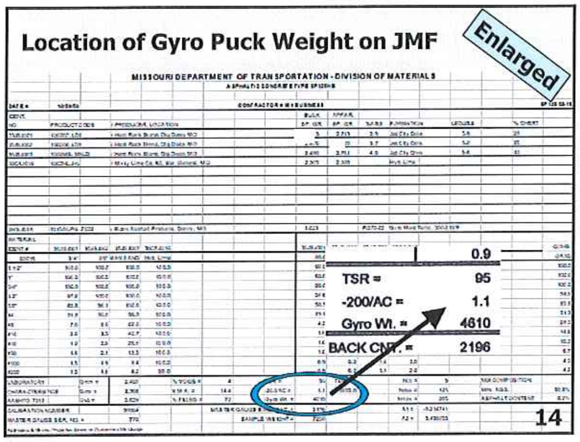


Volumetrics/Binder Content Sample

- Get 2 portions for the 2 volumetric pucks.



Location of Gyro Puck Weight on JMF

MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

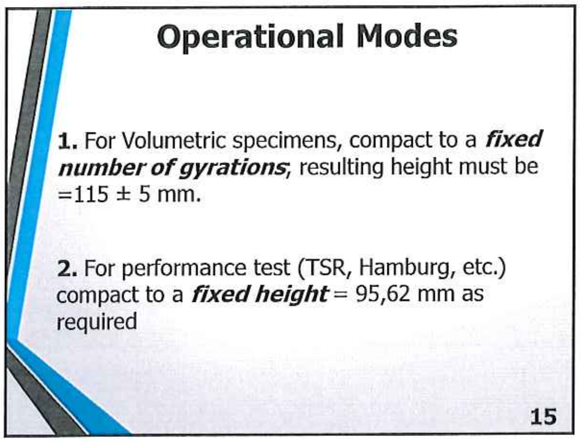
0.9

TSR = 95

-200/AC = 1.1

Gyro Wt. = 4610

BACK CNT. = 2196

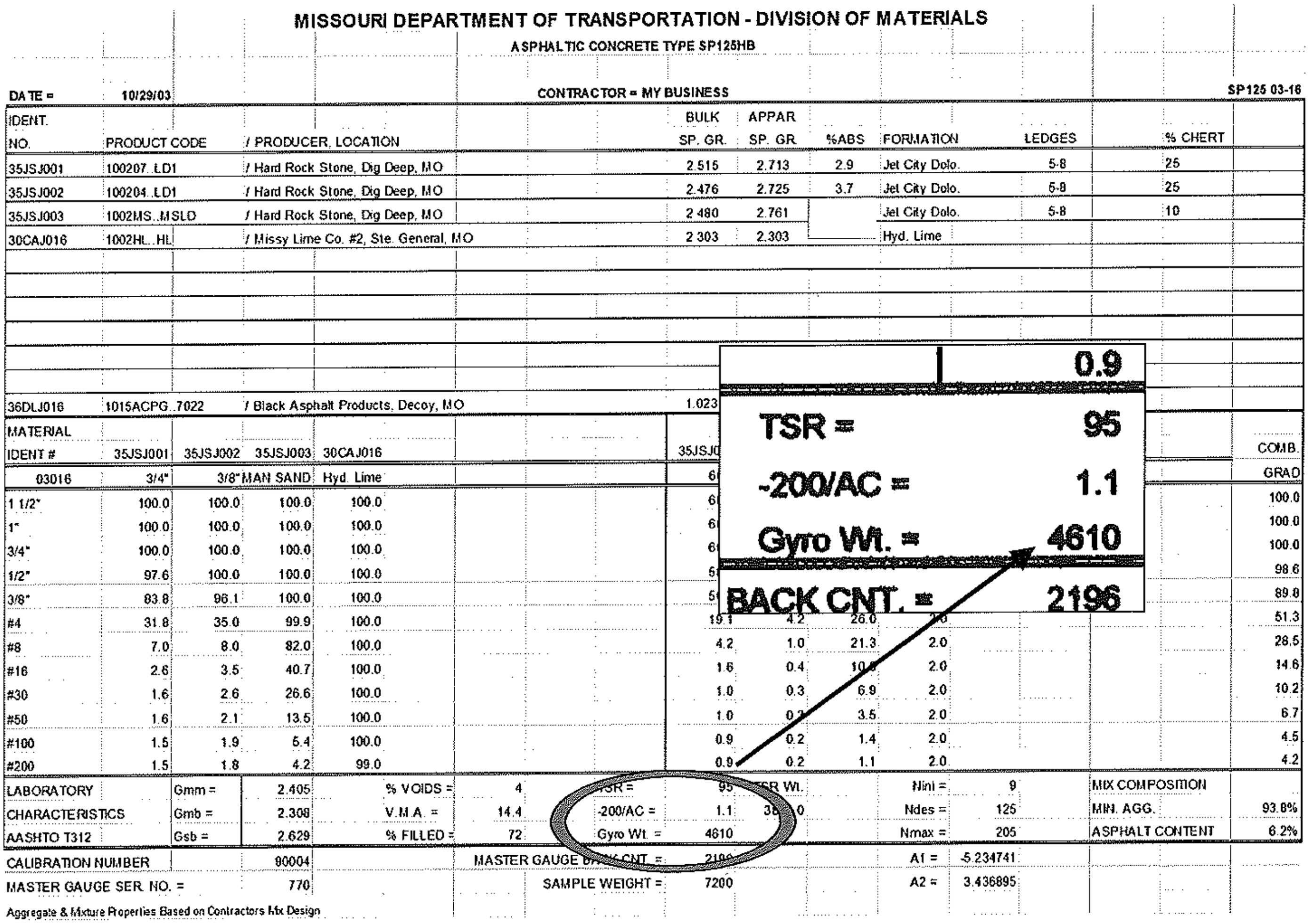


Operational Modes

1. For Volumetric specimens, compact to a ***fixed number of gyrations***, resulting height must be =115 ± 5 mm.

2. For performance test (TSR, Hamburg, etc.) compact to a ***fixed height*** = 95,62 mm as required

Location of Gyro Puck Weight on JMF



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ASPHALTIC CONCRETE TYPE SP125HB

DATE = 10/29/03

CONTRACTOR = MY BUSINESS

SP125 03-16

IDENT. NO.	PRODUCT CODE	/ PRODUCER, LOCATION	BULK SP. GR.	APPAR SP. GR.	%ABS	FORMATION	LEDGES	% CHERT
35JSJ001	100207..LD1	/ Hard Rock Stone, Dig Deep, MO	2.515	2.713	2.9	Jet City Dolo.	5-8	25
35JSJ002	100204..LD1	/ Hard Rock Stone, Dig Deep, MO	2.476	2.725	3.7	Jet City Dolo.	5-8	25
35JSJ003	1002MS..MSLD	/ Hard Rock Stone, Dig Deep, MO	2 480	2.761		Jet City Dolo.	5-8	10
30CAJ016	1002HL..HL	/ Missy Lime Co. #2, Ste. General, MO	2 303	2.303		Hyd. Lime		
36DLJ016	1015ACPG..7022	/ Black Asphalt Products, Decoy, MO	1.023					

MATERIAL IDENT #	35JSJ001	35JSJ002	35JSJ003	30CAJ016	35JSJ0				COMB.
03016	3/4"	3/8"	MAN SAND	Hyd. Lime					GRAD
1 1/2"	100.0	100.0	100.0	100.0					100.0
1"	100.0	100.0	100.0	100.0					100.0
3/4"	100.0	100.0	100.0	100.0					100.0
1/2"	97.6	100.0	100.0	100.0					98.6
3/8"	83.8	96.1	100.0	100.0					89.8
#4	31.8	35.0	99.9	100.0	19.1	4.2	26.0		51.3
#8	7.0	8.0	82.0	100.0	4.2	1.0	21.3	2.0	28.5
#16	2.6	3.5	40.7	100.0	1.6	0.4	10.[illegible]	2.0	14.6
#30	1.6	2.6	26.6	100.0	1.0	0.3	6.9	2.0	10.2
#50	1.6	2.1	13.5	100.0	1.0	0.[illegible]	3.5	2.0	6.7
#100	1.5	1.9	5.4	100.0	0.9	0.2	1.4	2.0	4.5
#200	1.5	1.8	4.2	99.0	0.9	0.2	1.1	2.0	4.2

LABORATORY	Gmm =	2.405	% VOIDS =	4	TSR =	95	TSR Wt.	Nini =	9	MIX COMPOSITION	
CHARACTERISTICS	Gmb =	2.308	V.M.A. =	14.4	-200/AC =	1.1	38[illegible]0	Ndes =	125	MIN. AGG.	93.8%
AASHTO T312	Gsb =	2.629	% FILLED =	72	Gyro Wt. =	4610		Nmax =	205	ASPHALT CONTENT	6.2%

CALIBRATION NUMBER 90004

MASTER GAUGE [illegible] CNT. = 219[illegible]

A1 = -5.234741

MASTER GAUGE SER. NO. = 770

SAMPLE WEIGHT = 7200

A2 = 3.436895

Aggregate & Mixture Properties Based on Contractors Mix Design

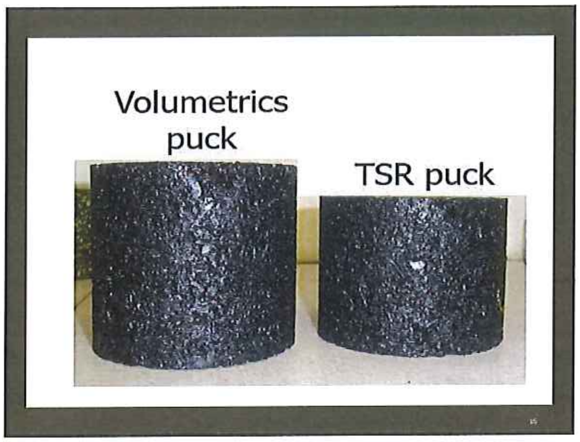
0.9

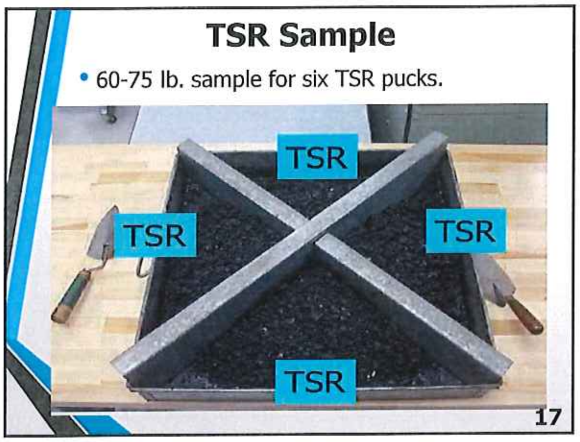
TSR = 95

-200/AC = 1.1

Gyro Wt. = 4610

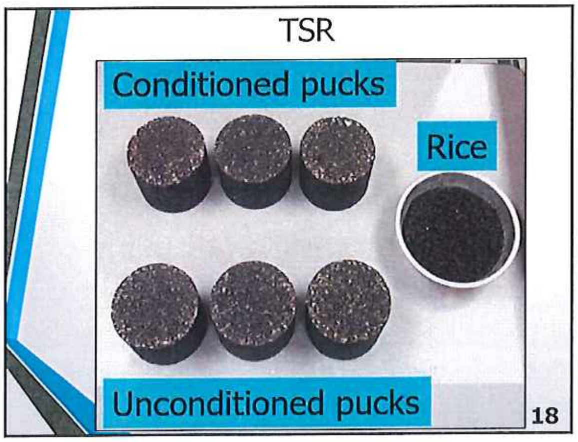
BACK CNT. = 2196



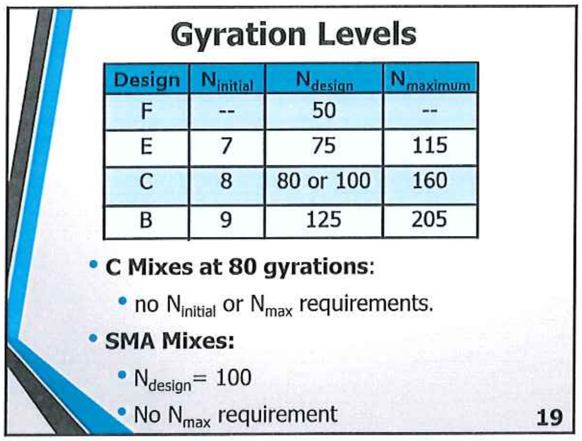


TSR Sample

- 60-75 lb. sample for six TSR pucks.



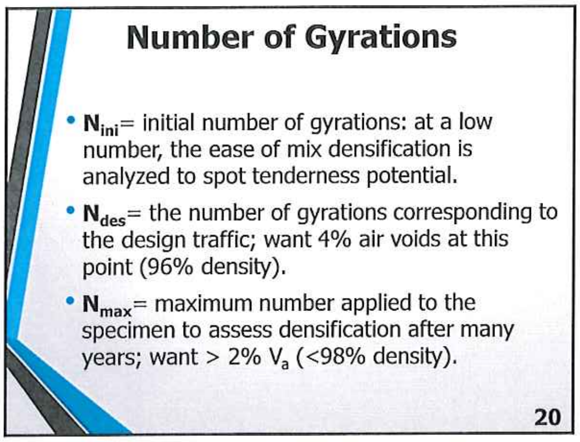
TSR



Gyration Levels

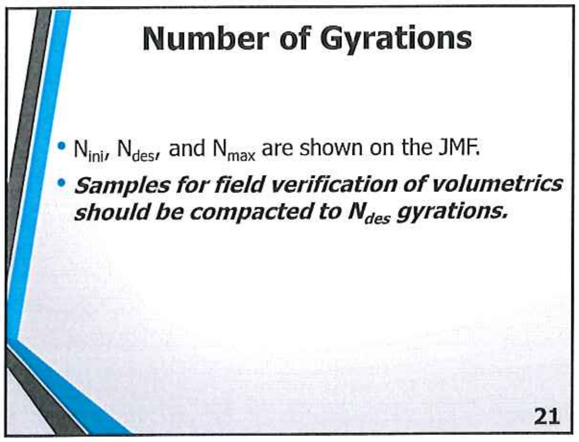
Design	$N_{initial}$	N_{design}	$N_{maximum}$
F	--	50	--
E	7	75	115
C	8	80 or 100	160
B	9	125	205

- **C Mixes at 80 gyrations:**
  - no $N_{initial}$ or N_{max} requirements.
- **SMA Mixes:**
  - N_{design}= 100
  - No N_{max} requirement



Number of Gyrations

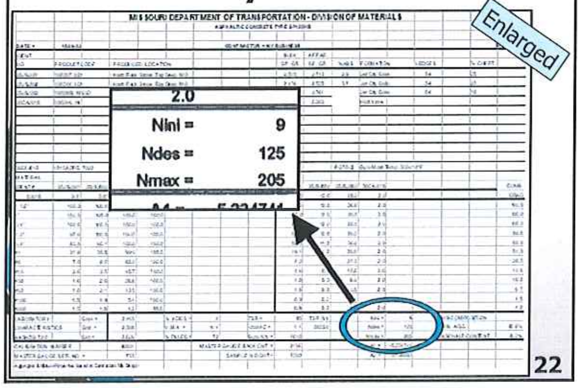
- **N_{ini}**= initial number of gyrations: at a low number, the ease of mix densification is analyzed to spot tenderness potential.
- **N_{des}**= the number of gyrations corresponding to the design traffic; want 4% air voids at this point (96% density).
- **N_{max}**= maximum number applied to the specimen to assess densification after many years; want > 2% V_a (<98% density).



Number of Gyrations

- N_{ini}, N_{des}, and N_{max} are shown on the JMF.
- ***Samples for field verification of volumetrics should be compacted to N_{des} gyrations.***

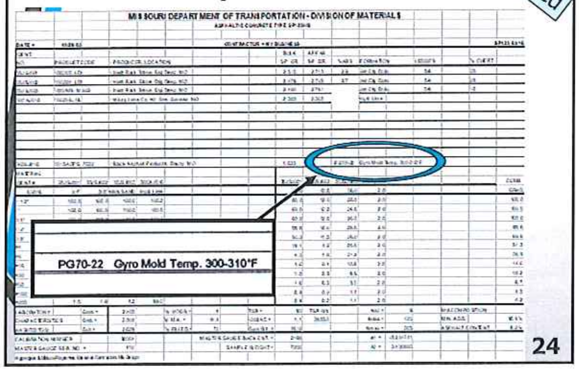
Location of Gyration Info on JMF



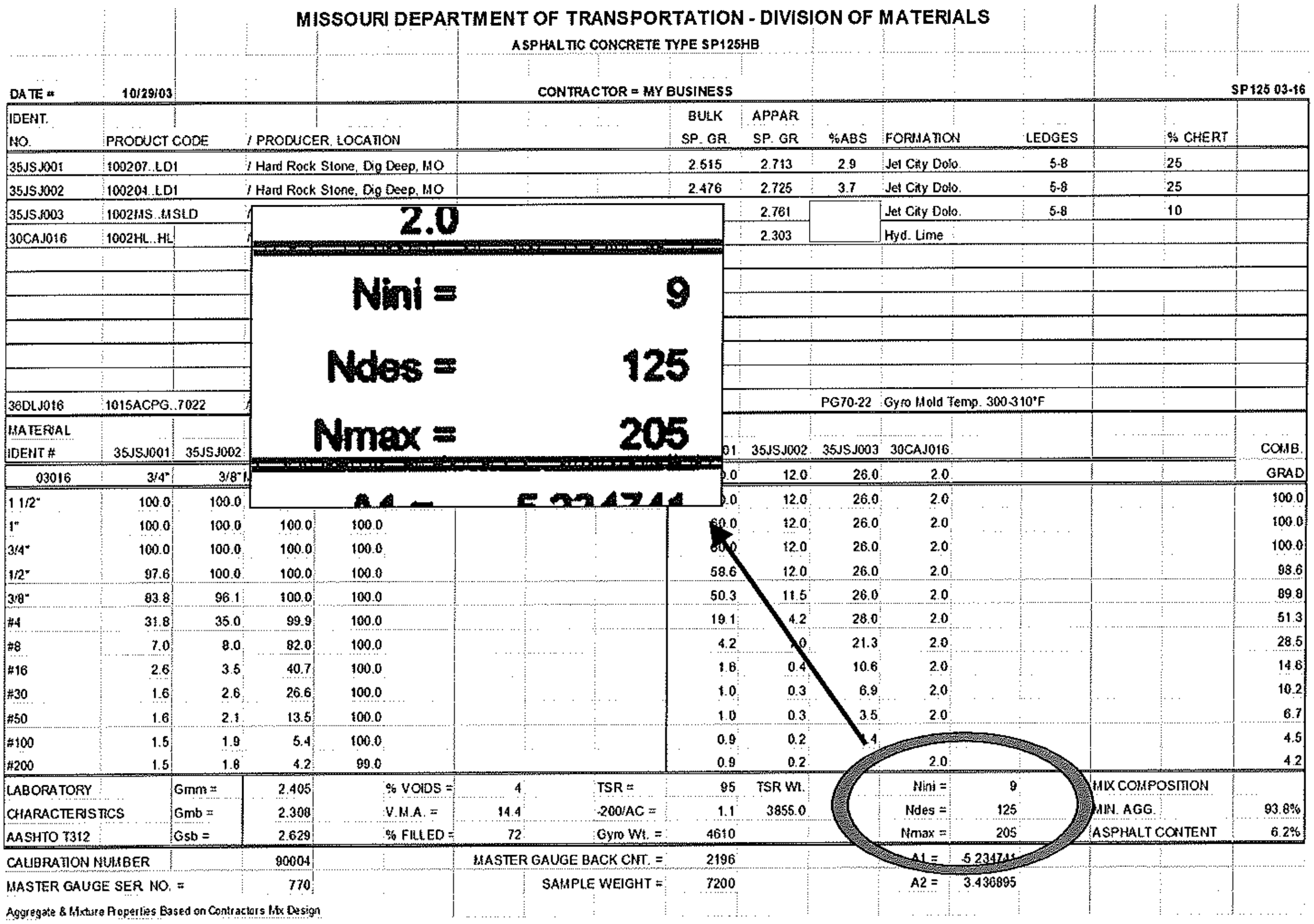
Sample Prep.

- Weigh enough mix to achieve the desired height and/or void target. Adjust specimen weight as needed during the design phase of establishing a mix design.
- Condition mixture as required in R30 for the type of specimens to be molded.
- Heat mix to molding temperature. (See JMF)

Location of Gyro Molding Temperature on JMF



Location of Gyration Info on JMF



MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

ASPHALTIC CONCRETE TYPE SP125HB

DATE = 10/29/03 CONTRACTOR = MY BUSINESS SP125 03-16

IDENT. NO.	PRODUCT CODE	/ PRODUCER, LOCATION	BULK SP. GR.	APPAR SP. GR	%ABS	FORMATION	LEDGES	% CHERT
35JSJ001	100207..LD1	/ Hard Rock Stone, Dig Deep, MO	2.515	2.713	2.9	Jet City Dolo.	5-8	25
35JSJ002	100204..LD1	/ Hard Rock Stone, Dig Deep, MO	2.476	2.725	3.7	Jet City Dolo.	5-8	25
35JSJ003	1002MS..MSLD	/		2.761		Jet City Dolo.	5-8	10
30CAJ016	1002HL..HL	/		2.303		Hyd. Lime		
36DLJ016	1015ACPG..7022	/			PG70-22	Gyro Mold Temp. 300-310°F		

MATERIAL IDENT #	35JSJ001	35JSJ002			01	35JSJ002	35JSJ003	30CAJ016	COMB.
03016	3/4"	3/8"			.0	12.0	26.0	2.0	GRAD
1 1/2"	100.0	100.0			.0	12.0	26.0	2.0	100.0
1"	100.0	100.0	100.0	100.0	60.0	12.0	26.0	2.0	100.0
3/4"	100.0	100.0	100.0	100.0	60.0	12.0	26.0	2.0	100.0
1/2"	97.6	100.0	100.0	100.0	58.6	12.0	26.0	2.0	98.6
3/8"	83.8	96.1	100.0	100.0	50.3	11.5	26.0	2.0	89.8
#4	31.8	35.0	99.9	100.0	19.1	4.2	28.0	2.0	51.3
#8	7.0	8.0	82.0	100.0	4.2	[illegible]	21.3	2.0	28.5
#16	2.6	3.5	40.7	100.0	1.6	0.4	10.6	2.0	14.6
#30	1.6	2.6	26.6	100.0	1.0	0.3	6.9	2.0	10.2
#50	1.6	2.1	13.5	100.0	1.0	0.3	3.5	2.0	6.7
#100	1.5	1.9	5.4	100.0	0.9	0.2	1.4		4.5
#200	1.5	1.8	4.2	99.0	0.9	0.2		2.0	4.2

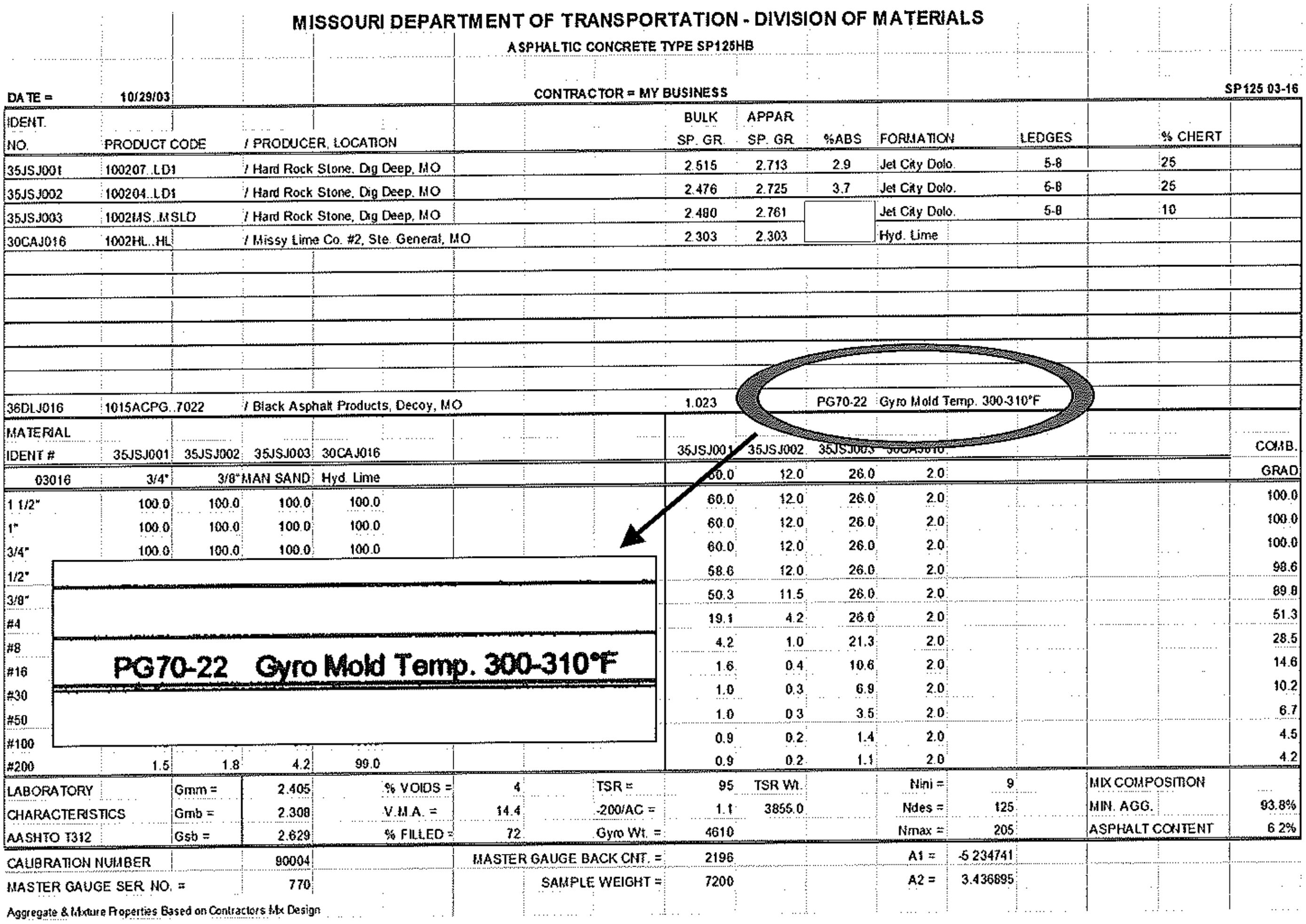
LABORATORY	Gmm =	2.405	% VOIDS =	4	TSR =	95	TSR Wt.	Nini =	9	MIX COMPOSITION	
CHARACTERISTICS	Gmb =	2.308	V.M.A. =	14.4	-200/AC =	1.1	3855.0	Ndes =	125	MIN. AGG.	93.8%
AASHTO T312	Gsb =	2.629	% FILLED =	72	Gyro Wt. =	4610		Nmax =	205	ASPHALT CONTENT	6.2%

CALIBRATION NUMBER 90004 MASTER GAUGE BACK CNT. = 2196 A1 = 5.234741

MASTER GAUGE SER. NO. = 770 SAMPLE WEIGHT = 7200 A2 = 3.436895

Aggregate & Mixture Properties Based on Contractors Mix Design

Location of Gyro Molding Temperature on JMF



MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

ASPHALTIC CONCRETE TYPE SP125HB

DATE = 10/29/03 CONTRACTOR = MY BUSINESS SP125 03-16

IDENT. NO.	PRODUCT CODE	/ PRODUCER, LOCATION	BULK SP. GR.	APPAR SP. GR	%ABS	FORMATION	LEDGES	% CHERT
35JSJ001	100207..LD1	/ Hard Rock Stone, Dig Deep, MO	2.515	2.713	2.9	Jet City Dolo.	5-8	25
35JSJ002	100204..LD1	/ Hard Rock Stone, Dig Deep, MO	2.476	2.725	3.7	Jet City Dolo.	6-8	25
35JSJ003	1002MS..MSLD	/ Hard Rock Stone, Dig Deep, MO	2.480	2.761		Jet City Dolo.	5-8	10
30CAJ016	1002HL..HL	/ Missy Lime Co. #2, Ste. General, MO	2.303	2.303		Hyd. Lime		
36DLJ016	1015ACPG..7022	/ Black Asphalt Products, Decoy, MO	1.023		PG70-22	Gyro Mold Temp. 300-310°F		

MATERIAL IDENT #	35JSJ001	35JSJ002	35JSJ003	30CAJ016	35JSJ001	35JSJ002	35JSJ003	30CAJ016	COMB. GRAD
03016	3/4"	3/8"	MAN SAND	Hyd. Lime	60.0	12.0	26.0	2.0	
1 1/2"	100.0	100.0	100.0	100.0	60.0	12.0	26.0	2.0	100.0
1"	100.0	100.0	100.0	100.0	60.0	12.0	26.0	2.0	100.0
3/4"	100.0	100.0	100.0	100.0	60.0	12.0	26.0	2.0	100.0
1/2"					58.6	12.0	26.0	2.0	98.6
3/8"					50.3	11.5	26.0	2.0	89.8
#4					19.1	4.2	26.0	2.0	51.3
#8					4.2	1.0	21.3	2.0	28.5
#16					1.6	0.4	10.6	2.0	14.6
#30					1.0	0.3	6.9	2.0	10.2
#50					1.0	0.3	3.5	2.0	6.7
#100					0.9	0.2	1.4	2.0	4.5
#200	1.5	1.8	4.2	99.0	0.9	0.2	1.1	2.0	4.2

PG70-22 Gyro Mold Temp. 300-310°F

LABORATORY	Gmm =	2.405	% VOIDS =	4	TSR =	95	TSR Wt.		Nini =	9	MIX COMPOSITION	
CHARACTERISTICS	Gmb =	2.308	V.M.A. =	14.4	-200/AC =	1.1	3855.0		Ndes =	125	MIN. AGG.	93.8%
AASHTO T312	Gsb =	2.629	% FILLED =	72	Gyro Wt. =	4610			Nmax =	205	ASPHALT CONTENT	6.2%
CALIBRATION NUMBER		90004			MASTER GAUGE BACK CNT. =	2196			A1 =	-5.234741		
MASTER GAUGE SER. NO. =		770			SAMPLE WEIGHT =	7200			A2 =	3.436895		

Aggregate & Mixture Properties Based on Contractors Mix Design

Procedure - Verification

Verify the gyratory on a cold (Powered up 10-15 min) And clean machine.

1) Daily during use or
2) If gyratory compactor is moved.

Calibrate:

1) Annually or
2) If verification fails.

More on verification and calibration after procedure.

Procedure - Pre-compaction

- Preheat gyratory mold and plates to molding temperature (see JMF) for ≥ 30 min.
- Reduce loose mix according to AASHTO R47.
- Place the mix in a preheated oven set to JMF molding temperature.
- Place a thermometer in the loose mix to check temperature before molding.
- When loose mix is at molding temperature, move quickly to compaction.

Procedure - Compaction

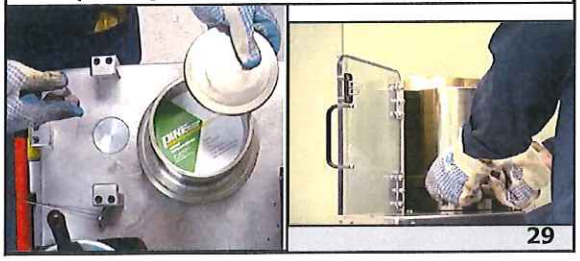
- Pull the mold items out of the oven.
  - Assemble if needed.
- Place a paper disc to the bottom.

Procedure - Compaction

- Add a funnel on the top of the mold.
- At the oven, check if mix is at molding temperature.
- If on temperature, place the mix in the mold in one lift. Scraping the pan and spatula to include all of the sample into the mold.

Procedure - Compaction

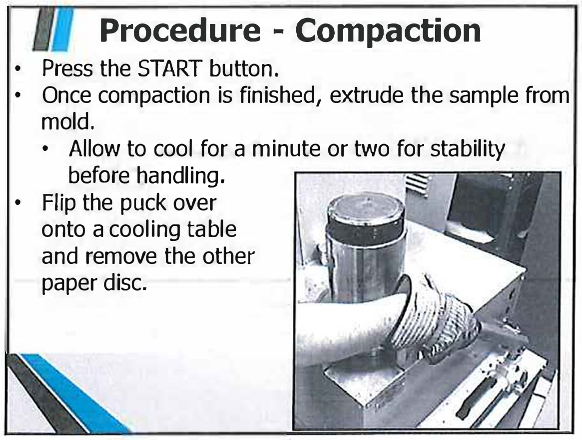
- Level the mix and place a paper disc on top the sample.
- Place the lid to the mold with beveled side facing up.
- Place the mold into the gyratory compactor.
- Verify settings on the gyro are correct.



Procedure - Compaction

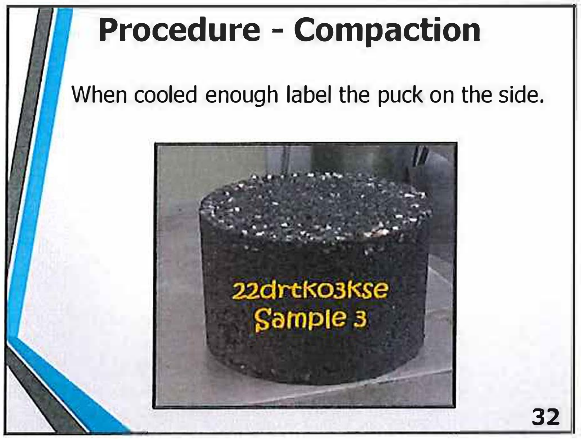
Items to verify:

- Verify 150mm specimen diameter.
- Verify compaction pressure = 600 kPa.
- For Volumetric pucks,
  - Set gyrations = Ndes from JMF.
- For TSR pucks,
  - Set specimen height to 95 mm.



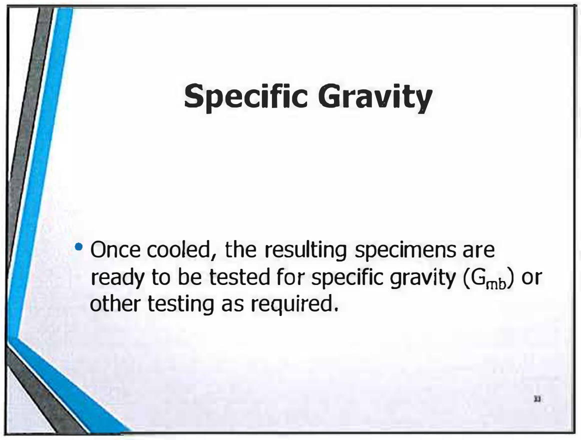
Procedure - Compaction

- Press the START button.
- Once compaction is finished, extrude the sample from mold.
  - Allow to cool for a minute or two for stability before handling.
- Flip the puck over onto a cooling table and remove the other paper disc.



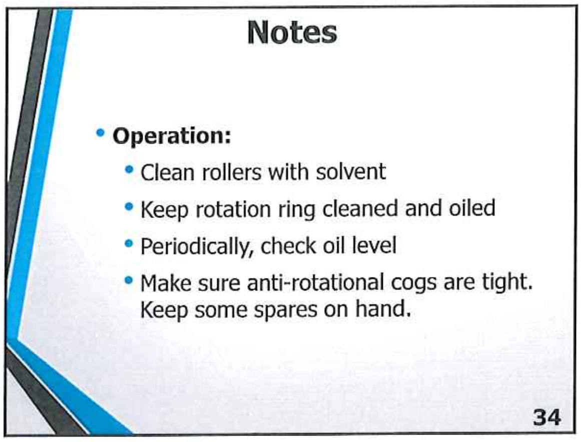
Procedure - Compaction

When cooled enough label the puck on the side.



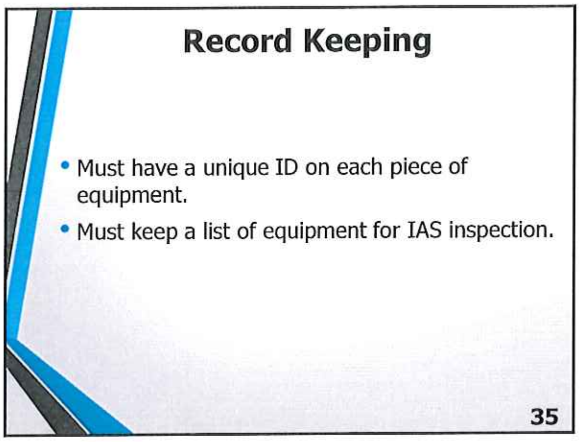
Specific Gravity

- Once cooled, the resulting specimens are ready to be tested for specific gravity (G_{mb}) or other testing as required.



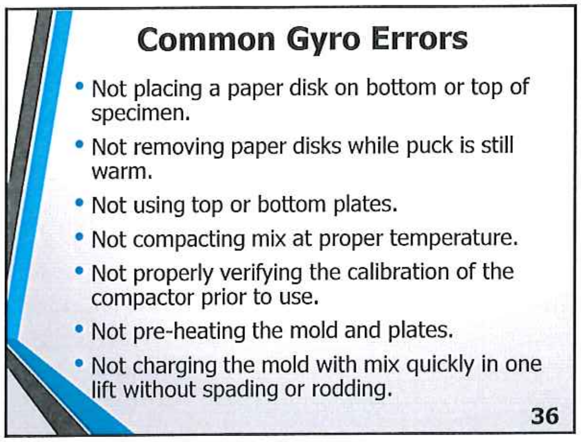
Notes

- **Operation:**
  - Clean rollers with solvent
  - Keep rotation ring cleaned and oiled
  - Periodically, check oil level
  - Make sure anti-rotational cogs are tight. Keep some spares on hand.



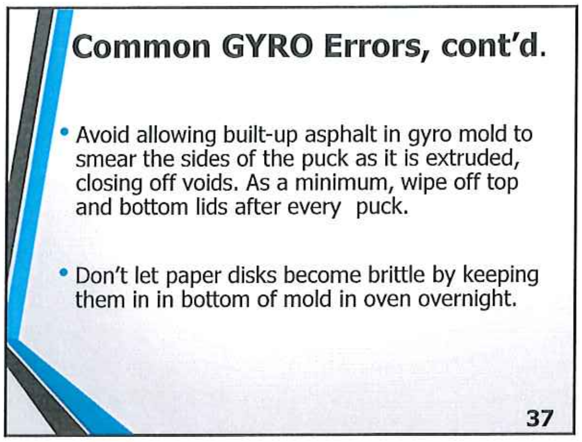
Record Keeping

- Must have a unique ID on each piece of equipment.
- Must keep a list of equipment for IAS inspection.



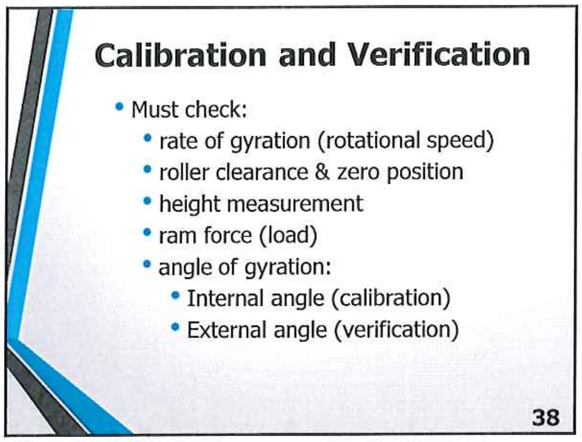
Common Gyro Errors

- Not placing a paper disk on bottom or top of specimen.
- Not removing paper disks while puck is still warm.
- Not using top or bottom plates.
- Not compacting mix at proper temperature.
- Not properly verifying the calibration of the compactor prior to use.
- Not pre-heating the mold and plates.
- Not charging the mold with mix quickly in one lift without spading or rodding.



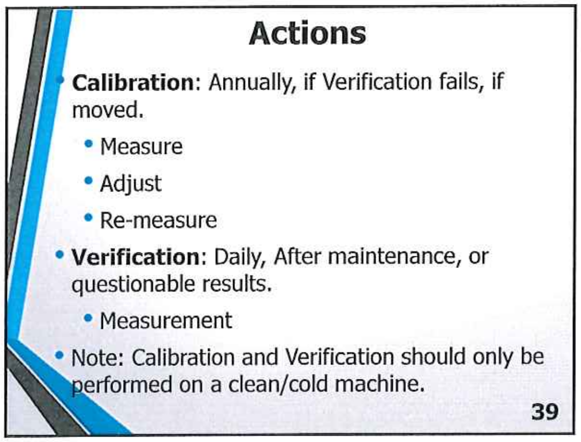
Common GYRO Errors, cont'd.

- Avoid allowing built-up asphalt in gyro mold to smear the sides of the puck as it is extruded, closing off voids. As a minimum, wipe off top and bottom lids after every puck.
- Don't let paper disks become brittle by keeping them in in bottom of mold in oven overnight.



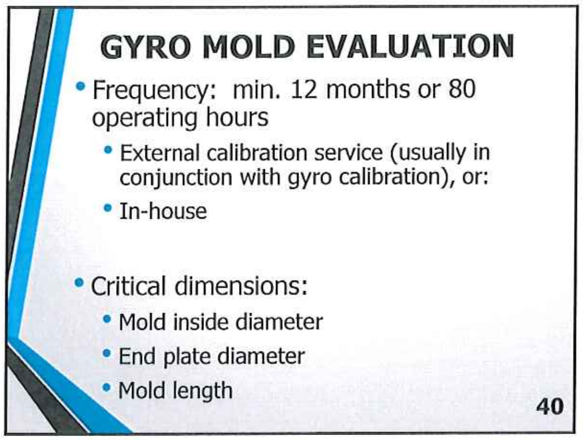
Calibration and Verification

- Must check:
  - rate of gyration (rotational speed)
  - roller clearance & zero position
  - height measurement
  - ram force (load)
  - angle of gyration:
    - Internal angle (calibration)
    - External angle (verification)



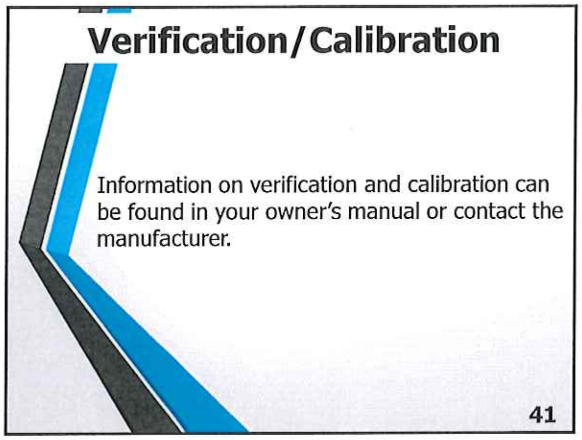
Actions

- **Calibration**: Annually, if Verification fails, if moved.
  - Measure
  - Adjust
  - Re-measure
- **Verification**: Daily, After maintenance, or questionable results.
  - Measurement
- Note: Calibration and Verification should only be performed on a clean/cold machine.



GYRO MOLD EVALUATION

- Frequency: min. 12 months or 80 operating hours
  - External calibration service (usually in conjunction with gyro calibration), or:
  - In-house
- Critical dimensions:
  - Mold inside diameter
  - End plate diameter
  - Mold length



Verification/Calibration

Information on verification and calibration can be found in your owner's manual or contact the manufacturer.

AASHTO T 312: Specimen Compaction

Pre-Verification Checklist: (Note: State operation & frequency).	1	2	R
State required frequency of verification & calibration:			
Verify on a cold (powered up for 10-15 minutes) and clean machine 1) Daily during use, or 2) if gyro is moved			
Calibrate: 1) Annually, or 2) If verification fails			
Pre-Compaction Checklist: (Note: Proctor will tell you the type of specimen to be molded, you will explain the setting for the machine for that operation.)			
State & verify required parameters for compaction:			
1. Verify 150 mm specimen diameter			
2. Verify compaction pressure = 600 kPa			
3. For **Volumetric** pucks, SET GYRATIONS = N_{des} (from JMF)			
4. For **TSR** pucks, set SPEC. HT. (specimen height) = 95.0 mm			
5. Preheat gyratory mold and plates to molding temperature. (see JMF) for ≥ 30 minutes)			
6. Loose Mix sample must be reduced according to AASHTO R47. (see JMF for information)			
7. Place the mix in a preheated oven set to molding temp. (See JMF for temp.)			
8. Place a thermometer in the loose mix to check temperature.			
9. When loose mix is at molding temperature, move quickly to compaction.			
Compaction Procedure: (Mold specimen, proctor can assist with machine operation as needed.) CAUTION!! Use PPE, everything is HOT!			
10. Pull the hot mold items out of the oven.			
11. Assemble mold & bottom plate (If necessary) & insert a paper disk into the bottom of the mold and place a funnel on the top.			
12. Check if mix is at molding temperature, if so, take the loose mix from the oven, place it in the mold in 1 lift. a. Scrape pan and spatula clean to include all of the sample to the mold.			
13. Level the surface of loose mix in the mold, place 2nd paper disk on top.			
14. Place top plate on top beveled side up.			
15. Place mold in machine according to manufactures instructions.			
16. Verify setting are correct on the Gyro, Press START and let compaction proceed.			
17. When the compaction has completed, open door and move mold to puck extrusion station. a. Note: Some machines will automatically extrude the sample.			

18. Carefully remove the top plate and paper disk. a. If the mix is tender, may need to cool a few seconds before handling to avoid collapse.			
19. After minimum cooling period to assure puck stability, carefully set puck upside-down on cooling rack, and remove 2nd paper disk ASAP			
20. Mark the puck for identification purposes on the side of the sample.			
PASS?			
FAIL?			

Proctor____Date__________________

Reviewer____Date__________________

TAB

Module 8

Module 8

Maximum Specific Gravity AASHTO T209

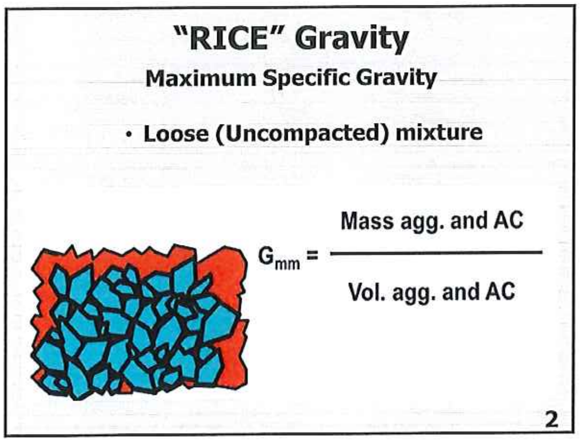
(Gmm), (Rice)

MoDOT

MODULE 8

MAX SPECIFIC GRAVITY "RICE" AASHTO T-209

1



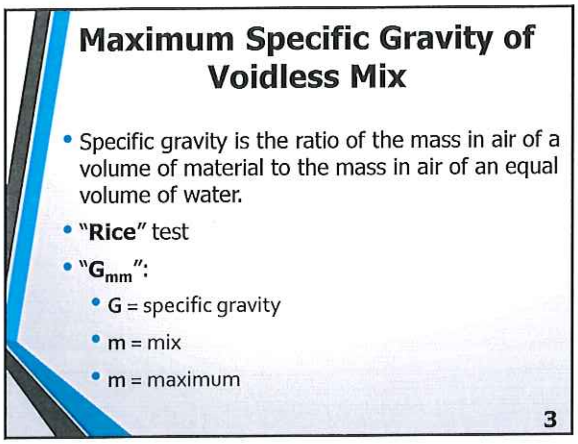
"RICE" Gravity

Maximum Specific Gravity

- **Loose (Uncompacted) mixture**

$$G_{mm} = \frac{\text{Mass agg. and AC}}{\text{Vol. agg. and AC}}$$

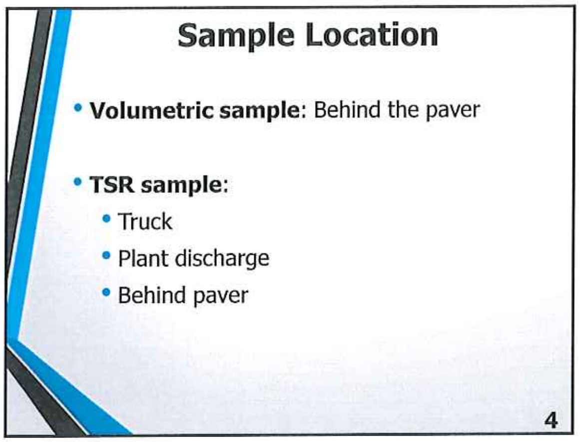
2



Maximum Specific Gravity of Voidless Mix

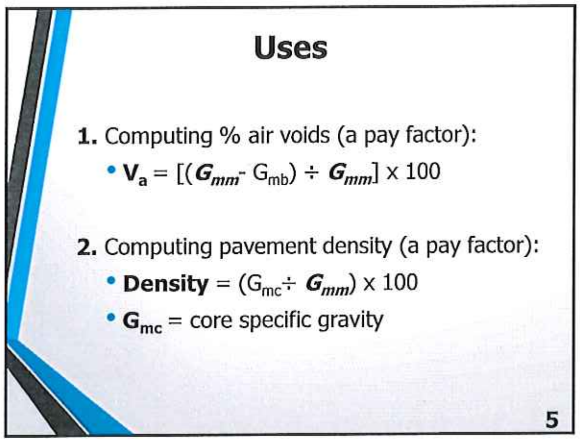
- Specific gravity is the ratio of the mass in air of a volume of material to the mass in air of an equal volume of water.
- "**Rice**" test
- "**G_{mm}**":
  - G = specific gravity
  - m = mix
  - m = maximum

3



Sample Location

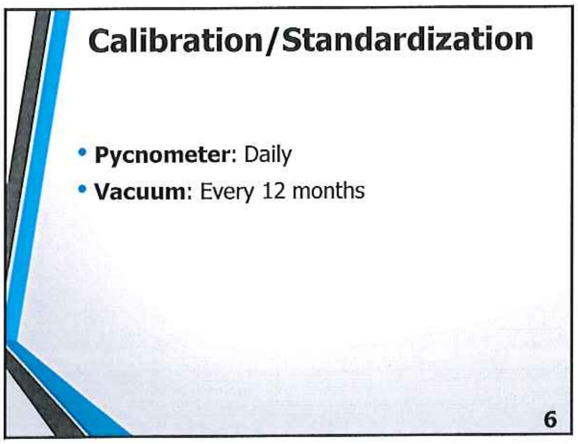
- **Volumetric sample**: Behind the paver
- **TSR sample**:
  - Truck
  - Plant discharge
  - Behind paver



Uses

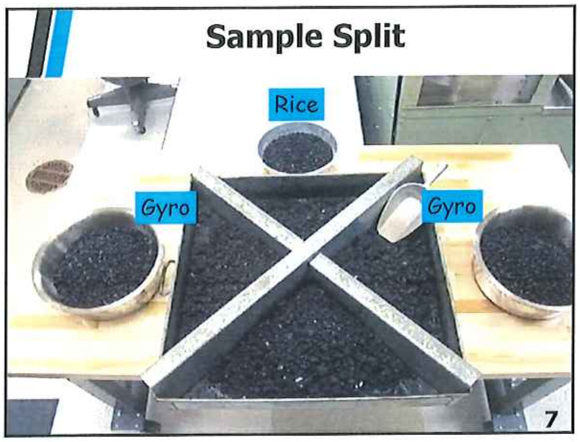
1. Computing % air voids (a pay factor):
  - $V_a = [(G_{mm} - G_{mb}) \div G_{mm}] \times 100$

2. Computing pavement density (a pay factor):
  - **Density** $= (G_{mc} \div G_{mm}) \times 100$
  - G_{mc} = core specific gravity

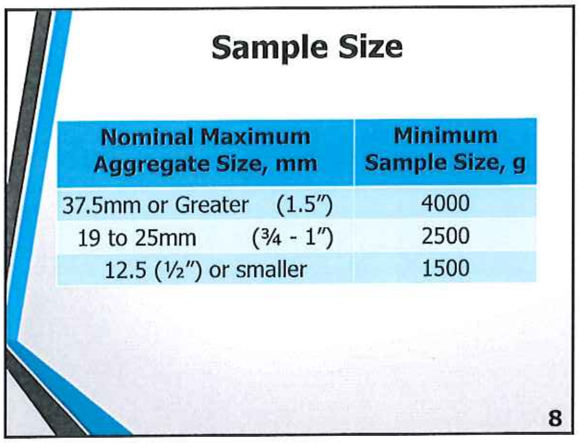


Calibration/Standardization

- **Pycnometer**: Daily
- **Vacuum**: Every 12 months

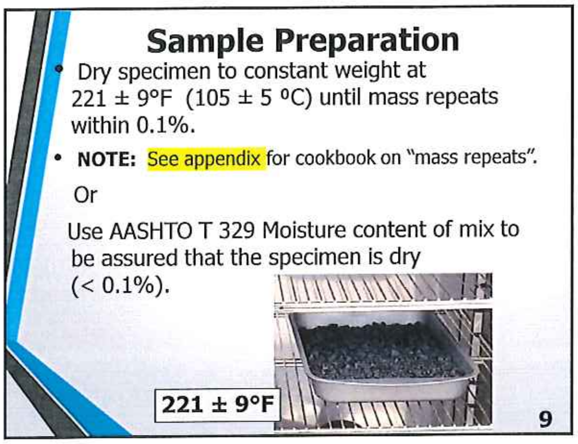


Sample Split



Sample Size

Nominal Maximum Aggregate Size, mm	Minimum Sample Size, g
37.5mm or Greater (1.5")	4000
19 to 25mm (¾ - 1")	2500
12.5 (½") or smaller	1500



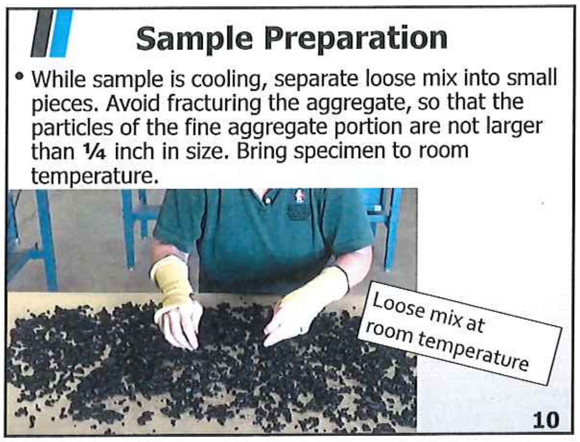
Sample Preparation

- Dry specimen to constant weight at 221 ± 9°F (105 ± 5 °C) until mass repeats within 0.1%.
- **NOTE:** See appendix for cookbook on "mass repeats".

Or

Use AASHTO T 329 Moisture content of mix to be assured that the specimen is dry (< 0.1%).

221 ± 9°F



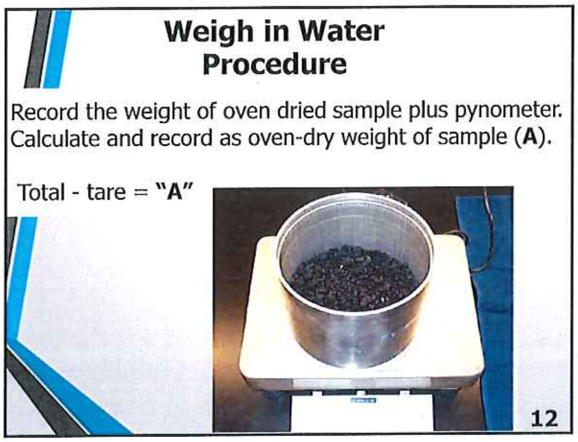
Sample Preparation

- While sample is cooling, separate loose mix into small pieces. Avoid fracturing the aggregate, so that the particles of the fine aggregate portion are not larger than ¼ inch in size. Bring specimen to room temperature.

Loose mix at room temperature

Weigh in Water Procedure

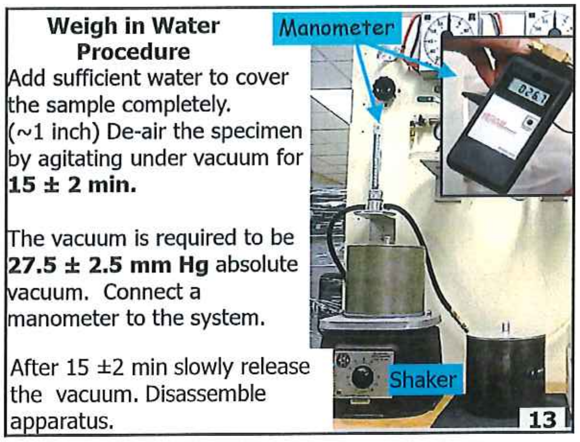
- Check level of the water bath and the temperature of the bath.
  - Temperature of the bath should be **77ºF (25°C).**
- Determine and record the empty weight of the Pycnometer (without lid).
- Place dry loose sample in pycnometer and level the out the top surface.



Weigh in Water Procedure

Record the weight of oven dried sample plus pynometer. Calculate and record as oven-dry weight of sample (**A**).

Total - tare = **"A"**



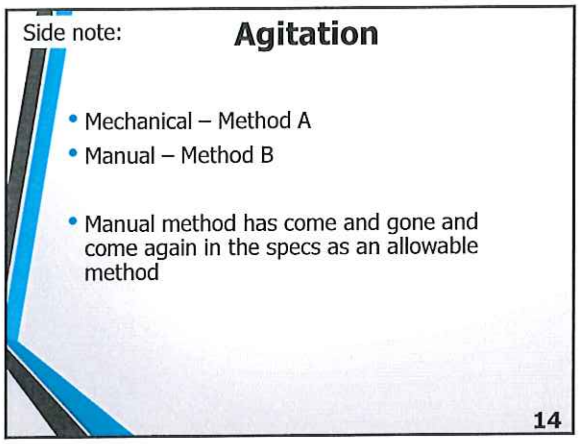
Weigh in Water Procedure

Add sufficient water to cover the sample completely. (~1 inch) De-air the specimen by agitating under vacuum for **15 ± 2 min.**

The vacuum is required to be **27.5 ± 2.5 mm Hg** absolute vacuum. Connect a manometer to the system.

After 15 ±2 min slowly release the vacuum. Disassemble apparatus.

13



Side note:

Agitation

- Mechanical – Method A
- Manual – Method B

- Manual method has come and gone and come again in the specs as an allowable method

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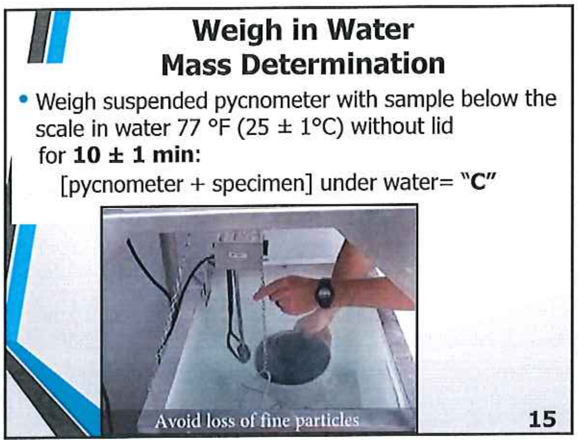


Weigh in Water Mass Determination

- Weigh suspended pycnometer with sample below the scale in water 77 °F (25 ± 1°C) without lid for **10 ± 1 min**:

  [pycnometer + specimen] under water= **"C"**

15

Weigh in Water
Pycnometer Standardization

- Remove specimen from pycnometer. Immediately determine weight under water of empty pycnometer.

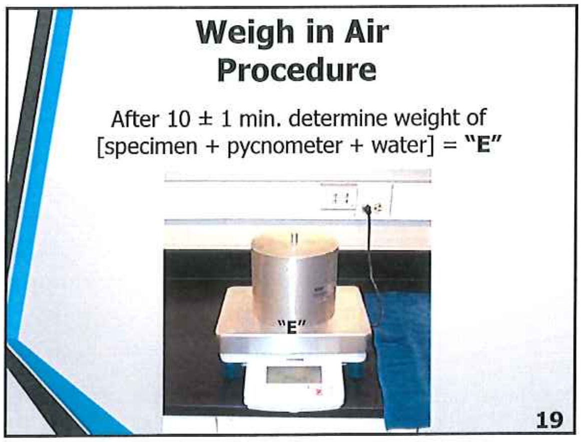
[pycnometer] under water= **"B"**

Weigh in Water
Calculation

- $Gmm = \frac{A}{(A+B-C)}$
  - A=Dry Sample
  - B=Container in Water
  - C=Sample and Container in Water

Weigh in Air
Procedure

Fill the pycnometer with water and bring the specimen to test temperature (25 ± 1°C).



Weigh in Air Procedure

After 10 ± 1 min. determine weight of [specimen + pycnometer + water] = **"E"**

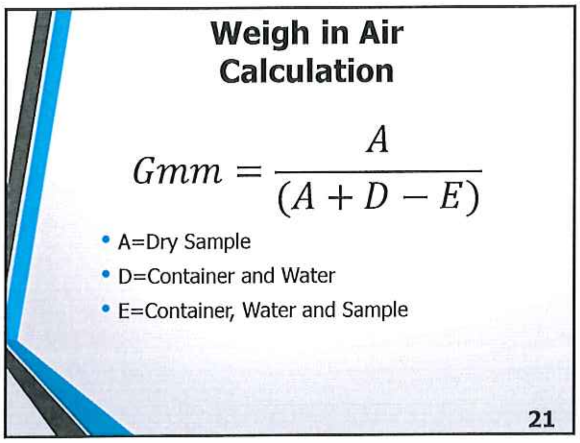
Weigh in Air Pycnometer Standardization

Determine weight of pycnometer full of water to determine its volume. The water is required to be at 25 ± 0.5 °C.

"D"

"D" will be too high with cold temperature & cloudiness.

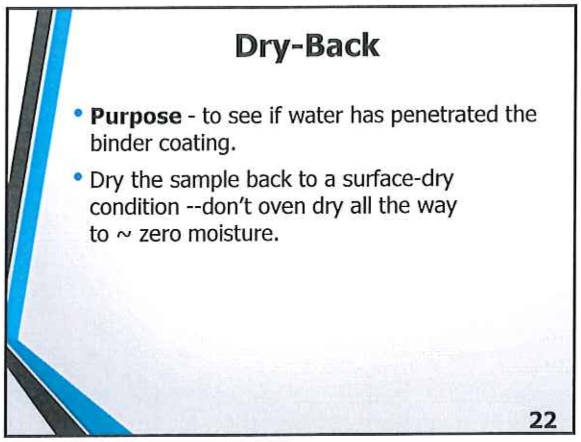
"D" will be too low with high temperature.



Weigh in Air Calculation

$$Gmm = \frac{A}{(A + D - E)}$$

- A=Dry Sample
- D=Container and Water
- E=Container, Water and Sample



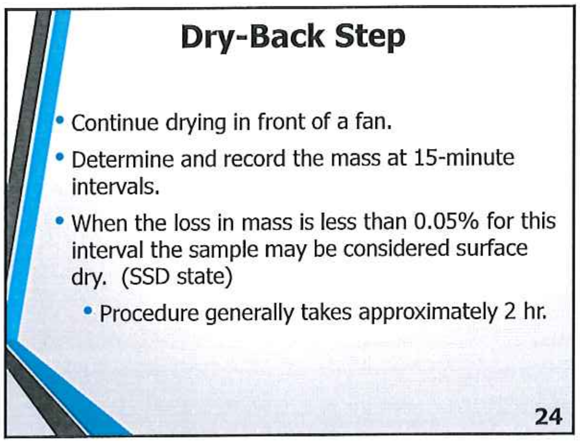
Dry-Back

- **Purpose** - to see if water has penetrated the binder coating.
- Dry the sample back to a surface-dry condition --don't oven dry all the way to ~ zero moisture.

Dry-Back Step

- If absorption of ***any*** coarse aggregate fraction is greater than **2.0%,** dry back the specimen to a surface dry condition and weigh. Use this weight ***"A_2" in the denominator in place of "A".***
- Absorption data is on the JMF.

Spread the sample out in front of a fan



Dry-Back Step

- Continue drying in front of a fan.
- Determine and record the mass at 15-minute intervals.
- When the loss in mass is less than 0.05% for this interval the sample may be considered surface dry. (SSD state)
  - Procedure generally takes approximately 2 hr.

Dry-Back Calculation "A_2"

- Knowing mass of specimen and mass of water displaced (volume of specimen), calculate G_{mm}

$$Gmm = \frac{A}{(A_2+B-C)}$$

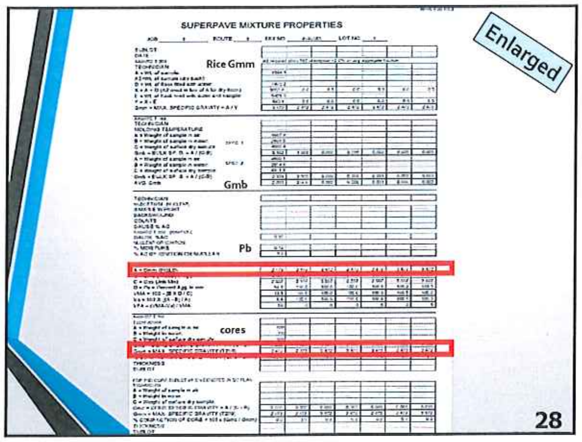
"**C**" will be incorrect if water temperature is not standard.

When to Implement Dry-Back

- If coarse aggregate absorptions are excessive, perform on first lot (all sublots).
- If initial Gmm and the dry-back Gmm are within 0.002 of each other in each of the first 4 sublots, the dry-back procedure may be reduced to once per 4 sublots *(FAQ)*.

Use of G_{mm}

- Calculate Air Voids
- Calculate Core Density



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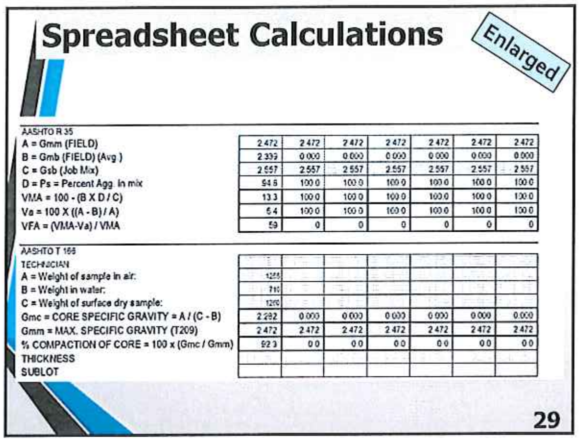


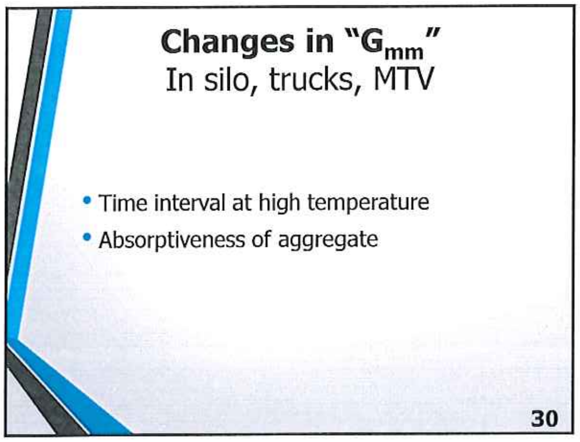
Spreadsheet Calculations

AASHTO R 35							
A = Gmm (FIELD)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
B = Gmb (FIELD) (Avg.)	2.339	0.000	0.000	0.000	0.000	0.000	0.000
C = Gsb (Job Mix)	2.557	2.557	2.557	2.557	2.557	2.557	2.557
D = Ps = Percent Agg. in mix	94.6	100.0	100.0	100.0	100.0	100.0	100.0
VMA = 100 - (B X D / C)	13.3	100.0	100.0	100.0	100.0	100.0	100.0
Va = 100 X ((A - B) / A)	5.4	100.0	100.0	100.0	100.0	100.0	100.0
VFA = (VMA-Va) / VMA	59	0	0	0	0	0	0

AASHTO T 166							
TECHNICIAN							
A = Weight of sample in air:	1255						
B = Weight in water:	710						
C = Weight of surface dry sample:	1260						
Gmc = CORE SPECIFIC GRAVITY = A / (C - B)	2.282	0.000	0.000	0.000	0.000	0.000	0.000
Gmm = MAX. SPECIFIC GRAVITY (T209)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
% COMPACTION OF CORE = 100 x (Gmc / Gmm)	92.3	0.0	0.0	0.0	0.0	0.0	0.0
THICKNESS							
SUBLOT							

29

29



Changes in "G_{mm}"

In silo, trucks, MTV

- Time interval at high temperature
- Absorptiveness of aggregate

30

30

SUPERPAVE MIXTURE PROPERTIES

JOB 0 ROUTE 0 MIX NO. #VALUE! LOT NO. 0

Rice Gmm

A2 required when T85 absorption >2.0% on any aggregate fraction.

SUBLOT							
DATE							
AASHTO T 209 TECHNICIAN							
A = Wt. of sample:	1594.4						
A2=Wt. of sample (dry-back):							
D = Wt. of flask filled with water:	7472.2						
X = A + D (A2 used in lieu of A for dry-back)	9066.6	0.0	0.0	0.0	0.0	0.0	0.0
E = Wt. of flask filled with water and sample:	8421.5						
Y = X - E	645.1	0.0	0.0	0.0	0.0	0.0	0.0
Gmm = MAX. SPECIFIC GRAVITY = A / Y	2.472	2.472	2.472	2.472	2.472	2.472	2.472

AASHTO T 166 TECHNICIAN							
MOLDING TEMPERATURE							
A = Weight of sample in air:	4867.8						
B = Weight of sample in water: SPEC. 1	2801.9						
C = Weight of surface dry sample:	4880.4						
Gmb = BULK SP. G. = A / (C-B)	2.342	0.000	0.000	0.000	0.000	0.000	0.000
A = Weight of sample in air:	4899.1						
B = Weight of sample in water: SPEC. 2	2814.5						
C = Weight of surface dry sample:	4911.9						
Gmb = BULK SP. G. = A / (C-B)	2.336	0.000	0.000	0.000	0.000	0.000	0.000
AVG. Gmb	2.339	0.000	0.000	0.000	0.000	0.000	0.000

Gmb

TECHNICIAN							
MoDOT TM54 (NUCLEAR) SAMPLE WEIGHT							
BACKGROUND							
COUNTS							
GAUGE % AC							
AASHTO T 308 (IGNITION) GAUGE %AC	5.35						
NUCLEAR OR IGNITION % MOISTURE	0.12						
% AC BY IGNITION OR NUCLEAR	5.2						

Pb

A = Gmm (FIELD)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
B = Gmb (FIELD) (Avg)	2.339	0.000	0.000	0.000	0.000	0.000	0.000
C = Gsb (Job Mix)	2.557	2.557	2.557	2.557	2.557	2.557	2.557
D = Ps = Percent Agg. in mix	94.8	100.0	100.0	100.0	100.0	100.0	100.0
VMA = 100 - (B X D / C)	13.3	100.0	100.0	100.0	100.0	100.0	100.0
Va = 100 X ((A - B) / A)	5.4	100.0	100.0	100.0	100.0	100.0	100.0
VFA = [(VMA-Va) / VMA] * 100	59	0	0	0	0	0	0

cores

AASHTO T 166 TECHNICIAN							
A = Weight of sample in air:	1255						
B = Weight in water:	710						
C = Weight of surface dry sample:	1260						
Gmc = CORE SPECIFIC GRAVITY = A / (C - B)	2.282	0.000	0.000	0.000	0.000	0.000	0.000
Gmm = MAX. SPECIFIC GRAVITY (T209)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
% COMPACTION OF CORE = 100 x (Gmc / Gmm)	92.3	0.0	0.0	0.0	0.0	0.0	0.0
THICKNESS							
SUBLOT							

FOR 2ND CORE SUBLOT WHEN DENOTED IN QC PLAN TECHNICIAN							
A = Weight of sample in air:							
B = Weight in water:							
C = Weight of surface dry sample:							
Gmc = CORE SPECIFIC GRAVITY = A / (C - B)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gmm = MAX. SPECIFIC GRAVITY (T209)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
% COMPACTION OF CORE = 100 x (Gmc / Gmm)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
THICKNESS							
SUBLOT							

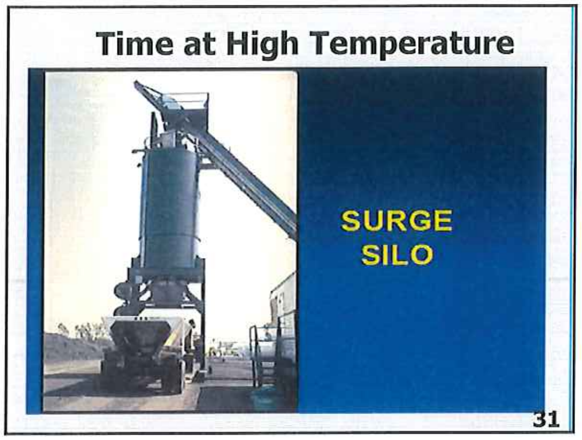
SPREADSHEET CALCULATIONS

AASHTO R 35

A = Gmm (FIELD)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
B = Gmb (FIELD) (Avg.)	2.339	0.000	0.000	0.000	0.000	0.000	0.000
C = Gsb (Job Mix)	2.557	2.557	2.557	2.557	2.557	2.557	2.557
D = Ps = Percent Agg. in mix	94.8	100.0	100.0	100.0	100.0	100.0	100.0
VMA = 100 - (B X D / C)	13.3	100.0	100.0	100.0	100.0	100.0	100.0
Va = 100 X ((A - B) / A)	5.4	100.0	100.0	100.0	100.0	100.0	100.0
VFA = (VMA-Va) / VMA	59	0	0	0	0	0	0

AASHTO T 166

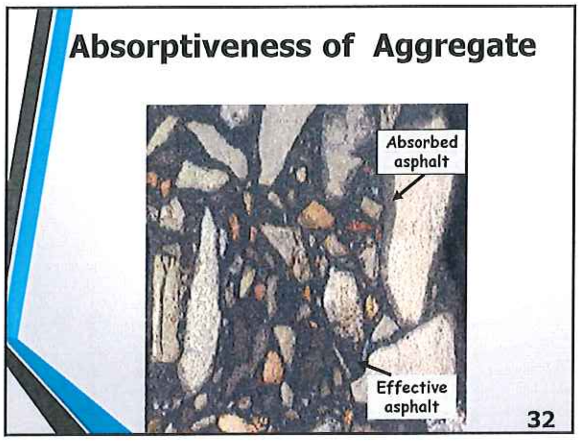
TECHNICIAN							
A = Weight of sample in air:	1255						
B = Weight in water:	710						
C = Weight of surface dry sample:	1260						
Gmc = CORE SPECIFIC GRAVITY = A / (C - B)	2.282	0.000	0.000	0.000	0.000	0.000	0.000
Gmm = MAX. SPECIFIC GRAVITY (T209)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
% COMPACTION OF CORE = 100 x (Gmc / Gmm)	92.3	0.0	0.0	0.0	0.0	0.0	0.0
THICKNESS							
SUBLOT							



Time at High Temperature

31

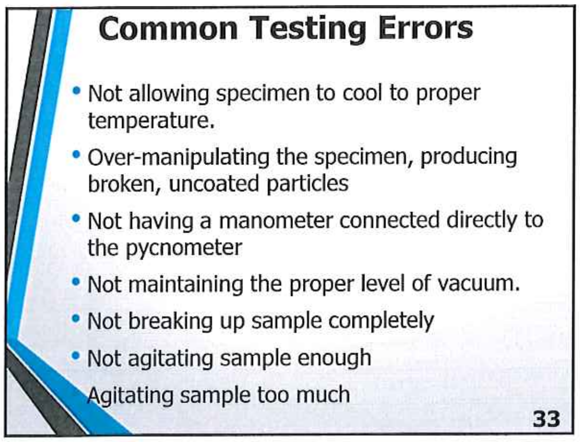
31



Absorptiveness of Aggregate

32

32

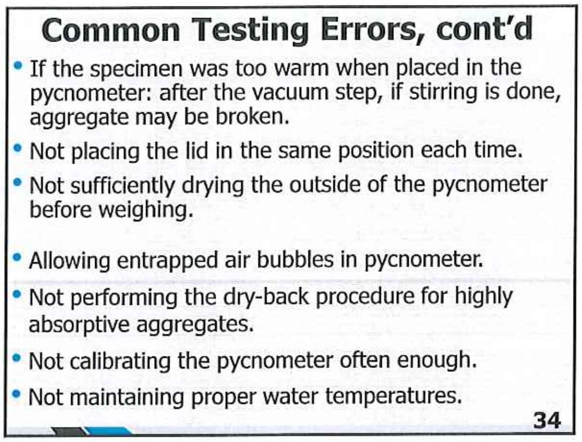


Common Testing Errors

- Not allowing specimen to cool to proper temperature.
- Over-manipulating the specimen, producing broken, uncoated particles
- Not having a manometer connected directly to the pycnometer
- Not maintaining the proper level of vacuum.
- Not breaking up sample completely
- Not agitating sample enough
- Agitating sample too much

33

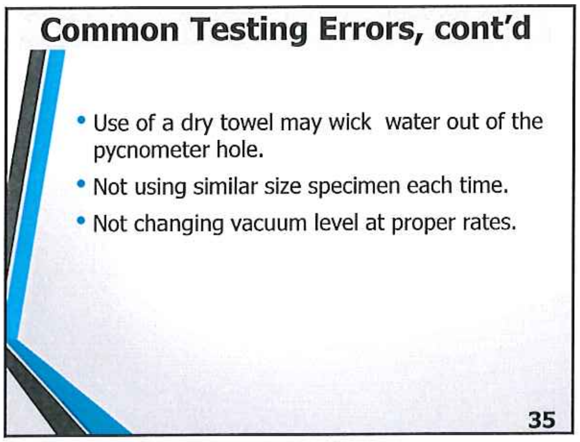
33



Common Testing Errors, cont'd

- If the specimen was too warm when placed in the pycnometer: after the vacuum step, if stirring is done, aggregate may be broken.
- Not placing the lid in the same position each time.
- Not sufficiently drying the outside of the pycnometer before weighing.
- Allowing entrapped air bubbles in pycnometer.
- Not performing the dry-back procedure for highly absorptive aggregates.
- Not calibrating the pycnometer often enough.
- Not maintaining proper water temperatures.

34



Common Testing Errors, cont'd

- Use of a dry towel may wick water out of the pycnometer hole.
- Not using similar size specimen each time.
- Not changing vacuum level at proper rates.

35

AASHTO T 209: Theoretical Maximum Specific Gravity (Rice Test): "Weigh In Water" Method

Trial#	1	2	R
Pre-Procedure Checklist: (State for proctor operation and frequency)			
State the following requirements for routine testing of a particular mix:			
1. Pycnometer calibration required daily			
2. Sample moisture content must be <0.1%: Verify by a) oven drying until mass repeats within 0.1% OR b) use results of AASHTO T 329			
3. Perform "dry-back" procedure if <u>ANY coarse aggregate fraction</u> has absorption > 2.0% (use surface-dry weight "A2" in place of "A" in the denominator of the non-dry-back Gmm equation			
Routine Rice Test Procedure: (Demonstrate procedure, proctor will shorten time frames where needed.)			
4. Separate particles while cooling sample: 1) Don't break aggregate; 2) Reduce sand-binder clumps to ≤ ¼"; 3) Cool until mix is at room temperature			
5. Determine and record empty weight of the pycnometer (without lid). Place and level sample in pycnometer. Record weight of sample + pycnometer. Calculate and record oven-dry weight of sample [A]			
6. Cover sample with approximately 1" of bath water			
7. Subject to specified vacuum while agitating for 15 ± 2 minutes			
8. Very slowly release vacuum, then disassemble apparatus			
9. Confirm that water bath temperature is in spec and water is at default level (are they?), then zero out the weigh-in-water system.			
10. Being careful not to expose the mix to the air, suspend pycnometer (without lid) and contents in water bath			
11. Determine and record combined mass of pycnometer and contents [C] after 10 ± 1 minutes of immersion			
12. After recording C, remove pycnometer from water bath, completely remove the contents, reset the weigh-in-water system to its default condition, re-suspend empty pycnometer (without lid) in water bath, then determine and record mass [B] after steady-state has been achieved (tank stops overflowing).			
13. Calculate non-dry-back Gmm = A / (A + B – C): Nearest 0.001?			
14. Calculate dry-back Gmm = A / (A2 + B – C): Nearest 0.001?			
PASS?			
FAIL?			

Proctor__________________________________ Date________________

Reviewer_________________________________ Date________________

AASHTO T 209: Theoretical Maximum Specific Gravity (Rice Test): “Weigh in Air” Method

Trial#	1	2	R
Pre-Procedure Checklist: {State for proctor operation & Frequency}			
State the following requirements for routine testing of a particular mix:			
1. Pycnometer calibration required daily			
2. Sample moisture content must be <0.1%: Verify by a) oven drying until mass repeats within 0.1% OR b) use results of AASHTO T 329			
3. Perform “dry-back” procedure if ANY coarse aggregate fraction has absorption > 2.0% (use surface-dry weight “A2” in place of “A” in the denominator of the non-dry-back Gmm equation			
Routine Rice Test Procedure: **{Demonstrate procedure, Proctor will shorten time frames}**			
4. Separate particles while cooling sample: 1) Don’t break aggregate; 2) Reduce sand-binder clumps to ≤ ¼”; 3) Cool until mix is at room temperature			
5. Determine and record empty weight of the pycnometer (without lid). Place and level sample in pycnometer. Record weight of sample + pycnometer. Calculate oven-dry weight of sample [A]			
6. Cover sample with approximately 1” of bath water			
7. Subject to specified vacuum while agitating for 15 ± 2 minutes			
8. Immediately after the 15 ± 2-minute time period (i.e. the vacuum application stops), very slowly release vacuum.			
9. Start 10 ± 1 minute time period in which the final weight must be obtained (i.e., finish the test). Disassemble apparatus.			
10. Being careful not to expose the mix to the air, slowly submerge pycnometer in water bath at the specified temperature (is it?) and carefully place capillary lid on pycnometer			
11. Just prior to end of 10 ± 1 minute time period, remove pycnometer, dry off the exterior, then determine and record total weight [E]			
12. After recording E, completely remove contents, re-submerge empty pycnometer in water bath, place capillary lid on pycnometer, wait 10 ± 1 minutes for temperature to stabilize, remove pycnometer, dry off the exterior, then determine and record total weight [D]			
13. Calculate non-dry-back Gmm = A / (A + D – E): Nearest 0.001?			
14. Calculate dry-back Gmm = A / (A2 + D – E): Nearest 0.001?			
PASS?			
FAIL?			

Proctor______________________________ Date______________

Reviewer_____________________________ Date______________

TAB

Module 9

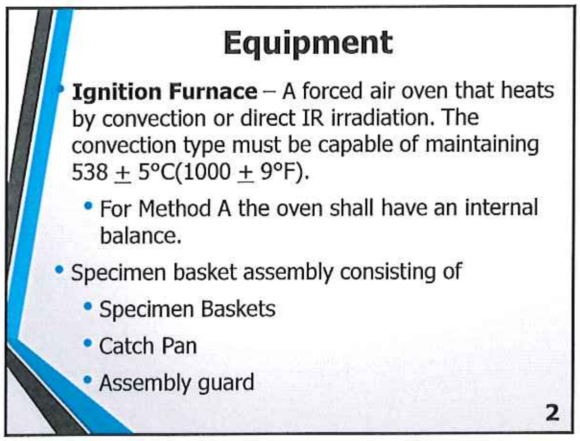
Module 9

Binder Ignition
AC Content
AASHTO T308

MODULE 9

BINDER IGNITION OVEN
AC CONTENT
AASHTO T308

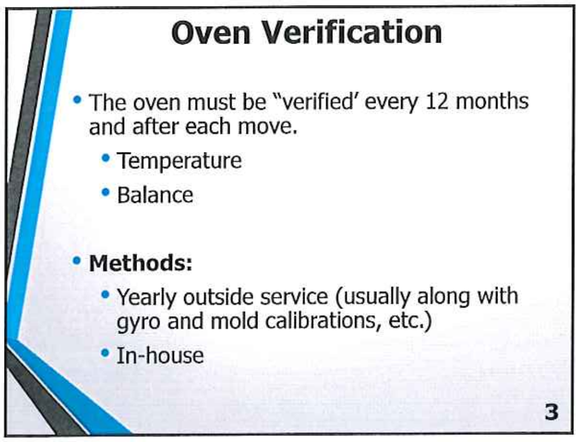
1



Equipment

- **Ignition Furnace** – A forced air oven that heats by convection or direct IR irradiation. The convection type must be capable of maintaining 538 ± 5°C(1000 ± 9°F).
  - For Method A the oven shall have an internal balance.
- Specimen basket assembly consisting of
  - Specimen Baskets
  - Catch Pan
  - Assembly guard

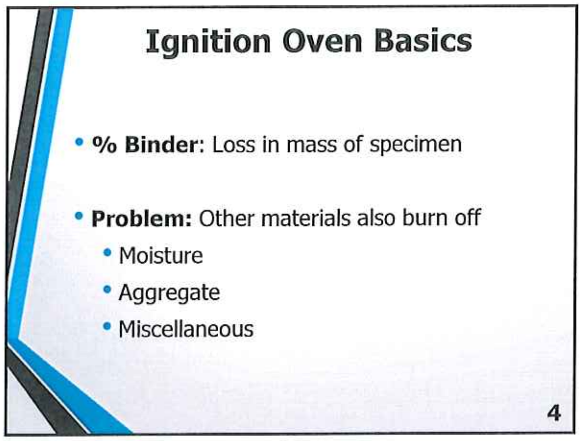
2



Oven Verification

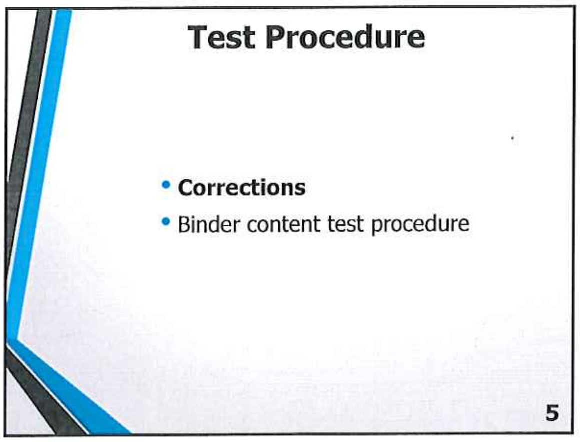
- The oven must be “verified’ every 12 months and after each move.
  - Temperature
  - Balance
- **Methods:**
  - Yearly outside service (usually along with gyro and mold calibrations, etc.)
  - In-house

3



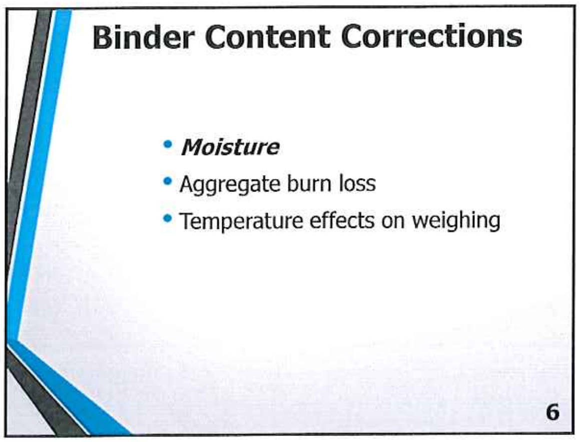
Ignition Oven Basics

- **% Binder**: Loss in mass of specimen
- **Problem:** Other materials also burn off
  - Moisture
  - Aggregate
  - Miscellaneous



Test Procedure

- **Corrections**
- Binder content test procedure



Binder Content Corrections

- ***Moisture***
- Aggregate burn loss
- Temperature effects on weighing

Moisture Correction

- Moisture in mix will evaporate.
- This will count as binder unless corrected.
- Correction (2 methods):
  - Dry mix to a constant mass at 110 ± 5 C prior to testing.
  - "Aging"—must still verify that constant mass has been achieved.

  Or
  - Determine moisture content of mix (AASHTO T 329), subtract it from the apparent binder content.

Moisture Content (AASHTO T 329)

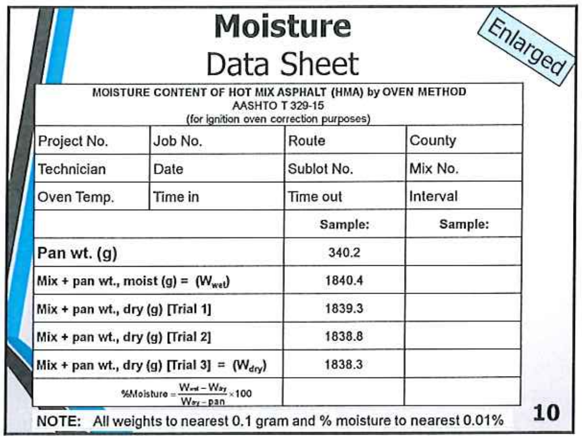
- Temperature:
  - Within the JMF mixing temperature range.
  - If unavailable, use 325 ±25 F
- Initial drying time is 90 ± 5 minutes.
- Continue drying checking at 30 ± 5 min intervals until the mass changes less than 0.05% from the previous mass.
- Moisture is now calculated based on *dry* weight of HMA.

$$MC = \left[\frac{M_{i(wet)} - M_{i(dry)}}{M_{i(dry)}}\right] X100$$

MC = % moisture
$M_{i(wet)}$ = initial mass of mix, wet
$M_{f(dry)}$ = final mass of mix, dry

Rounding

- When calculating, round to nearest 0.01% for moisture content, binder content, and Cf
- When comparing to specification, round binder content to nearest 0.1%



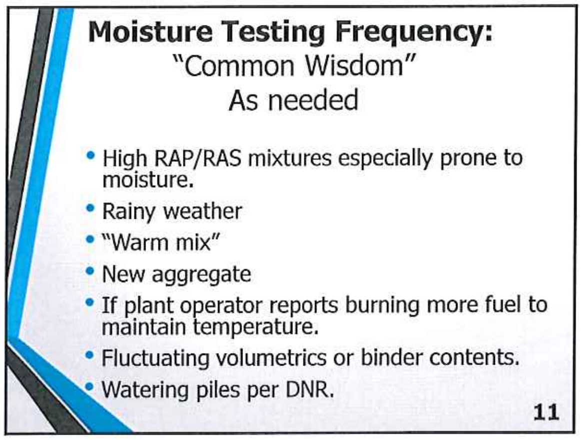
Moisture
Data Sheet

Enlarged

MOISTURE CONTENT OF HOT MIX ASPHALT (HMA) by OVEN METHOD
AASHTO T 329-15
(for ignition oven correction purposes)

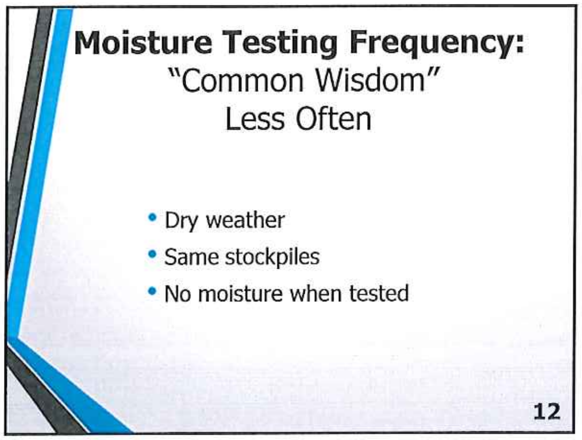
Project No.	Job No.	Route	County
Technician	Date	Sublot No.	Mix No.
Oven Temp.	Time in	Time out	Interval
		Sample:	**Sample:**
Pan wt. (g)		340.2	
Mix + pan wt., moist (g) = (W_{wet})		1840.4	
Mix + pan wt., dry (g) [Trial 1]		1839.3	
Mix + pan wt., dry (g) [Trial 2]		1838.8	
Mix + pan wt., dry (g) [Trial 3] = (W_{dry})		1838.3	
$\%Moisture = \frac{W_{wet} - W_{dry}}{W_{dry} - pan} \times 100$			

NOTE: All weights to nearest 0.1 gram and % moisture to nearest 0.01%



Moisture Testing Frequency:
"Common Wisdom"
As needed

- High RAP/RAS mixtures especially prone to moisture.
- Rainy weather
- "Warm mix"
- New aggregate
- If plant operator reports burning more fuel to maintain temperature.
- Fluctuating volumetrics or binder contents.
- Watering piles per DNR.



Moisture Testing Frequency:
"Common Wisdom"
Less Often

- Dry weather
- Same stockpiles
- No moisture when tested

Moisture
Data Sheet

MOISTURE CONTENT OF HOT MIX ASPHALT (HMA) by OVEN METHOD
AASHTO T 329-15
(for ignition oven correction purposes)

Project No.	Job No.	Route	County
Technician	Date	Sublot No.	Mix No.
Oven Temp.	Time in	Time out	Interval

	Sample:	**Sample:**
Pan wt. (g)	340.2	
Mix + pan wt., moist (g) = (W_{wet})	1840.4	
Mix + pan wt., dry (g) [Trial 1]	1839.3	
Mix + pan wt., dry (g) [Trial 2]	1838.8	
Mix + pan wt., dry (g) [Trial 3] = (W_{dry})	1838.3	
$\%\text{Moisture} = \frac{W_{wet} - W_{dry}}{W_{dry} - \text{pan}} \times 100$		

NOTE: All weights to nearest 0.1 gram and % moisture to nearest 0.01%

Binder Content Corrections

- **Moisture**
- **Aggregate burn loss**
- Temperature effects on weighing

Asphalt Binder Correction Factor
(Aggregate Correction Factor)

- To correct for loss of mass during the mix ignition due to aggregate burn-off.
- Determined during mix design by mix designer (usually QC).
- Re-determined if mix design changes (e.g. >5% change in stockpiled aggregate proportions).
- Re-determined if a different oven is used (QA or QC).

Asphalt Binder Correction Factor
(Aggregate Correction Factor), cont'd.

- **C_F Procedure**:
  - Mix specimen in lab with dry aggregate at a known (***actual***) % binder.
  - Input "zero" for the C_F
  - Burn, obtain ***measured*** ***(apparent)***% binder.
  - The difference between the ***measured*** and the ***actual*** % binder is the Asphalt Binder Correction Factor (C_F).
  - If the C_F is > 1.0%, re-determine at a lower temperature.

Definitions

- **M** = mass (g)
- **Mi(dry)** = Mass of mix before burning, dry already.
- **Mf** = Final mass of mix after burning (binder and some aggregate burned off).
- **(Mi(dry) – Mf)** = Binder & aggregate burned off.
- **Magg** = Initial unburned mass of just the aggregate, dry.
- **(Mi(dry) – Mi(agg))** = Mix mass minus aggregate mass is the mass of binder, initially.

Asphalt Binder Correction Factor (Aggregate Correction Factor), cont'd.

- Lab-produced sample (dry)

$$C_f = Measured - Actual$$

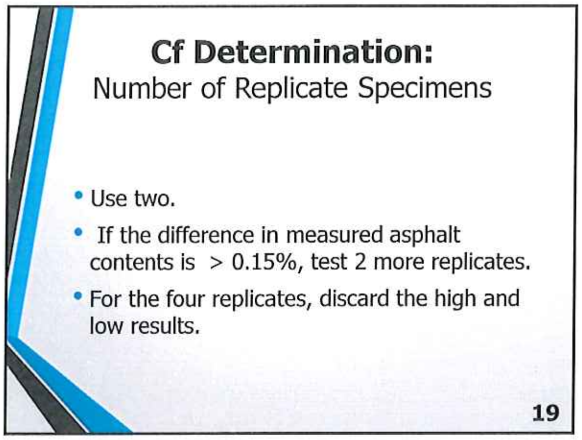
- Math:

$$C_f = \left[\frac{M_{i(dry)} - M_f}{M_{i(dry)}}\right] - \left[\frac{M_{i(dry)} - M_{i(agg)}}{M_{i(dry)}}\right]$$

- The difference is the aggregate mass loss
- The ***Measured*** binder content can be from the oven ticket
- The ***Actual*** binder content can be from a bench scale
- If the C_F is > 1.0%, re-determine at a lower temperature

Convection Oven Temperatures

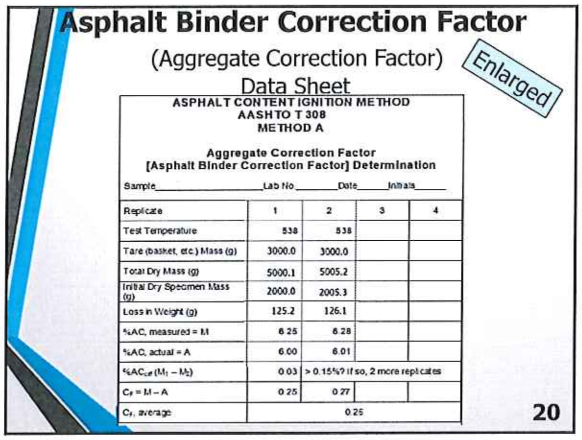
- **AASHTO:**
  - Normal: 538 C
  - High C_F's (>1.0%): 482 C
- **MoDOT:**
  - Normal: 538 C
  - High C_F's: if >1.0% try 482 C
  - Very high C_F's: if >1.0% at 482 C, use 427 C



Cf Determination:

Number of Replicate Specimens

- Use two.
- If the difference in measured asphalt contents is > 0.15%, test 2 more replicates.
- For the four replicates, discard the high and low results.



Asphalt Binder Correction Factor

(Aggregate Correction Factor)

Data Sheet

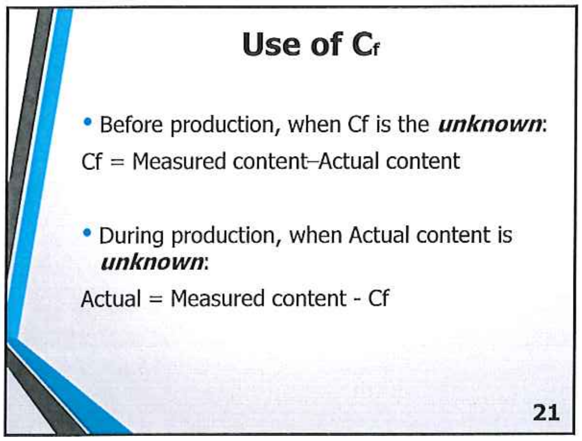
Enlarged

ASPHALT CONTENT IGNITION METHOD
AASHTO T 308
METHOD A

Aggregate Correction Factor
[Asphalt Binder Correction Factor] Determination

Sample________________Lab No_______Date_____Initials_____

Replicate	1	2	3	4
Test Temperature	538	538		
Tare (basket, etc.) Mass (g)	3000.0	3000.0		
Total Dry Mass (g)	5000.1	5005.2		
Initial Dry Specimen Mass (g)	2000.0	2005.3		
Loss in Weight (g)	125.2	126.1		
%AC, measured = M	6.25	6.28		
%AC, actual = A	6.00	6.01		
$\%AC_{diff}$ $(M_1 - M_2)$	0.03	> 0.15%? If so, 2 more replicates		
$C_f = M - A$	0.25	0.27		
C_f, average	0.25			



Use of C_f

- Before production, when Cf is the ***unknown***:

Cf = Measured content–Actual content

- During production, when Actual content is ***unknown***:

Actual = Measured content - Cf

Asphalt Binder Correction Factor

(Aggregate Correction Factor)

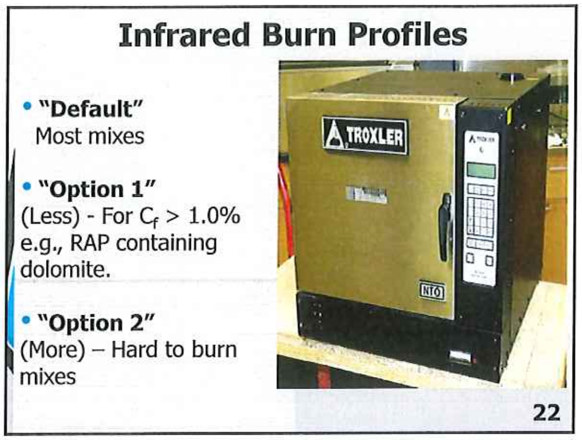
Data Sheet

ASPHALT CONTENT IGNITION METHOD
(AASHTO T 308)
METHOD A

Aggregate Correction Factor [Asphalt Binder Correction Factor] Determination

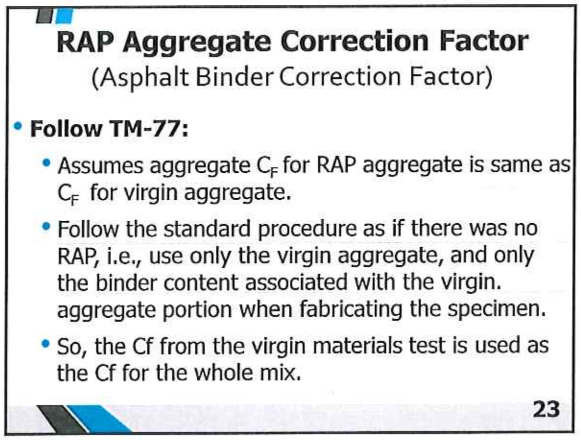
Sample______________________Lab No.________Date______Initials______

Replicate	1	2	3	4
Test Temperature	538	538		
Tare (basket, etc.) Mass (g)	3000.0	3000.0		
Total Dry Mass (g)	5000.1	5005.2		
Initial Dry Specimen Mass (g)	2000.0	2005.3		
Loss in Weight (g)	125	126		
%AC, measured = M	6.25	6.28		
%AC, actual = A	6.00	6.01		
%AC$_{diff}$ ($M_1 - M_2$)	0.03	> 0.15%? If so, 2 more replicates		
$C_F = M - A$	0.25	0.27		
C_F, average	0.26			



Infrared Burn Profiles

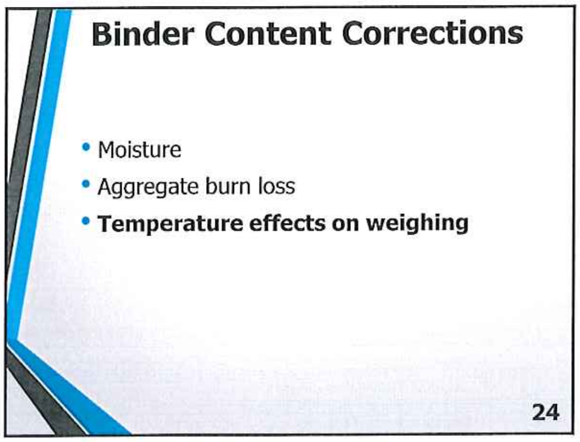
- **"Default"**
  Most mixes
- **"Option 1"**
  (Less) - For $C_f > 1.0\%$ e.g., RAP containing dolomite.
- **"Option 2"**
  (More) – Hard to burn mixes



RAP Aggregate Correction Factor

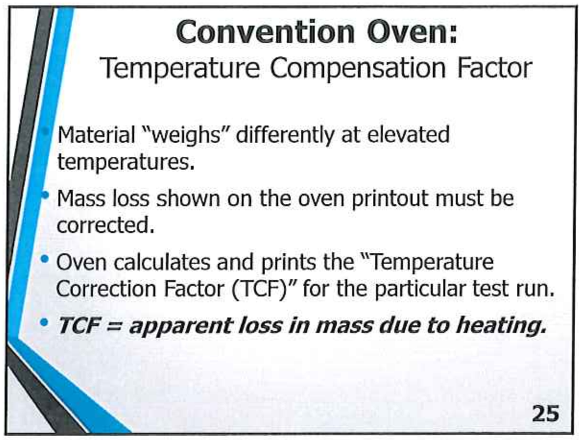
(Asphalt Binder Correction Factor)

- **Follow TM-77:**
  - Assumes aggregate C_F for RAP aggregate is same as C_F for virgin aggregate.
  - Follow the standard procedure as if there was no RAP, i.e., use only the virgin aggregate, and only the binder content associated with the virgin. aggregate portion when fabricating the specimen.
  - So, the Cf from the virgin materials test is used as the Cf for the whole mix.



Binder Content Corrections

- Moisture
- Aggregate burn loss
- **Temperature effects on weighing**



Convention Oven:

Temperature Compensation Factor

- Material "weighs" differently at elevated temperatures.
- Mass loss shown on the oven printout must be corrected.
- Oven calculates and prints the "Temperature Correction Factor (TCF)" for the particular test run.
- ***TCF = apparent loss in mass due to heating.***

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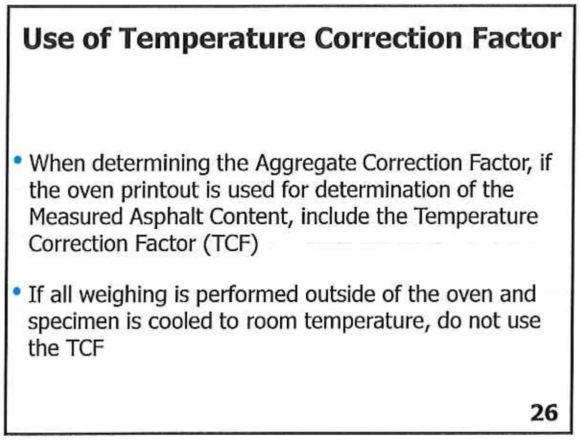
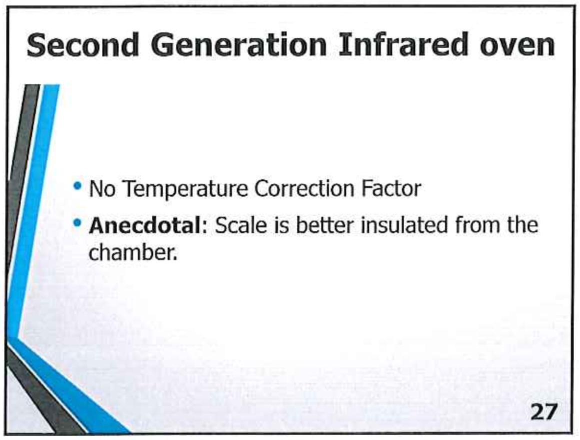


Use of Temperature Correction Factor

- When determining the Aggregate Correction Factor, if the oven printout is used for determination of the Measured Asphalt Content, include the Temperature Correction Factor (TCF)
- If all weighing is performed outside of the oven and specimen is cooled to room temperature, do not use the TCF

26



Second Generation Infrared oven

- No Temperature Correction Factor
- **Anecdotal**: Scale is better insulated from the chamber.

27

Test Procedure

- Corrections
- **Binder content test procedure**

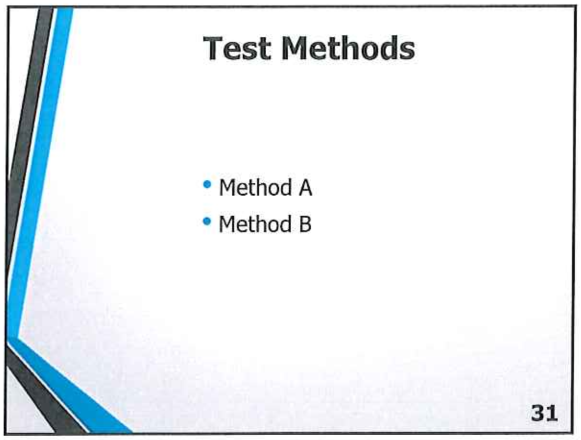
Reheating

EPG 403.1.5

- If a retained sample must be reheated:
  - Gently warm the sample until workable.
  - Spread it in a large pan and reheat—this will minimize the damage caused by reheating.

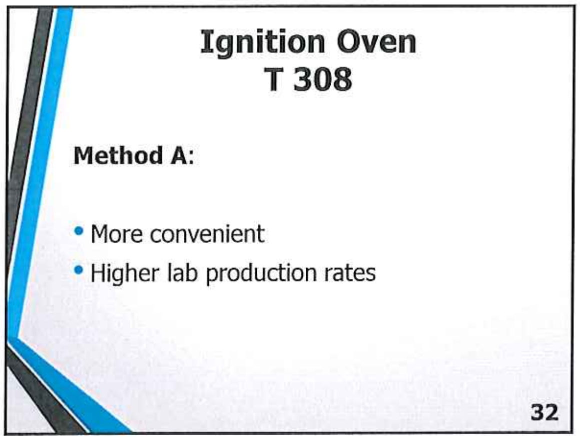
Ignition Oven Specimen Size

Mix	NMS, in.	Specimen Size, g
SP048 & BP-3	#4	1200-1700
SP095	3/8	1200-1700
SP125, BP-1 & BP-2	1/2	1500-2000
SP190 & Bit Base	3/4	2000-2500
SP250	1	3000-3500



Test Methods

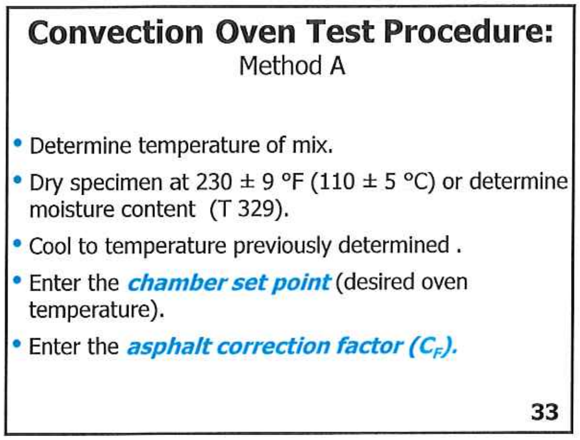
- Method A
- Method B



Ignition Oven
T 308

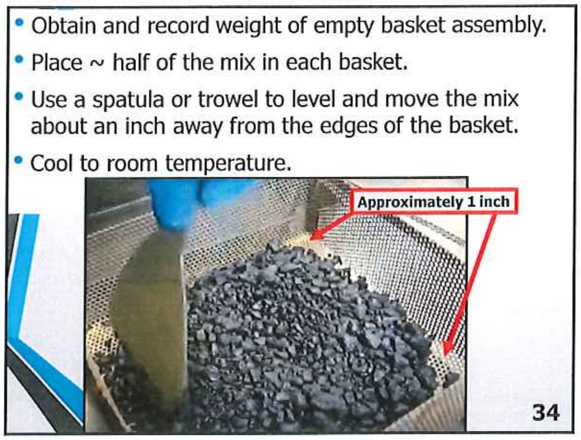
Method A:

- More convenient
- Higher lab production rates

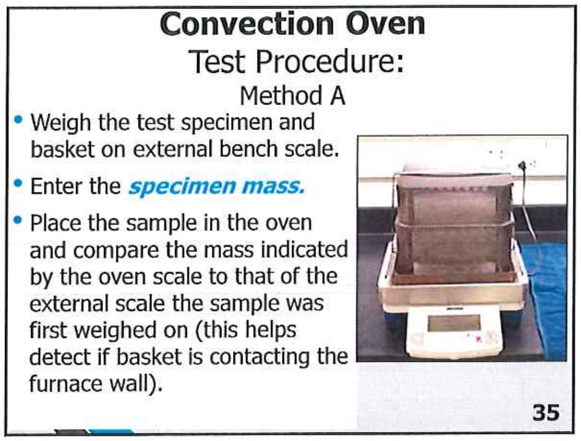


Convection Oven Test Procedure:
Method A

- Determine temperature of mix.
- Dry specimen at 230 ± 9 °F (110 ± 5 °C) or determine moisture content (T 329).
- Cool to temperature previously determined .
- Enter the ***chamber set point*** (desired oven temperature).
- Enter the ***asphalt correction factor (C_F).***



- Obtain and record weight of empty basket assembly.
- Place ~ half of the mix in each basket.
- Use a spatula or trowel to level and move the mix about an inch away from the edges of the basket.
- Cool to room temperature.

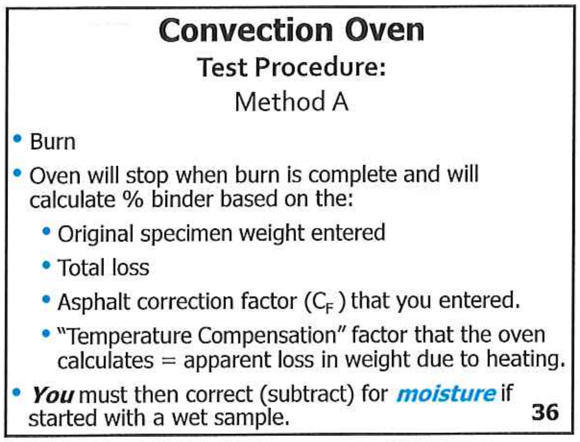


Convection Oven

Test Procedure:

Method A

- Weigh the test specimen and basket on external bench scale.
- Enter the ***specimen mass.***
- Place the sample in the oven and compare the mass indicated by the oven scale to that of the external scale the sample was first weighed on (this helps detect if basket is contacting the furnace wall).



Convection Oven

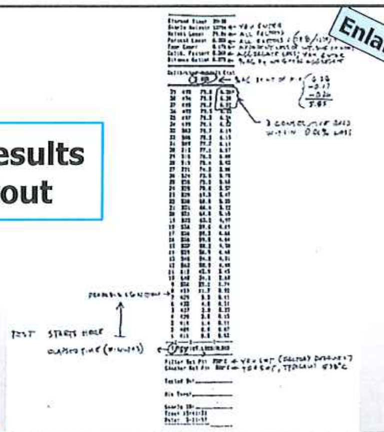
Test Procedure:

Method A

- Burn
- Oven will stop when burn is complete and will calculate % binder based on the:
  - Original specimen weight entered
  - Total loss
  - Asphalt correction factor (C_F) that you entered.
  - "Temperature Compensation" factor that the oven calculates = apparent loss in weight due to heating.
- ***You*** must then correct (subtract) for ***moisture*** if started with a wet sample.

Test Results Printout

Enlarged



Asphalt Content Ignition Method

(AASHTO T 308-10) Method A

Reproducing Oven Ticket Values

Enlarged

*If w_i = wet

Project No.	Job No.	Route	County
Technician	Date	Sublot No.	Mix No.

Empty Basket Assembly Weight (g). [T_A]	3000.2
Basket Assembly + Wet (or dry) Sample Weight (g). [T_i]	4270.2
Wet (or dry) Sample Weight (g). [$W_i = (T_i - T_A)$]	
Loss in Weight (g). [L] (from tape)	
Total % Loss. [$P_L = (L / W_i) \times 100$]	
Temperature Compensation (%). [C_T] (from tape)	
% AC, uncorrected. [$P_{bu} = P_L - C_T$]	
Aggregate Correction (Calibration) Factor (%). [C_f] (from tape)	
Calibrated %AC (from ignition oven tape). [$P_{b,a} = P_{bu} - C_f$]	
% Moisture Content. [MC] (previous test)*	-0.13
% AC, corrected (by weight of mix). [$P_b = P_{b,a} - MC$]*	

Asphalt Binder Correction Factor

(Formerly Aggregate Correction Factor)
Calculation

If final weighing is performed on bench top scale, calculation:

$$P_b = \left[\frac{M_i - M_f}{M_i} \times 100\right] - C_f - MC$$

Where:

M_i = initial mass of mix, wet or dry

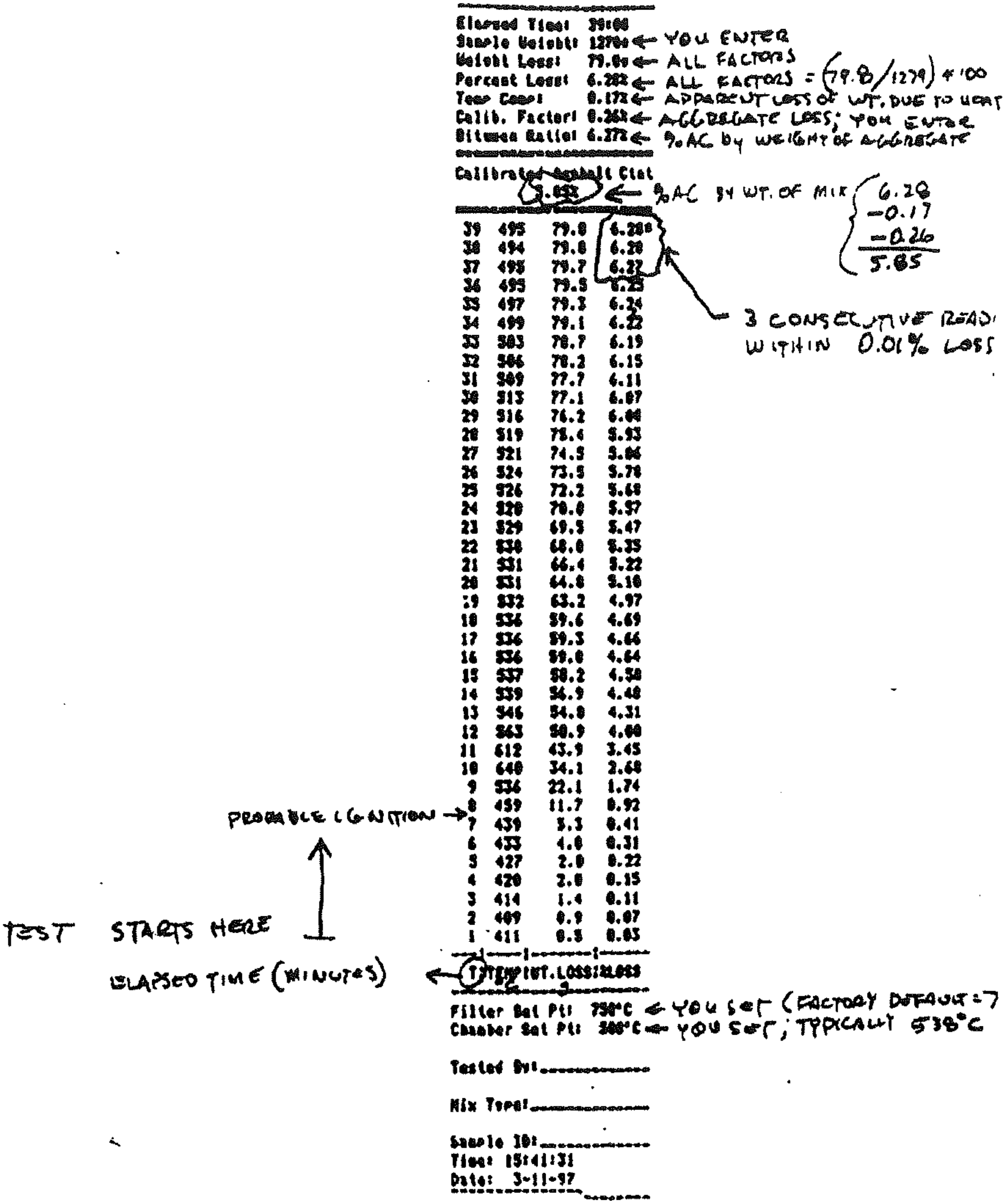
M_f = final mass of mix

MC = % moisture

C_f = Asphalt Binder Correction Factor

(old Aggregate Correction Factor)

Test Results Printout from Iginion Oven



```
Elapsed Time:  39:00
Sample Weight: 1279.0  <- YOU ENTER
Weight Loss:   79.8g   <- ALL FACTORS
Percent Loss:  6.28%   <- ALL FACTORS = (79.8/1279) * 100
Temp Comp:     0.17%   <- APPARENT LOSS OF WT. DUE TO HEAT
Calib. Factor: 0.26%   <- AGGREGATE LOSS; YOU ENTER
Bitumen Ratio: 6.27%   <- %AC BY WEIGHT OF AGGREGATE

Calibrated Asphalt Cnt:
        5.85%   <- %AC BY WT. OF MIX   6.28
                                      -0.17
                                      -0.26
                                       5.85

 39   495   79.8   6.28
 38   494   79.8   6.28
 37   495   79.7   6.27   <- 3 CONSECUTIVE READ
 36   495   79.5   6.25      WITHIN 0.01% LOSS
 35   497   79.3   6.24
 34   499   79.1   6.22
 33   503   78.7   6.19
 32   506   78.2   6.15
 31   509   77.7   6.11
 30   513   77.1   6.07
 29   516   76.2   6.00
 28   519   75.4   5.93
 27   521   74.5   5.86
 26   524   73.5   5.78
 25   526   72.2   5.68
 24   528   70.8   5.57
 23   529   69.5   5.47
 22   530   68.0   5.35
 21   531   66.4   5.22
 20   531   64.8   5.10
 19   532   63.2   4.97
 18   536   59.6   4.69
 17   536   59.3   4.66
 16   536   59.0   4.64
 15   537   58.2   4.58
 14   539   56.9   4.48
 13   546   54.8   4.31
 12   563   50.9   4.00
 11   612   43.9   3.45
 10   640   34.1   2.68
  9   536   22.1   1.74
  8   459   11.7   0.92
PROBABLE IGNITION ->
  7   439    5.3   0.41
  6   433    4.0   0.31
  5   427    2.8   0.22
  4   420    2.0   0.15
  3   414    1.4   0.11
  2   409    0.9   0.07
  1   411    0.5   0.03
---|-----|-------|------
 T |TEMP|WT.LOSS|%LOSS
----------------------
Filter Set Pt:  750°C  <- YOU SET (FACTORY DEFAULT = 7
Chamber Set Pt: 500°C  <- YOU SET, TYPICALLY 538°C

Tested By:____________

Mix Type:_____________

Sample ID:____________
Time: 15:41:31
Date:  3-11-97
----------------------
```

TEST STARTS HERE

ELAPSED TIME (MINUTES)

ASPHALT CONTENT IGNITION METHOD (AASHTO T 308-10) METHOD A

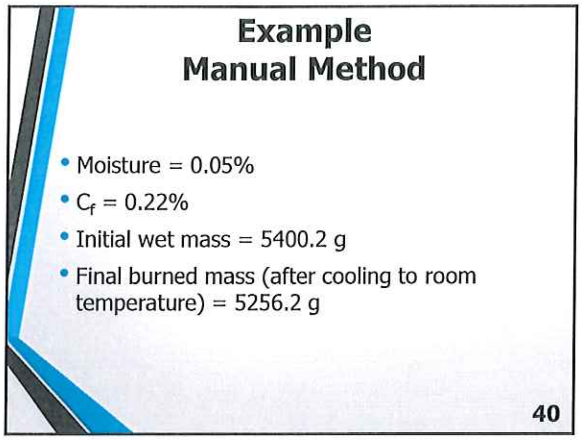
Reproducing Oven Ticket Values

Revised 12-9-15

*If w_i = wet

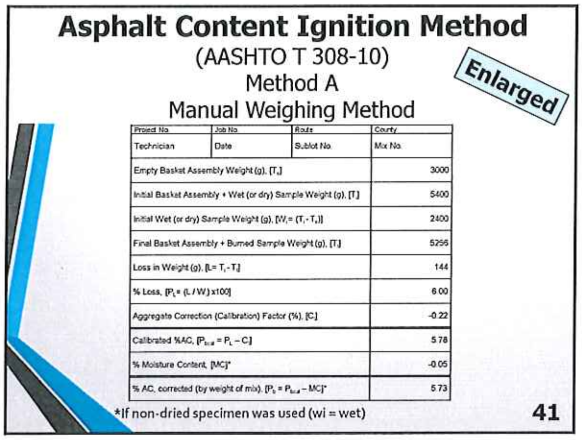
Project No.	Job No.	Route	County
Technician	Date	Sublot No.	Mix No.

Empty Basket Assembly Weight (g), [T_e]	3000.2
Basket Assembly + Wet (or dry) Sample Weight (g), [T_i]	4270.2
Wet (or dry) Sample Weight (g), [$W_i = (T_i - T_e)$]	
Loss in Weight (g), [L] (from tape)	
Total % Loss, [$P_L = (L / W_i)$ x100]	
Temperature Compensation (%), [C_{tc}] (from tape)	
% AC, uncorrected, [$P_{bu} = P_L - C_{tc}$]	
Aggregate Correction (Calibration) Factor (%), [C_f] (from tape)	
Calibrated %AC (from ignition oven tape), [$P_{bcal} = P_{bu} - C_f$]	
% Moisture Content, [MC] (previous test)*	-0.13
% AC, corrected (by weight of mix), [$P_b = P_{bcal} - MC$]*	



Example
Manual Method

- Moisture = 0.05%
- C_f = 0.22%
- Initial wet mass = 5400.2 g
- Final burned mass (after cooling to room temperature) = 5256.2 g



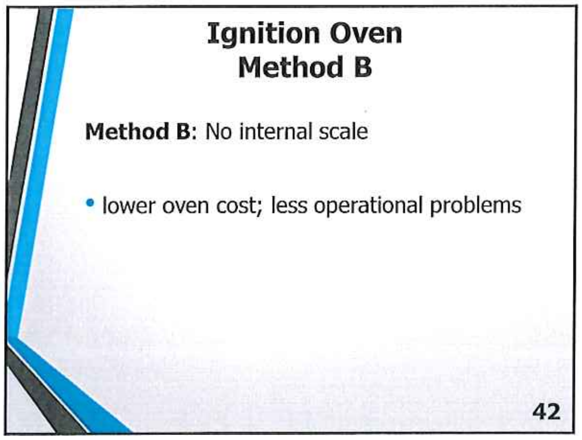
Asphalt Content Ignition Method

(AASHTO T 308-10)
Method A
Manual Weighing Method

Enlarged

Project No.	Job No.	Route	County
Technician	Date	Sublot No.	Mix No.
Empty Basket Assembly Weight (g), [T_e]			3000
Initial Basket Assembly + Wet (or dry) Sample Weight (g), [T_i]			5400
Initial Wet (or dry) Sample Weight (g), [W_i = (T_i - T_e)]			2400
Final Basket Assembly + Burned Sample Weight (g), [T_f]			5256
Loss in Weight (g), [L = T_i - T_f]			144
% Loss, [P_L = (L / W_i) x100]			6.00
Aggregate Correction (Calibration) Factor (%), [C]			-0.22
Calibrated %AC, [$P_{b,cal}$ = P_L – C]			5.78
% Moisture Content, [MC]*			-0.05
% AC, corrected (by weight of mix), [P_b = $P_{b,cal}$ – MC]*			5.73

*If non-dried specimen was used (wi = wet)



Ignition Oven
Method B

Method B: No internal scale

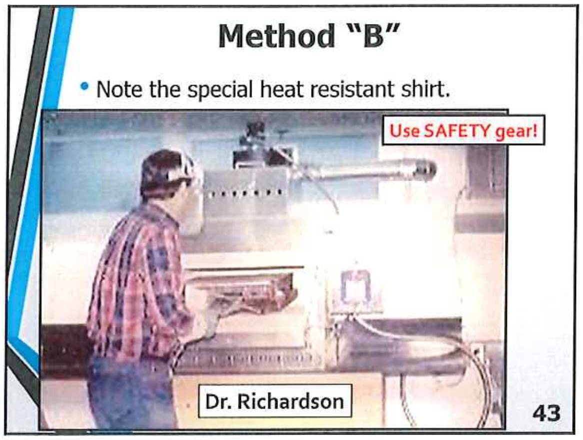
- lower oven cost; less operational problems

Asphalt Content Ignition Method

(AASHTO T 308-10)
METHOD A
Manual Weighing Method

Project No.	Job No.	Route	County
Technician	Date	Sublot No.	Mix No.
Empty Basket Assembly Weight (g), [T_e]			3000
Initial Basket Assembly + Wet (or dry) Sample Weight (g), [T_i]			5400
Initial Wet (or dry) Sample Weight (g), [$W_i = (T_i - T_e)$]			2400
Final Basket Assembly + Burned Sample Weight (g), [T_f]			5256
Loss in Weight (g), [$L = T_i - T_f$]			144
% Loss, [$P_L = (L / W_i) \times 100$]			6.00
Aggregate Correction (Calibration) Factor (%), [C_f]			-0.22
Calibrated %AC, [$P_{bcal} = P_L - C_f$]			5.78
% Moisture Content, [MC]*			-0.05
% AC, corrected (by weight of mix), [$P_b = P_{bcal} - MC$]*			5.73

- *If non-dried specimen was used (wi = wet)

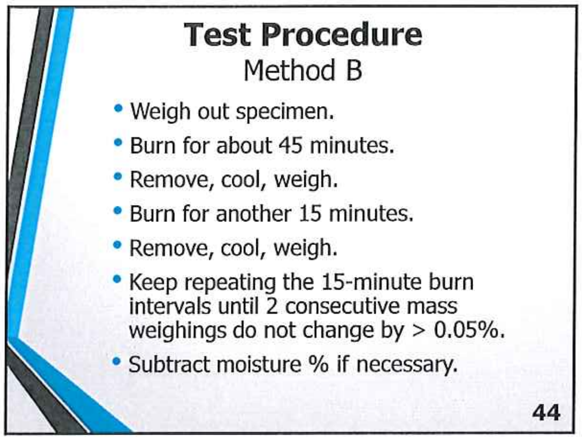


Method "B"

- Note the special heat resistant shirt.

Use SAFETY gear!

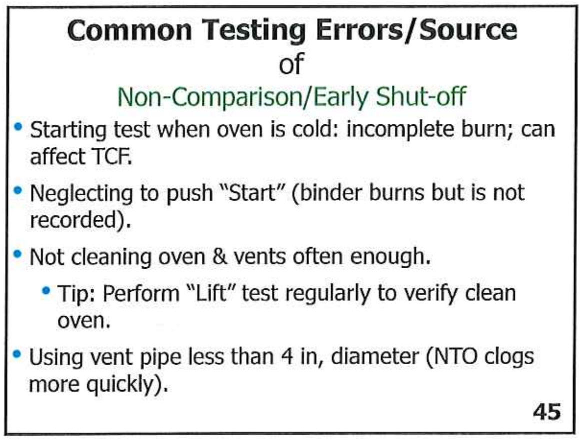
Dr. Richardson



Test Procedure

Method B

- Weigh out specimen.
- Burn for about 45 minutes.
- Remove, cool, weigh.
- Burn for another 15 minutes.
- Remove, cool, weigh.
- Keep repeating the 15-minute burn intervals until 2 consecutive mass weighings do not change by > 0.05%.
- Subtract moisture % if necessary.



Common Testing Errors/Source of Non-Comparison/Early Shut-off

- Starting test when oven is cold: incomplete burn; can affect TCF.
- Neglecting to push "Start" (binder burns but is not recorded).
- Not cleaning oven & vents often enough.
  - Tip: Perform "Lift" test regularly to verify clean oven.
- Using vent pipe less than 4 in, diameter (NTO clogs more quickly).

Common Testing Errors/Source
of
Non-Comparison/Early Shut-off

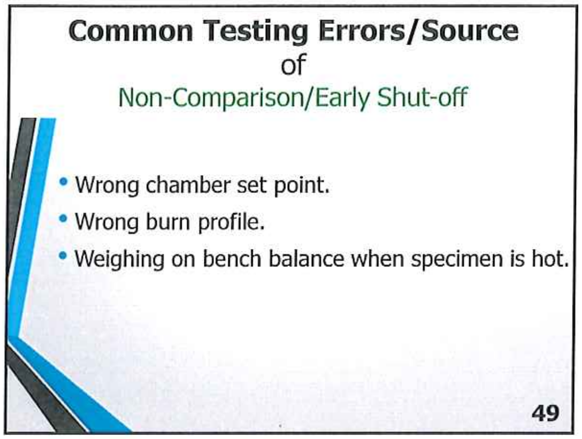
- Asphalt correction factor (C_F) not used
- Not cleaning baskets
- Allowing scale plate or support tubes to rub
- Not spreading specimen out
- Not tearing off ticket before opening oven door
- Allowing door to not latch correctly
- Not correcting for moisture (e.g., when plant speed increases, etc)

Common Testing Errors/Source
of
Non-Comparison/Early Shut-off

- Using an oversize specimen.
- Not using the same size specimen for asphalt correction factor (C_F) determination and all production tests.
- Using a plant-made specimen instead of a lab-made specimen for (C_F) determination.
- Not double-checking specimen weight on oven scale against exterior scale weight.

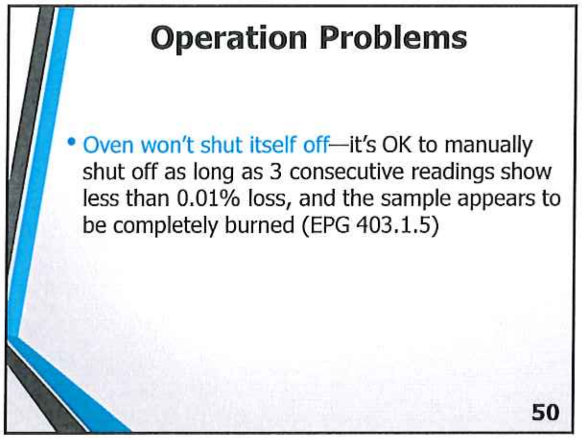
Common Testing Errors/Source
of
Non-Comparison/Early Shut-off

- Materials used for (C_F) determination not the same as project materials
- Inaccurate asphalt contents used for (C_F) determination
- QA & QC starting with different temperature specimens
- Door left open too long between loadings



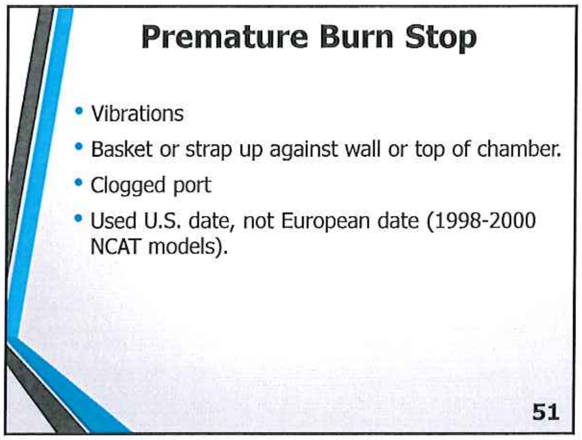
Common Testing Errors/Source of Non-Comparison/Early Shut-off

- Wrong chamber set point.
- Wrong burn profile.
- Weighing on bench balance when specimen is hot.



Operation Problems

- Oven won't shut itself off—it's OK to manually shut off as long as 3 consecutive readings show less than 0.01% loss, and the sample appears to be completely burned (EPG 403.1.5)

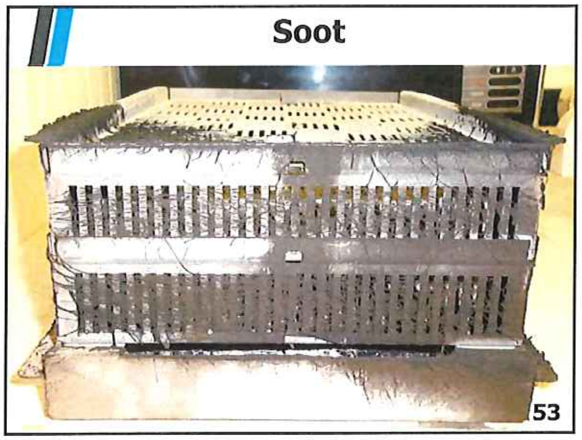


Premature Burn Stop

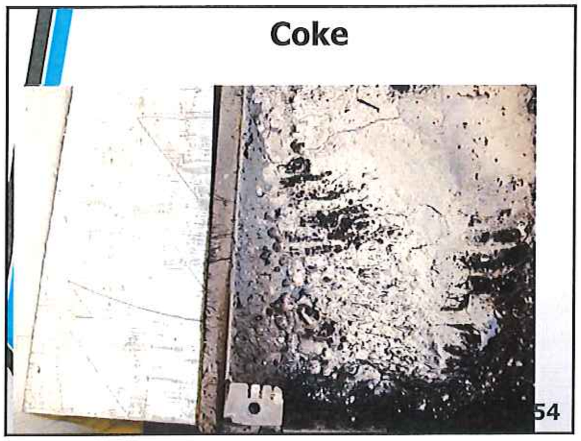
- Vibrations
- Basket or strap up against wall or top of chamber.
- Clogged port
- Used U.S. date, not European date (1998-2000 NCAT models).


NTO Incomplete Burn Pattern: Shingle Mix

52


Soot

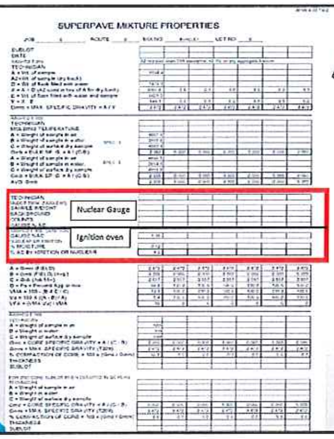
53


Coke

54

Content

- *Reporting binder content of mix*
- Binder content of RAP
- Aggregate gradation


SUPERPAVE MIXTURE PROPERTIES

Enlarged

Binder Portion

Enlarged

TECHNICIAN							
McDOT TM54 (NUCLEAR)							
SAMPLE WEIGHT							
BACKGROUND							
COUNTS							
GAUGE % AC							
AASHTO T 308 (IGNITION)							
GAUGE %AC	5.35						
NUCLEAR OR IGNITION							
% MOISTURE	0.12						
% AC BY IGNITION OR NUCLEAR	5.2						

APIW 4.00 7/6/2

SUPERPAVE MIXTURE PROPERTIES

JOB 0 ROUTE 0 MIX NO. #VALUE! LOT NO. 0

SUBLOT							
DATE							
AASHTO T 209	A2 required when T85 absorption >2.0% on any aggregate fraction.						
TECHNICIAN							
A = Wt. of sample:	1594.4						
A2=Wt. of sample (dry-back):							
D = Wt. of flask filled with water:	7472.2						
X = A + D (A2 used in lieu of A for dry-back)	9066.6	0.0	0.0	0.0	0.0	0.0	0.0
E = Wt. of flask filled with water and sample:	8421.5						
Y = X - E	645.1	0.0	0.0	0.0	0.0	0.0	0.0
Gmm = MAX. SPECIFIC GRAVITY = A / Y	2.472	2.472	2.472	2.472	2.472	2.472	2.472

AASHTO T 166							
TECHNICIAN							
MOLDING TEMPERATURE							
A = Weight of sample in air:	4867.8						
B = Weight of sample in water: SPEC. 1	2801.9						
C = Weight of surface dry sample:	4880.4						
Gmb = BULK SP. G. = A / (C-B)	2.342	0.000	0.000	0.000	0.000	0.000	0.000
A = Weight of sample in air:	4899.1						
B = Weight of sample in water: SPEC. 2	2814.5						
C = Weight of surface dry sample:	4911.9						
Gmb = BULK SP. G. = A / (C-B)	2.336	0.000	0.000	0.000	0.000	0.000	0.000
AVG. Gmb	2.339	0.000	0.000	0.000	0.000	0.000	0.000

Nuclear gage

TECHNICIAN							
MoDOT TM54 (NUCLEAR)							
SAMPLE WEIGHT							
BACKGROUND							
COUNTS							
GAUGE % AC							

Ignition oven

AASHTO T 308 (IGNITION)							
GAUGE %AC	5.35						
NUCLEAR OR IGNITION							
% MOISTURE	0.12						
% AC BY IGNITION OR NUCLEAR	5.2						

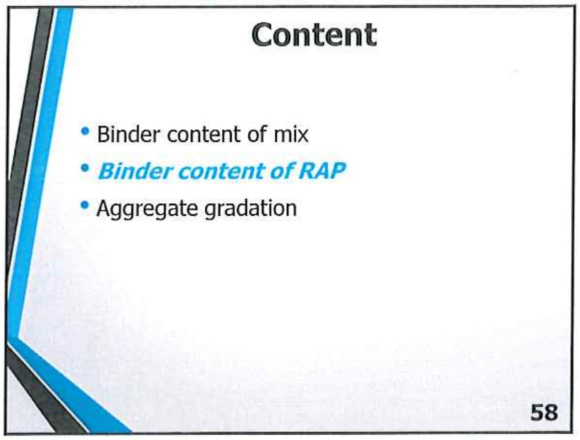
AASHTO R 35							
A = Gmm (FIELD)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
B = Gmb (FIELD) (Avg.)	2.339	0.000	0.000	0.000	0.000	0.000	0.000
C = Gsb (Job Mix)	2.557	2.557	2.557	2.557	2.557	2.557	2.557
D = Ps = Percent Agg. in mix	94.8	100.0	100.0	100.0	100.0	100.0	100.0
VMA = 100 - (B X D / C)	13.3	100.0	100.0	100.0	100.0	100.0	100.0
Va = 100 X ((A - B) / A)	5.4	100.0	100.0	100.0	100.0	100.0	100.0
VFA = (VMA-Va) / VMA	59	0	0	0	0	0	0

AASHTO T 166							
TECHNICIAN							
A = Weight of sample in air:	1255						
B = Weight in water:	710						
C = Weight of surface dry sample:	1260						
Gmc = CORE SPECIFIC GRAVITY = A / (C - B)	2.282	0.000	0.000	0.000	0.000	0.000	0.000
Gmm = MAX. SPECIFIC GRAVITY (T209)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
% COMPACTION OF CORE = 100 x (Gmc / Gmm)	92.3	0.0	0.0	0.0	0.0	0.0	0.0
THICKNESS							
SUBLOT							

FOR 2ND CORE SUBLOT WHEN DENOTED IN QC PLAN							
TECHNICIAN							
A = Weight of sample in air:							
B = Weight in water:							
C = Weight of surface dry sample:							
Gmc = CORE SPECIFIC GRAVITY = A / (C - B)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gmm = MAX. SPECIFIC GRAVITY (T209)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
% COMPACTION OF CORE = 100 x (Gmc / Gmm)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
THICKNESS							
SUBLOT							

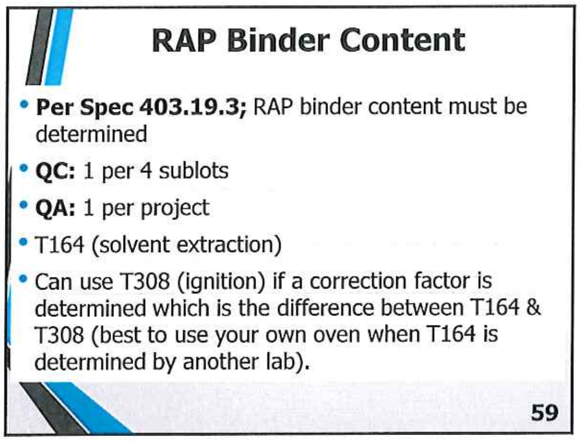
Binder Portion

TECHNICIAN							
MoDOT TM54 (NUCLEAR)							
SAMPLE WEIGHT							
BACKGROUND							
COUNTS							
GAUGE % AC							
AASHTO T 308 (IGNITION)							
GAUGE %AC	5.35						
NUCLEAR OR IGNITION							
% MOISTURE	0.12						
% AC BY IGNITION OR NUCLEAR	5.2						



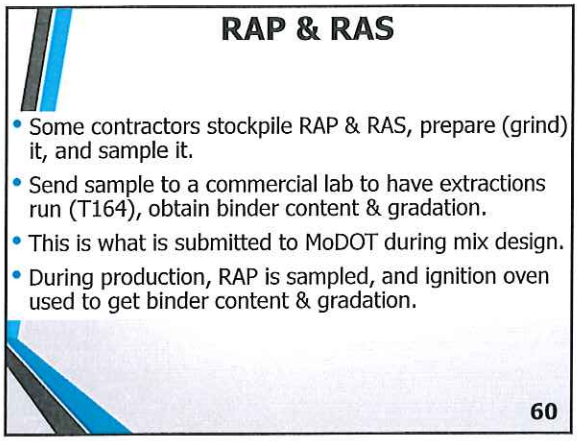
Content

- Binder content of mix
- ***Binder content of RAP***
- Aggregate gradation



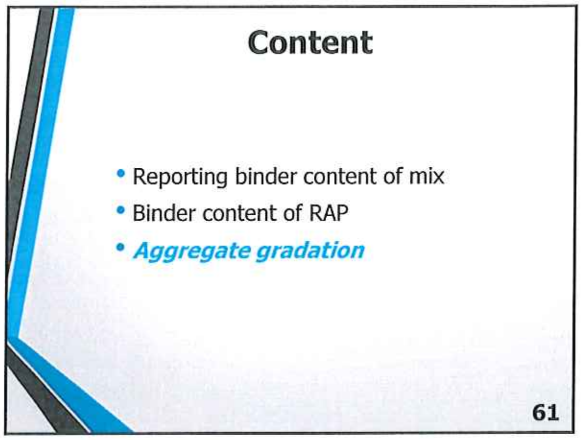
RAP Binder Content

- **Per Spec 403.19.3;** RAP binder content must be determined
- **QC:** 1 per 4 sublots
- **QA:** 1 per project
- T164 (solvent extraction)
- Can use T308 (ignition) if a correction factor is determined which is the difference between T164 & T308 (best to use your own oven when T164 is determined by another lab).



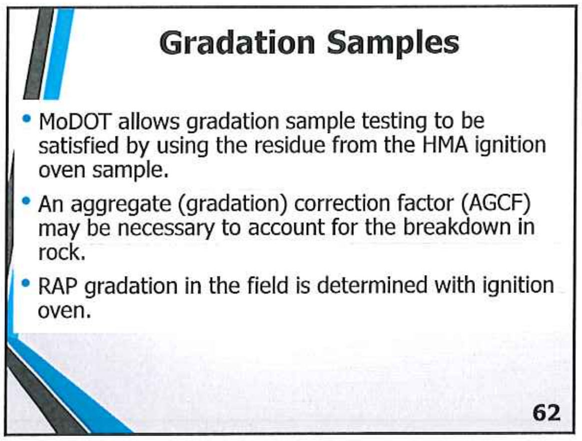
RAP & RAS

- Some contractors stockpile RAP & RAS, prepare (grind) it, and sample it.
- Send sample to a commercial lab to have extractions run (T164), obtain binder content & gradation.
- This is what is submitted to MoDOT during mix design.
- During production, RAP is sampled, and ignition oven used to get binder content & gradation.



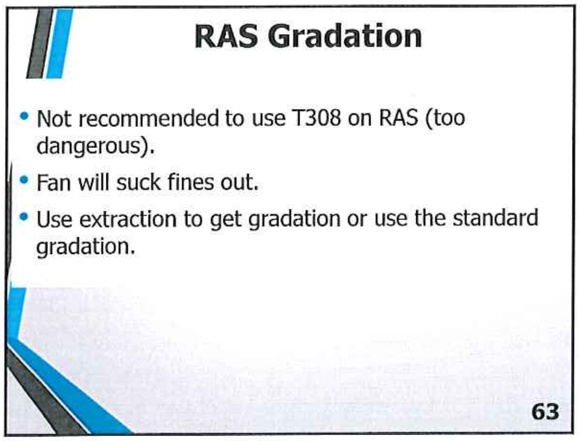
Content

- Reporting binder content of mix
- Binder content of RAP
- ***Aggregate gradation***



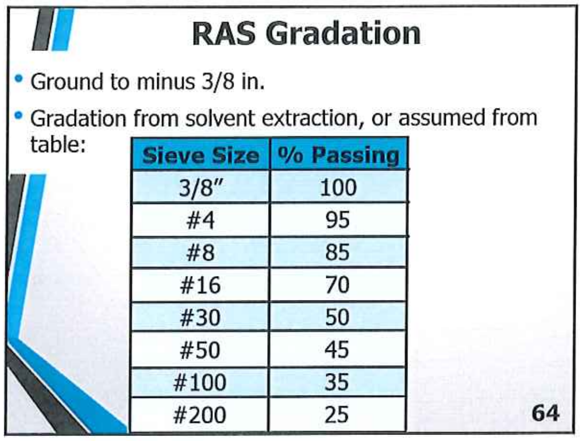
Gradation Samples

- MoDOT allows gradation sample testing to be satisfied by using the residue from the HMA ignition oven sample.
- An aggregate (gradation) correction factor (AGCF) may be necessary to account for the breakdown in rock.
- RAP gradation in the field is determined with ignition oven.



RAS Gradation

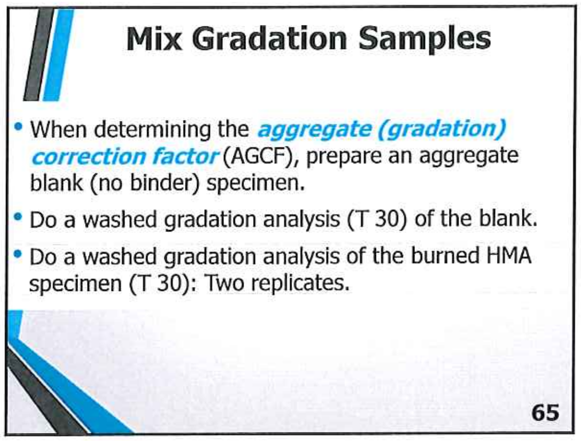
- Not recommended to use T308 on RAS (too dangerous).
- Fan will suck fines out.
- Use extraction to get gradation or use the standard gradation.



RAS Gradation

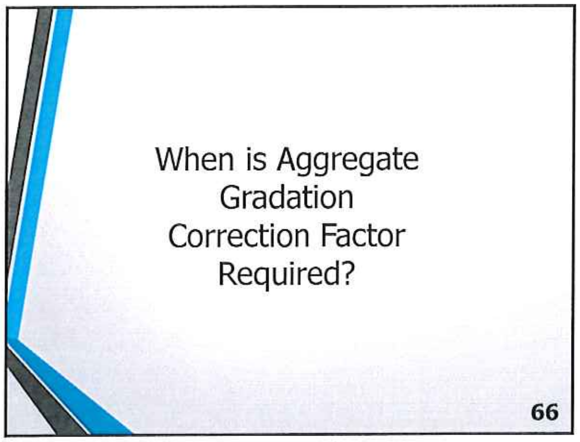
- Ground to minus 3/8 in.
- Gradation from solvent extraction, or assumed from table:

Sieve Size	% Passing
3/8"	100
#4	95
#8	85
#16	70
#30	50
#50	45
#100	35
#200	25

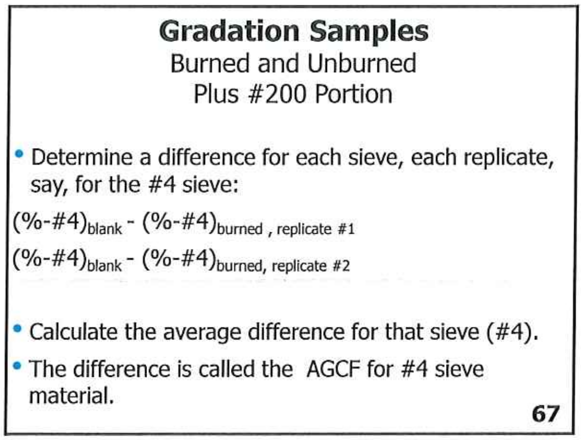


Mix Gradation Samples

- When determining the ***aggregate (gradation) correction factor*** (AGCF), prepare an aggregate blank (no binder) specimen.
- Do a washed gradation analysis (T 30) of the blank.
- Do a washed gradation analysis of the burned HMA specimen (T 30): Two replicates.



When is Aggregate
Gradation
Correction Factor
Required?



Gradation Samples

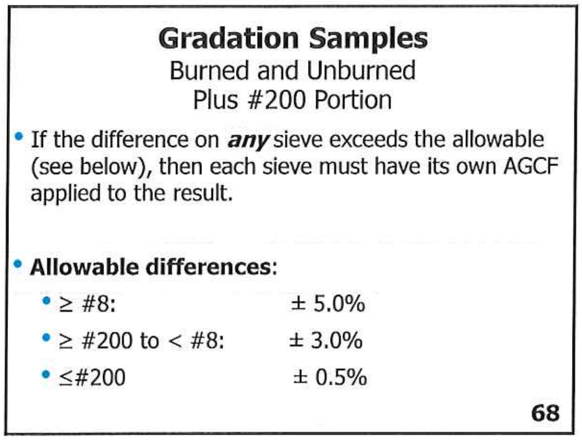
Burned and Unburned
Plus #200 Portion

- Determine a difference for each sieve, each replicate, say, for the #4 sieve:

$(\%\text{-}\#4)_{\text{blank}} - (\%\text{-}\#4)_{\text{burned , replicate \#1}}$

$(\%\text{-}\#4)_{\text{blank}} - (\%\text{-}\#4)_{\text{burned, replicate \#2}}$

- Calculate the average difference for that sieve (#4).
- The difference is called the AGCF for #4 sieve material.



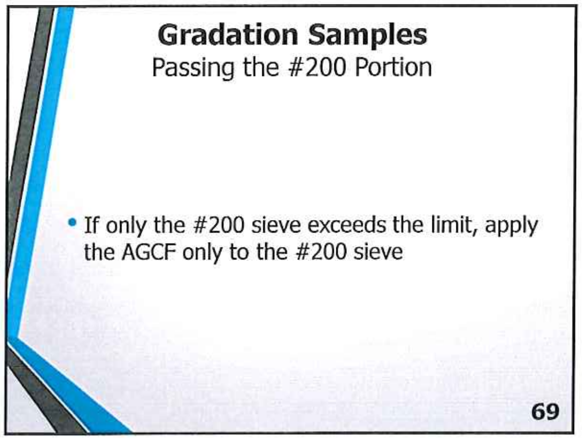
Gradation Samples

Burned and Unburned
Plus #200 Portion

- If the difference on ***any*** sieve exceeds the allowable (see below), then each sieve must have its own AGCF applied to the result.

- **Allowable differences**:

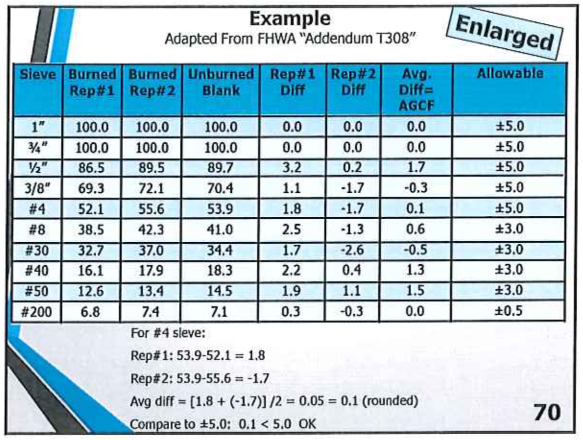
≥ #8:	± 5.0%
≥ #200 to < #8:	± 3.0%
≤#200	± 0.5%



Gradation Samples

Passing the #200 Portion

- If only the #200 sieve exceeds the limit, apply the AGCF only to the #200 sieve



Example

Adapted From FHWA "Addendum T308"

Enlarged

Sieve	Burned Rep#1	Burned Rep#2	Unburned Blank	Rep#1 Diff	Rep#2 Diff	Avg. Diff= AGCF	Allowable
1"	100.0	100.0	100.0	0.0	0.0	0.0	±5.0
¾"	100.0	100.0	100.0	0.0	0.0	0.0	±5.0
½"	86.5	89.5	89.7	3.2	0.2	1.7	±5.0
3/8"	69.3	72.1	70.4	1.1	-1.7	-0.3	±5.0
#4	52.1	55.6	53.9	1.8	-1.7	0.1	±5.0
#8	38.5	42.3	41.0	2.5	-1.3	0.6	±3.0
#30	32.7	37.0	34.4	1.7	-2.6	-0.5	±3.0
#40	16.1	17.9	18.3	2.2	0.4	1.3	±3.0
#50	12.6	13.4	14.5	1.9	1.1	1.5	±3.0
#200	6.8	7.4	7.1	0.3	-0.3	0.0	±0.5

For #4 sieve:

Rep#1: 53.9-52.1 = 1.8

Rep#2: 53.9-55.6 = -1.7

Avg diff = [1.8 + (-1.7)] /2 = 0.05 = 0.1 (rounded)

Compare to ±5.0: 0.1 < 5.0 OK

Example

Adapted from FHWA "Addendum T308"

Sieve	Burned Rep#1	Burned Rep#2	Unburned Blank	Rep# 1 Diff	Rep# 2 Diff	Avg Diff= AGCF	Allowable
1"	100.0	100.0	100.0	0.0	0.0	0.0	±5.0
$\frac{3}{4}$"	100.0	100.0	100.0	0.0	0.0	0.0	±5.0
$\frac{1}{2}$"	86.5	89.5	89.7	3.2	0.2	1.7	±5.0
3/8"	69.3	72.1	70.4	1.1	-1.7	-0.3	±5.0
#4	52.1	55.6	53.9	1.8	-1.7	0.1	±5.0
#8	38.5	42.3	41.0	2.5	-1.3	0.6	±3.0
#30	32.7	37.0	34.4	1.7	-2.6	-0.5	±3.0
#40	16.1	17.9	18.3	2.2	0.4	1.3	±3.0
#50	12.6	13.4	14.5	1.9	1.1	1.5	±3.0
#200	6.8	7.4	7.1	0.3	-0.3	0.0	±0.5

For #4 sieve:

Rep#1: 53.9-52.1 = 1.8

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Avg diff = [1.8 + (-1.7)] /2 = 0.05 = 0.1 (rounded)

Compare to ±5.0: 0.1 < 5.0 OK

TAB

Module 10

Module 10

Job Mix Formula
(JMF)

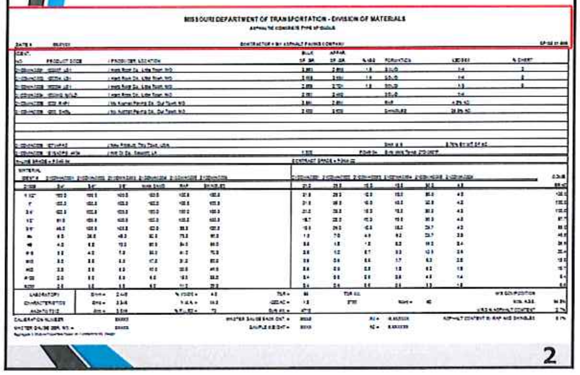
MoDOT

MODULE 10

JOB MIX FORMULA SHEET

(JMF)

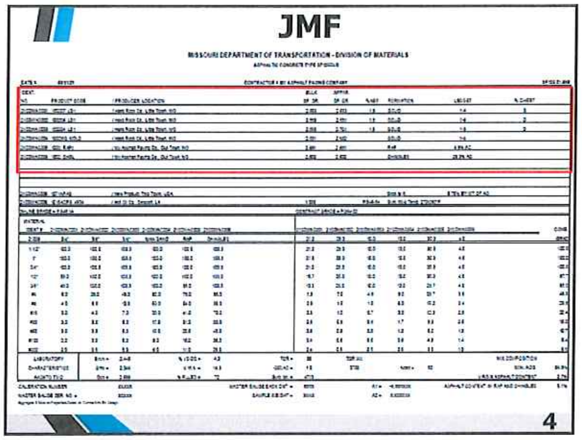
JMF



MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

JMF Header

- Contains Type of Mix
- Date Issued
- Contractor Issued to
- Mix Number



JMF

MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

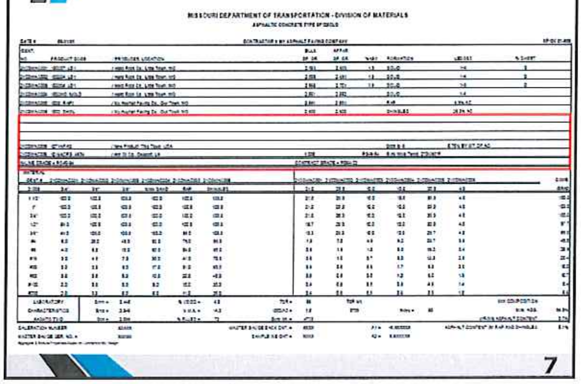
JMF Virgin Aggregate Information

- Product Ident. Number
- Product code
- Producer Location
- Bulk SP. (Specific) GR. (Gravity)
- Apparent SP. GR.
- %ABS (absorption)
- Formation
- Ledges
- %Chert

JMF Virgin Aggregate Information

- Each mix design is acceptable to use for a three-year period.
- Ledge information is generally updated annually by the aggregate producer and MoDOT.
- If the product remains close (ledge is same, gravity, absorption, etc.), acceptable to use JMF information

JMF



MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

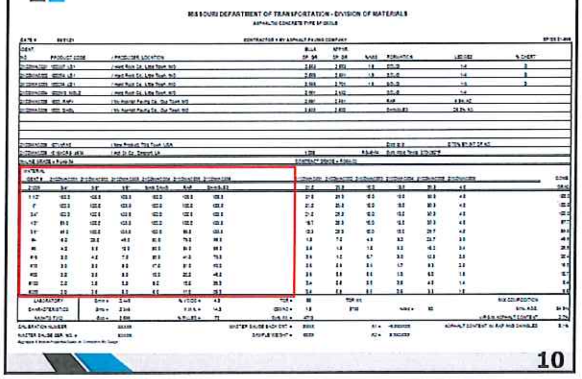
JMF
Binder and Additive Information

- Product Ident. Number
- Product code
- Producer Location
- Bulk SpGr
- PG Grade
- Molding Temperature

JMF
Binder and Additive Information

- Additives such as Warm Mix additives, Rejuvenators, Fibers are shown in this area.
  - Name of product
  - Supplier
  - Rate of incorporation

JMF



MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

10

10

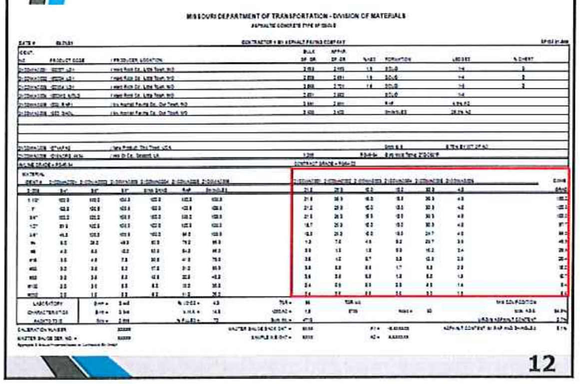
JMF
Individual Aggregate Gradations

- This area contains the gradation of individual aggregate fractions to include RAP & RAS if applicable.

11

11

JMF



MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

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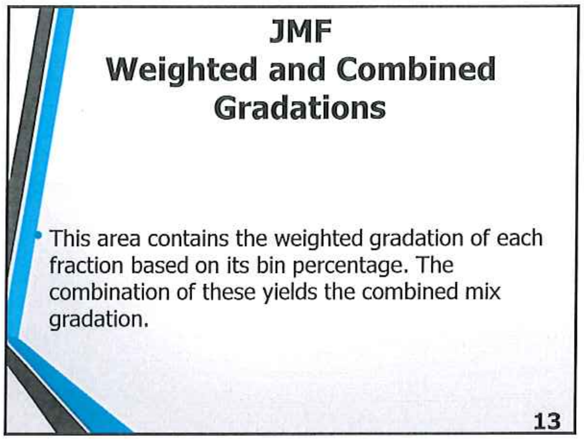
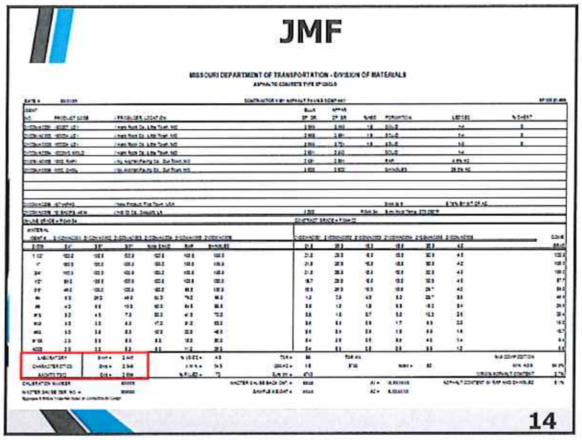


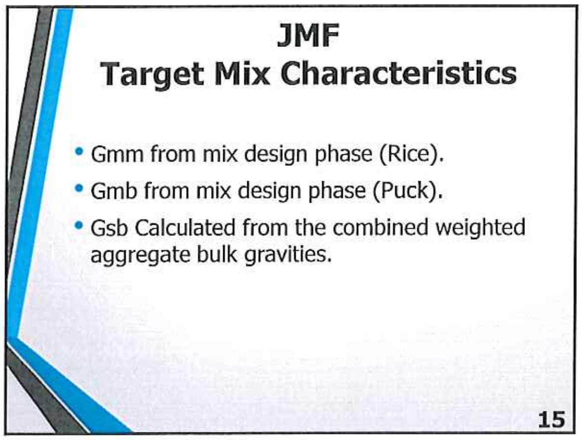
JMF
Weighted and Combined Gradations

- This area contains the weighted gradation of each fraction based on its bin percentage. The combination of these yields the combined mix gradation.



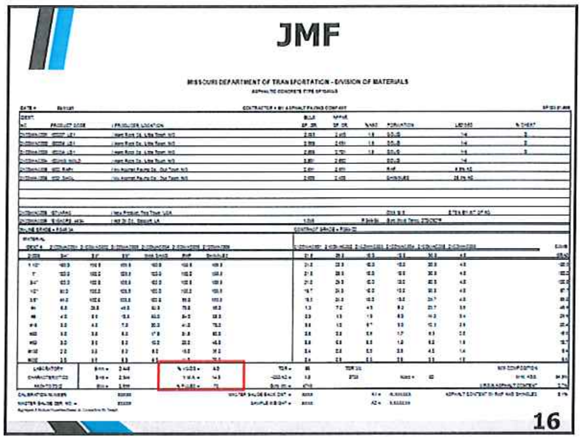
JMF

MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS



JMF
Target Mix Characteristics

- Gmm from mix design phase (Rice).
- Gmb from mix design phase (Puck).
- Gsb Calculated from the combined weighted aggregate bulk gravities.



JMF

MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

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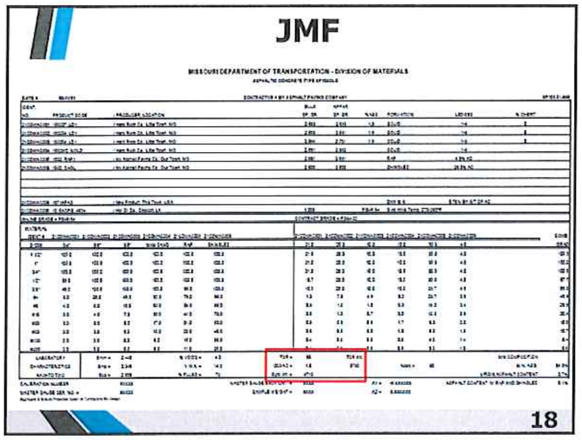
16

JMF
Target Voids, VMA and VFA

- Voids Specified.
- VMA and VFA generated during the mix design phase adhering to specifications.

17

17



JMF

MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

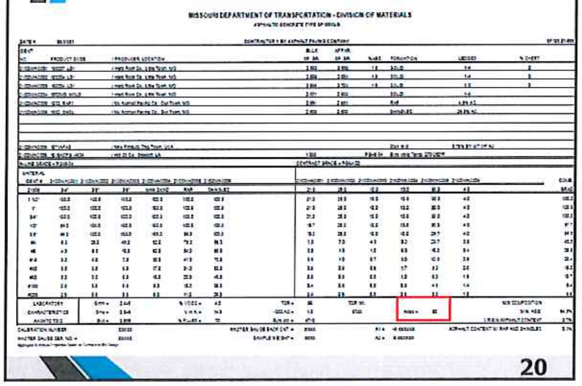
18

18

JMF
TSR, Dust/Binder, Specimen Weights

- TSR results from the design phase.
- Dust to Binder ratio (limited by specification).
- Specimen weights for pucks:
  - Ndes (approx. 115mm)
  - TSR (95mm)

JMF



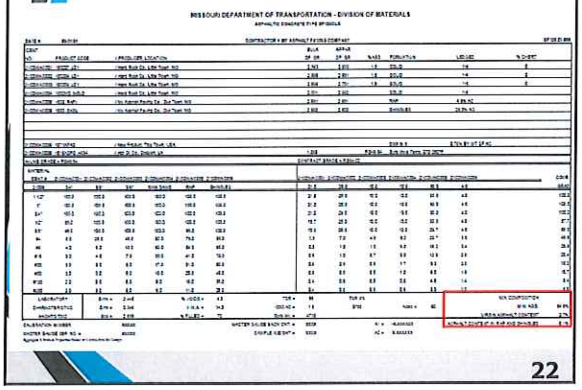
MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

JMF
Gyration Levels

- Number of Gyrations for
  - Nini
  - Ndes
  - Nmax

  Volumetric pucks are made to Ndes during production.
  - LG mixes only specify Ndes gyrations.

JMF


MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

JMF
Mix Composition

- Percentages of Aggregate and AC are in this area. If RAP and/or RAS are being used, then the percentage of virgin AC along with the Total AC are provided.

MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

ASPHALTIC CONCRETE TYPE SP125CLG

DATE = 03/01/21

CONTRACTOR = MY ASPHALT PAVING COMPANY

SP125 21-999

IDENT. NO.	PRODUCT CODE	/ PRODUCER, LOCATION	BULK SP. GR.	APPAR. SP. GR.	%ABS	FORMATION	LEDGES	% CHERT
21CDMAC001	100207..LD1	/ Hard Rock Co., Little Town, MO	2.563	2.693	1.9	SOLID	1-4	0
21CDMAC002	100204..LD1	/ Hard Rock Co., Little Town, MO	2.558	2.691	1.9	SOLID	1-4	0
21CDMAC003	100204..LD1	/ Hard Rock Co., Little Town, MO	2.566	2.701	1.9	SOLID	1-3	0
21CDMAC004	1002MS..MSLD	/ Hard Rock Co., Little Town, MO	2.551	2.682		SOLID	1-4	
21CDMAC005	1002..RAP1	/ My Asphalt Paving Co., Our Town, MO	2.691	2.691		RAP	4.9% AC	
21CDMAC006	1002..SHGL	/ My Asphalt Paving Co., Our Town, MO	2.600	2.600		SHINGLES	26.3% AC	
21CDMAC006	1071APAS	/ New Product, This Town, USA				Stick to It	0.75% BY WT OF AC	
21CDMAC006	1015ACPG..4634	/ Hot Oil Co., Seaport, LA	1.035		PG46-34	Gyro Mold Temp. 270-280°F		

IN-LINE GRADE = PG46-34

CONTRACT GRADE = PG64-22

MATERIAL IDENT #	21CDMAC001	21CDMAC002	21CDMAC003	21CDMAC004	21CDMAC005	21CDMAC006	21CDMAC001	21CDMAC002	21CDMAC003	21CDMAC004	21CDMAC005	21CDMAC006	COMB.
21008	3/4"	3/8"	3/8"	MAN SAND	RAP	SHINGLES	21.0	25.0	10.0	10.0	30.0	4.0	GRAD
1 1/2"	100.0	100.0	100.0	100.0	100.0	100.0	21.0	25.0	10.0	10.0	30.0	4.0	100.0
1"	100.0	100.0	100.0	100.0	100.0	100.0	21.0	25.0	10.0	10.0	30.0	4.0	100.0
3/4"	100.0	100.0	100.0	100.0	100.0	100.0	21.0	25.0	10.0	10.0	30.0	4.0	100.0
1/2"	89.0	100.0	100.0	100.0	100.0	100.0	18.7	25.0	10.0	10.0	30.0	4.0	97.7
3/8"	49.0	100.0	100.0	100.0	99.0	100.0	10.3	25.0	10.0	10.0	29.7	4.0	89.0
#4	6.0	28.0	49.0	92.0	79.0	95.0	1.3	7.0	4.9	9.2	23.7	3.8	49.9
#8	4.0	6.0	10.0	60.0	54.0	85.0	0.8	1.5	1.0	6.0	16.2	3.4	28.9
#16	3.0	4.0	7.0	30.0	41.0	70.0	0.6	1.0	0.7	3.0	12.3	2.8	20.4
#30	3.0	3.0	6.0	17.0	31.0	50.0	0.6	0.8	0.6	1.7	9.3	2.0	15.0
#50	3.0	3.0	5.0	10.0	20.0	45.0	0.6	0.8	0.5	1.0	6.0	1.8	10.7
#100	2.0	3.0	5.0	8.0	15.0	35.0	0.4	0.8	0.5	0.8	4.5	1.4	8.4
#200	2.0	3.0	5.0	6.0	11.0	25.0	0.4	0.8	0.5	0.6	3.3	1.0	6.6

LABORATORY CHARACTERISTICS AASHTO T312											
	Gmm =	2.445	% VOIDS =	4.0	TSR =	86	TSR Wt.			MIX COMPOSITION	
	Gmb =	2.346	V.M.A. =	14.3	-200/AC =	1.5	3700	Ndes =	80	MIN. AGG.	94.9%
	Gsb =	2.599	% FILLED =	72	Gyro Wt. =	4710				VIRGIN ASPHALT CONTENT	2.7%

CALIBRATION NUMBER XXXXX

MASTER GAUGE SER. NO. = XXXXX

MASTER GAUGE BACK CNT. = XXXX

SAMPLE WEIGHT = XXXX

A1 = -X.XXXXXX

A2 = X.XXXXXX

ASPHALT CONTENT W/ RAP AND SHINGLES 5.1%

Aggregate & Mixture Properties Based on Contractors Mix Design

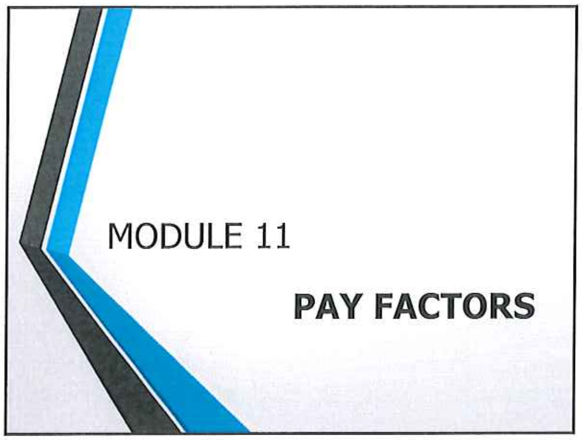
TAB

Module 11

Module 11

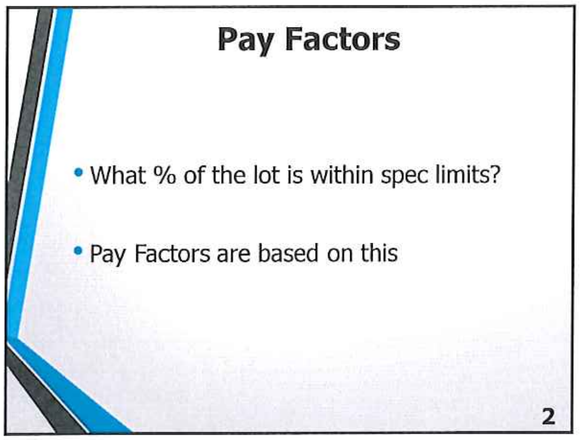
Pay Factors

MoDOT



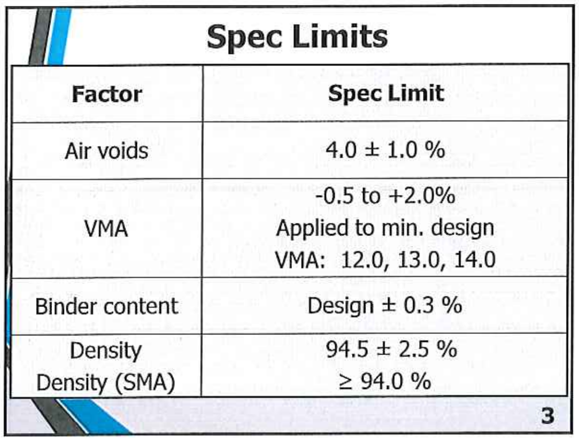
MODULE 11

PAY FACTORS



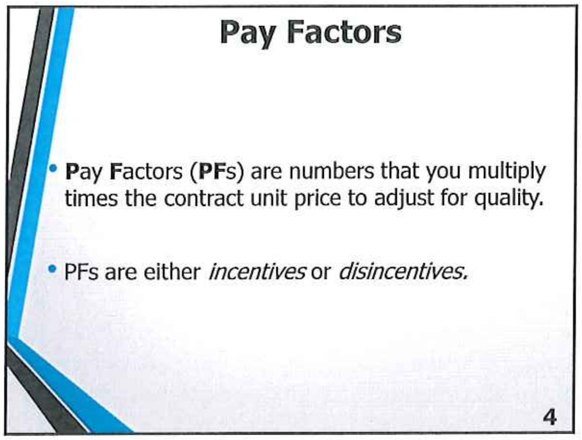
Pay Factors

- What % of the lot is within spec limits?
- Pay Factors are based on this



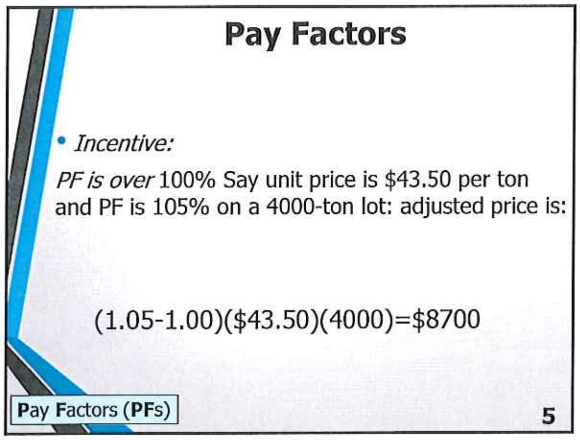
Spec Limits

Factor	Spec Limit
Air voids	4.0 ± 1.0 %
VMA	-0.5 to +2.0% Applied to min. design VMA: 12.0, 13.0, 14.0
Binder content	Design ± 0.3 %
Density Density (SMA)	94.5 ± 2.5 % ≥ 94.0 %



Pay Factors

- **P**ay **F**actors (**PFs**) are numbers that you multiply times the contract unit price to adjust for quality.
- PFs are either *incentives* or *disincentives.*

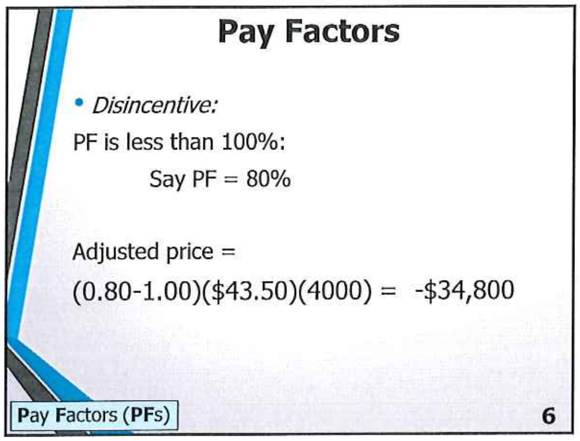


Pay Factors

- *Incentive:*

PF is over 100% Say unit price is $43.50 per ton and PF is 105% on a 4000-ton lot: adjusted price is:

(1.05-1.00)($43.50)(4000)=$8700



Pay Factors

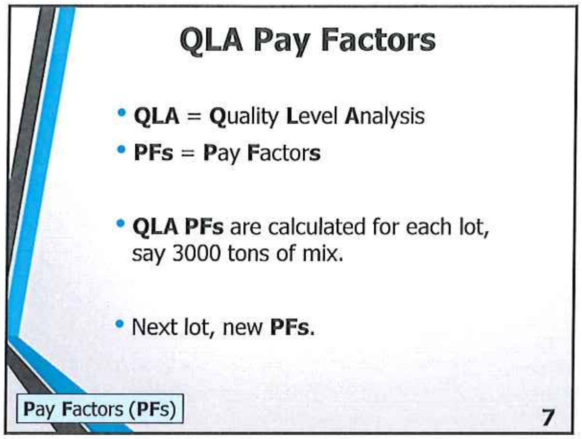
- *Disincentive:*

PF is less than 100%:

Say PF = 80%

Adjusted price =

(0.80-1.00)($43.50)(4000) = -$34,800



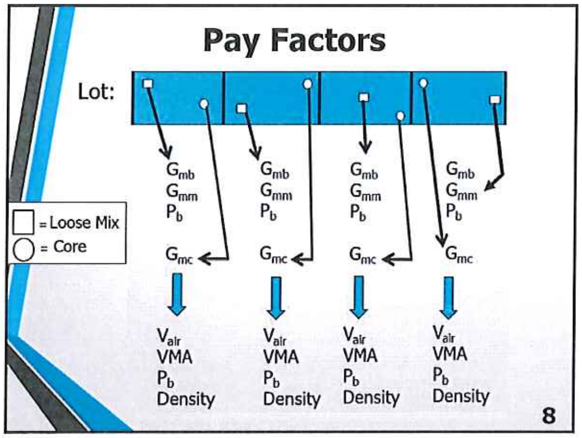
QLA Pay Factors

- **QLA** = **Q**uality **L**evel **A**nalysis
- **PFs** = **P**ay **F**actor**s**

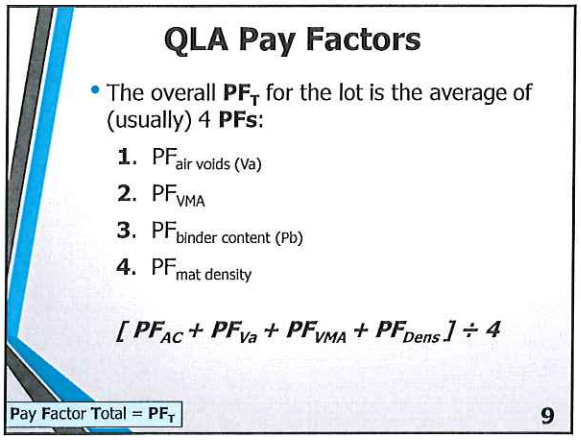
- **QLA PFs** are calculated for each lot, say 3000 tons of mix.

- Next lot, new **PFs**.

Pay Factors (**PFs**)



Pay Factors



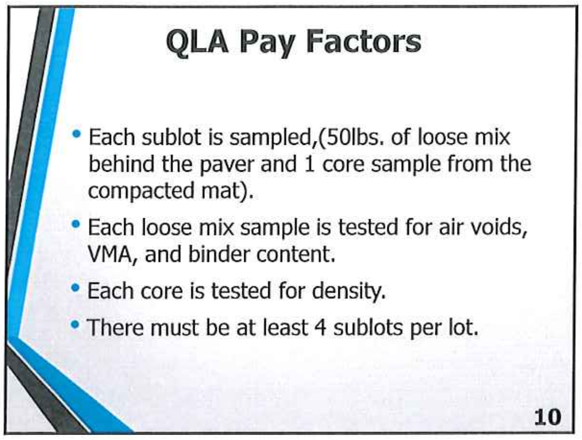
QLA Pay Factors

- The overall **PF_T** for the lot is the average of (usually) 4 **PFs**:

1. $PF_{\text{air voids (Va)}}$
2. PF_{VMA}
3. $PF_{\text{binder content (Pb)}}$
4. $PF_{\text{mat density}}$

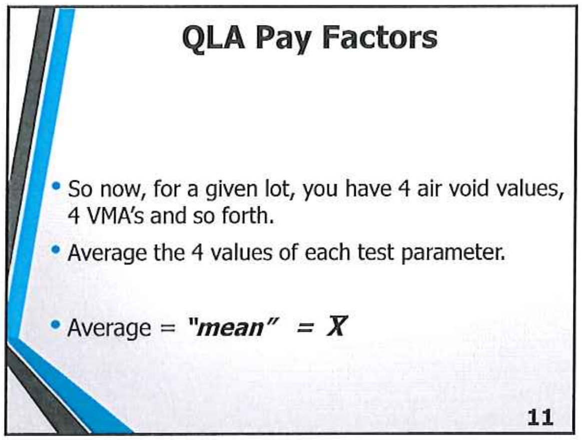
$$[\ PF_{AC} + PF_{Va} + PF_{VMA} + PF_{Dens}\ ] \div 4$$

Pay Factor Total = **PF_T**



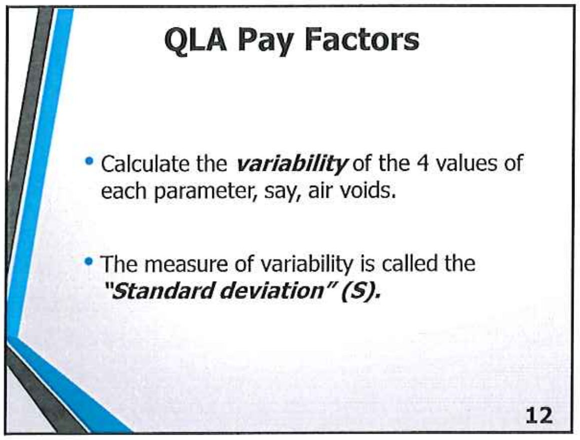
QLA Pay Factors

- Each sublot is sampled,(50lbs. of loose mix behind the paver and 1 core sample from the compacted mat).
- Each loose mix sample is tested for air voids, VMA, and binder content.
- Each core is tested for density.
- There must be at least 4 sublots per lot.



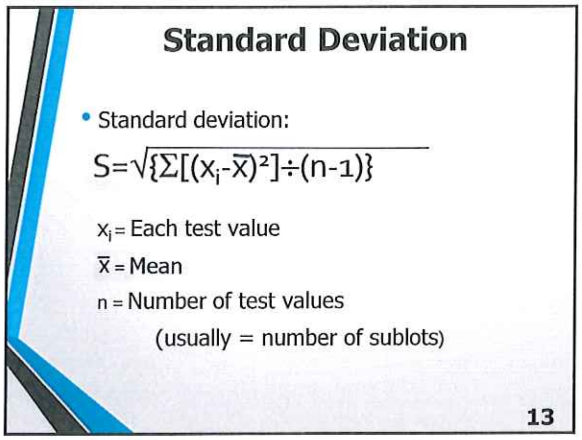
QLA Pay Factors

- So now, for a given lot, you have 4 air void values, 4 VMA's and so forth.
- Average the 4 values of each test parameter.
- Average = ***"mean"*** = $\bar{X}$



QLA Pay Factors

- Calculate the ***variability*** of the 4 values of each parameter, say, air voids.
- The measure of variability is called the ***"Standard deviation" (S).***



Standard Deviation

- Standard deviation:

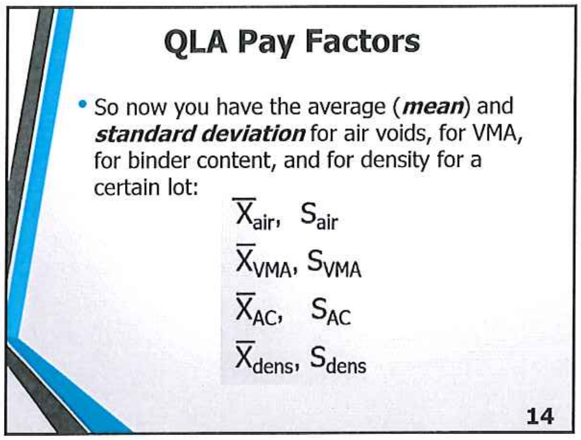
$$S=\sqrt{\{\Sigma[(x_i-\overline{x})^2]\div(n-1)\}}$$

x_i = Each test value

$\overline{x}$ = Mean

n = Number of test values

(usually = number of sublots)



QLA Pay Factors

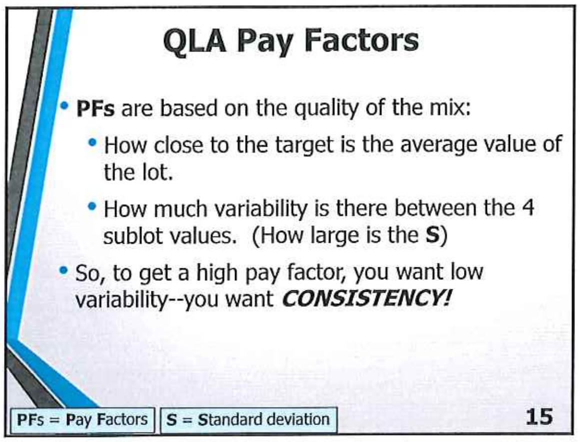
- So now you have the average (***mean***) and ***standard deviation*** for air voids, for VMA, for binder content, and for density for a certain lot:

$\overline{X}_{air}$, S_{air}

$\overline{X}_{VMA}$, S_{VMA}

$\overline{X}_{AC}$, S_{AC}

$\overline{X}_{dens}$, S_{dens}



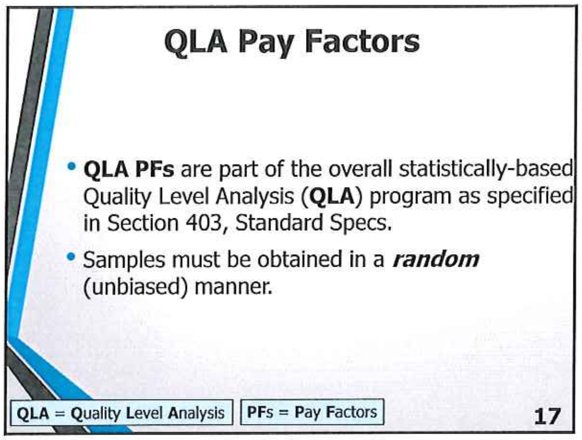
QLA Pay Factors

- **PFs** are based on the quality of the mix:
  - How close to the target is the average value of the lot.
  - How much variability is there between the 4 sublot values. (How large is the **S**)
- So, to get a high pay factor, you want low variability--you want ***CONSISTENCY!***

PFs = Pay Factors | **S** = Standard deviation

Consistency of Mix

- Consistent gradation
- Consistent baghouse fines feed
- Consistent binder content
- Consistent temperature
- Consistent cleanliness:
  - Low deleterious materials
  - High sand equivalent
- Consistent construction operations

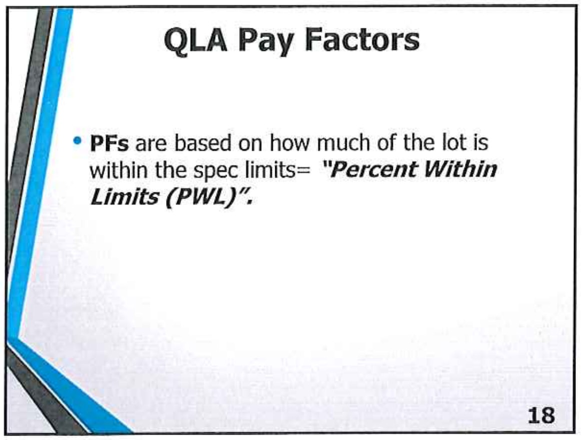


QLA Pay Factors

- **QLA PFs** are part of the overall statistically-based Quality Level Analysis (**QLA**) program as specified in Section 403, Standard Specs.
- Samples must be obtained in a ***random*** (unbiased) manner.

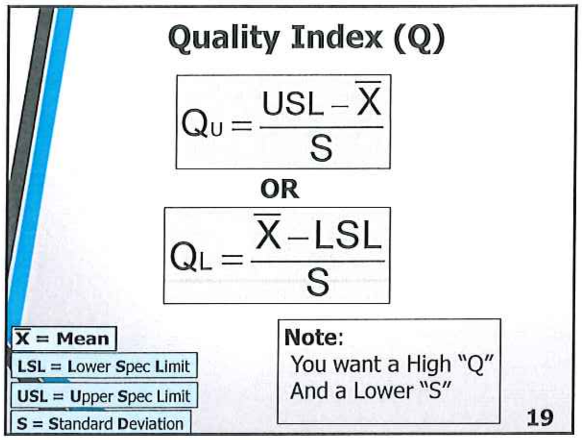
QLA = Quality Level Analysis

PFs = Pay Factors



QLA Pay Factors

- **PFs** are based on how much of the lot is within the spec limits= ***"Percent Within Limits (PWL)".***



Quality Index (Q)

$$Q_U = \frac{USL - \overline{X}}{S}$$

OR

$$Q_L = \frac{\overline{X} - LSL}{S}$$

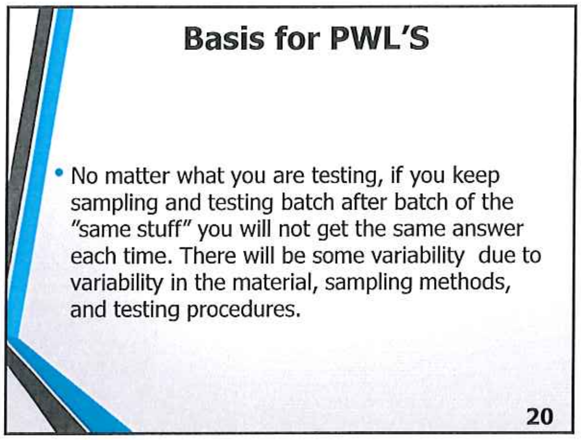
X = Mean

LSL = Lower Spec Limit

USL = Upper Spec Limit

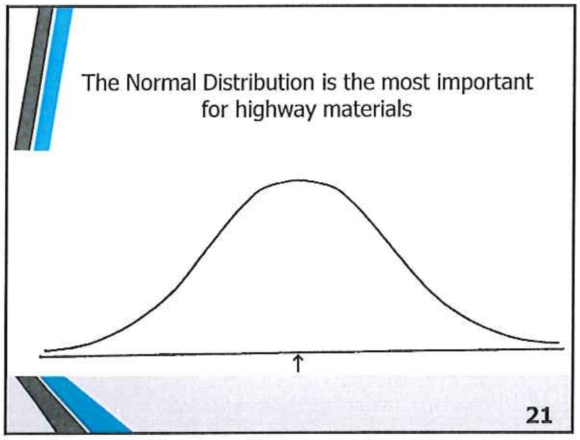
S = Standard Deviation

Note:
You want a High "Q"
And a Lower "S"

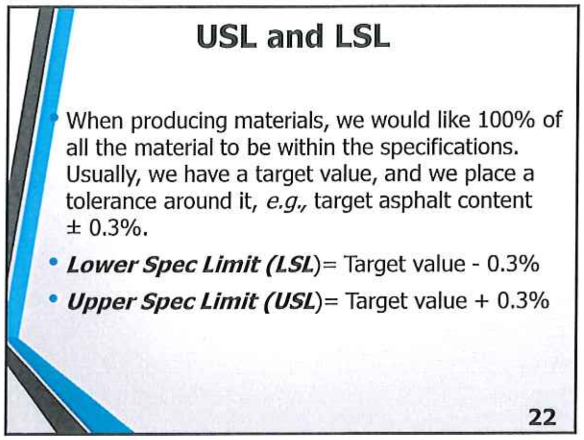


Basis for PWL'S

- No matter what you are testing, if you keep sampling and testing batch after batch of the "same stuff" you will not get the same answer each time. There will be some variability due to variability in the material, sampling methods, and testing procedures.



The Normal Distribution is the most important for highway materials



USL and LSL

- When producing materials, we would like 100% of all the material to be within the specifications. Usually, we have a target value, and we place a tolerance around it, *e.g.,* target asphalt content ± 0.3%.
- ***Lower Spec Limit (LSL)***= Target value - 0.3%
- ***Upper Spec Limit (USL)***= Target value + 0.3%

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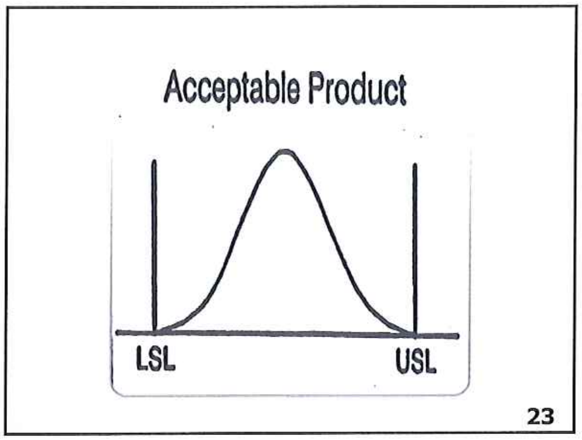

Acceptable Product

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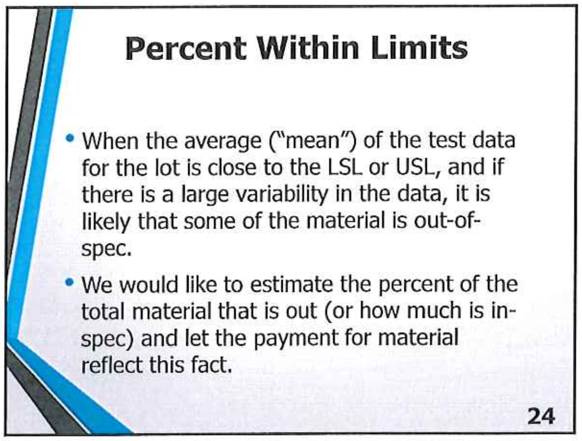

Percent Within Limits

- When the average ("mean") of the test data for the lot is close to the LSL or USL, and if there is a large variability in the data, it is likely that some of the material is out-of-spec.
- We would like to estimate the percent of the total material that is out (or how much is in-spec) and let the payment for material reflect this fact.

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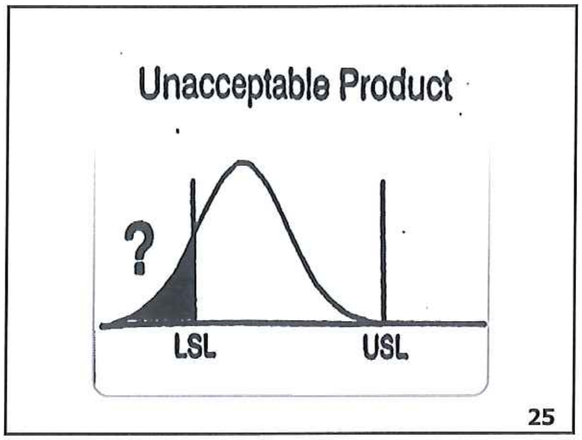
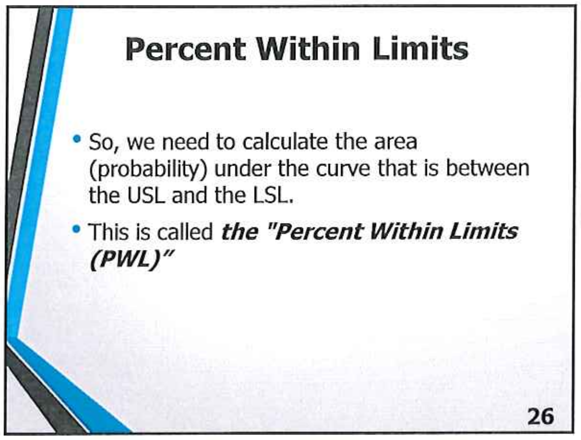
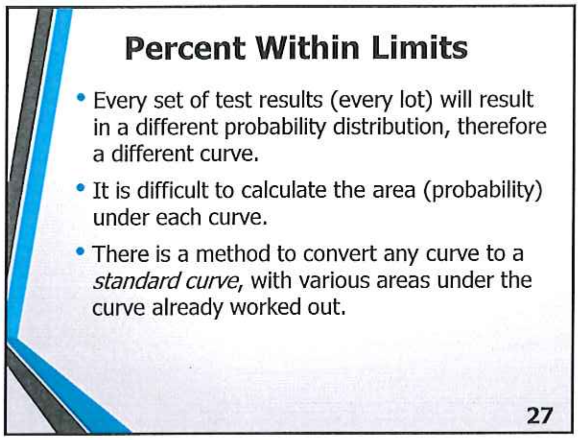


Unacceptable Product



Percent Within Limits

- So, we need to calculate the area (probability) under the curve that is between the USL and the LSL.
- This is called ***the "Percent Within Limits (PWL)"***

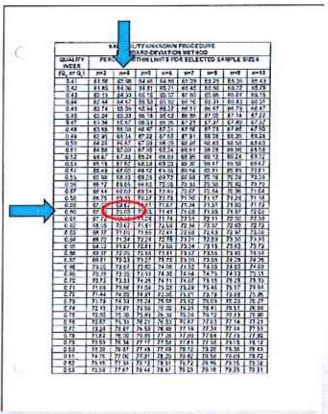


Percent Within Limits

- Every set of test results (every lot) will result in a different probability distribution, therefore a different curve.
- It is difficult to calculate the area (probability) under each curve.
- There is a method to convert any curve to a *standard curve*, with various areas under the curve already worked out.

Percent Within Limits

- The areas under the standard curve (probabilities) are published in a table called the ***"Quality Index " table***. (502.15.8)
- To obtain the probability value from the Q-table, you must use your curve's statistical characteristics: mean (x) and standard deviation (S) to calculate Q.



Enlarged

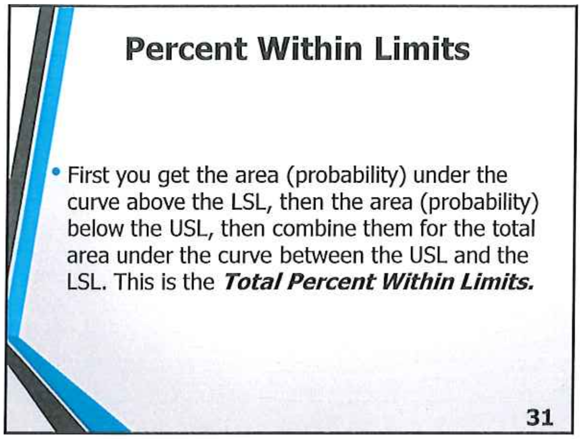
Quality Index (Q)

$$Q_L = \frac{\overline{X} - LSL}{S}$$

OR

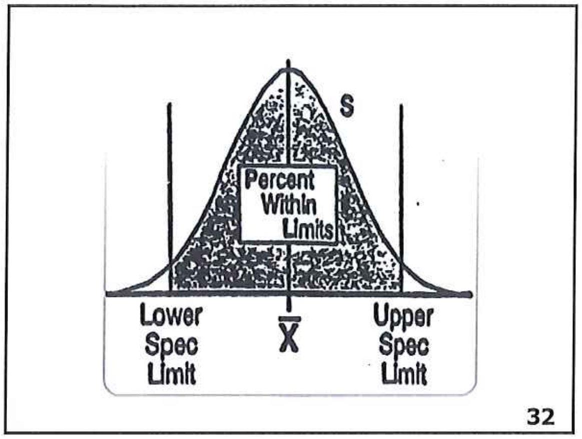
$$Q_U = \frac{USL - \overline{X}}{S}$$

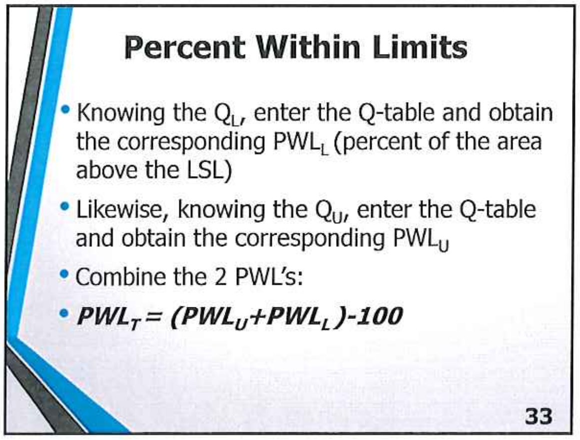
VA ILITY-UNKNOWN PROCEDURE S NDARD-DEVIATION METHOD								
QUALITY INDEX	PERC WITHIN LIMITS FOR SELECTED SAMPLE SIZES							
(Q_U or Q_L)	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
0.41	61.56	63.66	64.46	64.86	65.09	65.25	65.36	65.43
0.42	61.85	64.00	64.81	65.21	65.45	65.60	65.72	65.79
0.43	62.15	64.33	65.15	65.57	65.80	65.96	66.07	66.15
0.44	62.44	64.67	65.50	65.92	66.16	66.31	66.43	66.51
0.45	62.74	65.00	65.84	66.27	66.51	66.67	66.79	66.87
0.46	63.04	65.33	66.18	66.62	66.86	67.02	67.14	67.22
0.47	63.34	65.67	66.53	66.96	67.21	67.37	67.49	67.57
0.48	63.65	66.00	66.87	67.31	67.56	67.73	67.85	67.93
0.49	63.95	66.34	67.22	67.65	67.91	68.08	68.20	68.28
0.50	64.25	66.67	67.56	68.00	68.26	68.43	68.55	68.63
0.51	64.56	67.00	67.90	68.34	68.61	68.78	68.90	68.98
0.52	64.87	67.33	68.24	68.69	68.95	69.12	69.24	69.32
0.53	65.18	67.67	68.58	69.03	69.30	69.47	69.59	69.67
0.54	65.49	68.00	68.92	69.38	69.64	69.81	69.93	70.01
0.55	65.80	68.33	69.26	69.72	69.99	70.16	70.28	70.36
0.56	66.12	68.66	69.60	70.06	70.33	70.50	70.62	70.70
0.57	66.44	69.00	69.94	70.40	70.67	70.84	70.96	71.04
0.58	66.75	69.33	70.27	70.73	71.00	71.17	71.29	71.38
0.59	67.07	69.67	70.61	71.07	71.34	71.51	71.63	71.72
0.60	67.39	70.00	70.95	71.41	71.68	71.85	71.97	72.06
0.61	67.72	70.33	71.28	71.74	72.01	72.11	72.30	72.39
0.62	68.05	70.67	71.61	72.08	72.34	72.37	72.63	72.72
0.63	68.37	71.00	71.95	72.41	72.68	72.63	72.97	73.06
0.64	68.70	71.34	72.28	72.75	73.01	72.89	73.30	73.39
0.65	69.03	71.67	72.61	73.08	73.34	73.15	73.63	73.72
0.66	69.37	72.00	72.94	73.41	73.67	73.55	73.95	74.04
0.67	69.71	72.33	73.27	73.73	73.99	73.95	74.28	74.36
0.68	70.05	72.67	73.60	74.06	74.32	74.35	74.60	74.69
0.69	70.39	73.00	73.93	74.38	74.64	74.75	74.93	75.01
0.70	70.73	73.33	74.26	74.71	74.97	75.15	75.25	75.33
0.71	71.08	73.66	74.59	75.03	75.29	75.46	75.57	75.64
0.72	71.44	74.00	74.91	75.35	75.61	75.78	75.88	75.96
0.73	71.79	74.33	75.24	75.68	75.92	76.09	76.20	76.27
0.74	72.15	74.67	75.56	76.00	76.24	76.41	76.51	76.59
0.75	72.50	75.00	75.89	76.32	76.56	76.72	76.83	76.90
0.76	72.87	75.33	76.21	76.63	76.87	77.03	77.14	77.21
0.77	73.24	75.67	76.53	76.95	77.18	77.34	77.44	77.51
0.78	73.62	76.00	76.85	77.26	77.50	77.64	77.75	77.82
0.79	73.99	76.34	77.17	77.58	77.81	77.95	78.05	78.12
0.80	74.36	76.67	77.49	77.89	78.12	78.26	78.36	78.43
0.81	74.75	77.00	77.81	78.20	78.42	78.56	78.66	78.72
0.82	75.15	77.33	78.12	78.51	78.72	78.86	78.95	79.02
0.83	75.54	77.67	78.44	78.81	79.03	79.16	79.25	79.31



Percent Within Limits

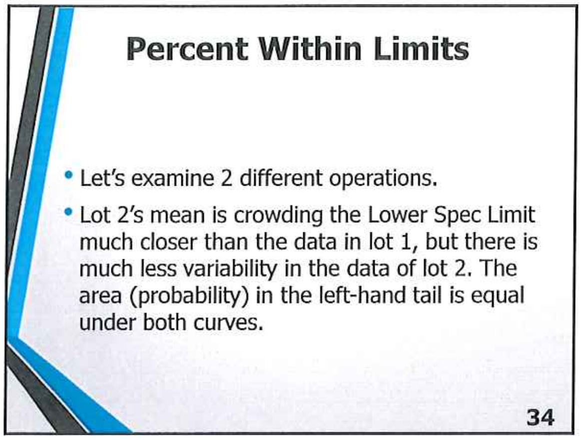
- First you get the area (probability) under the curve above the LSL, then the area (probability) below the USL, then combine them for the total area under the curve between the USL and the LSL. This is the ***Total Percent Within Limits.***





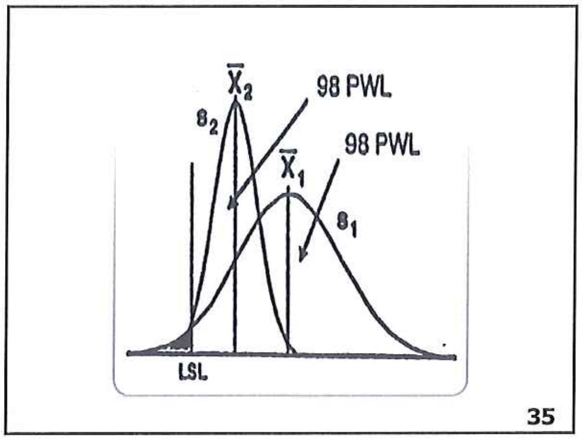
Percent Within Limits

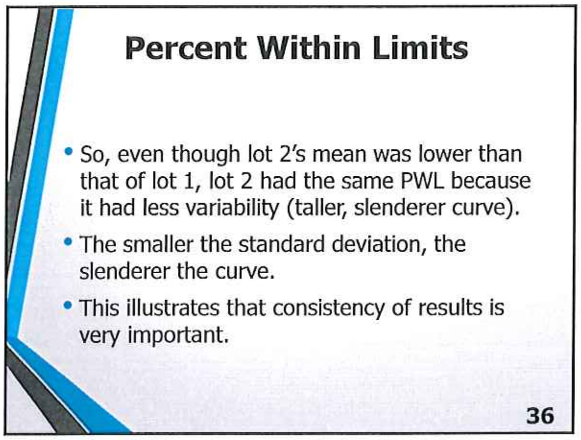
- Knowing the Q_L, enter the Q-table and obtain the corresponding PWL_L (percent of the area above the LSL)
- Likewise, knowing the Q_U, enter the Q-table and obtain the corresponding PWL_U
- Combine the 2 PWL's:
- $PWL_T = (PWL_U + PWL_L) - 100$



Percent Within Limits

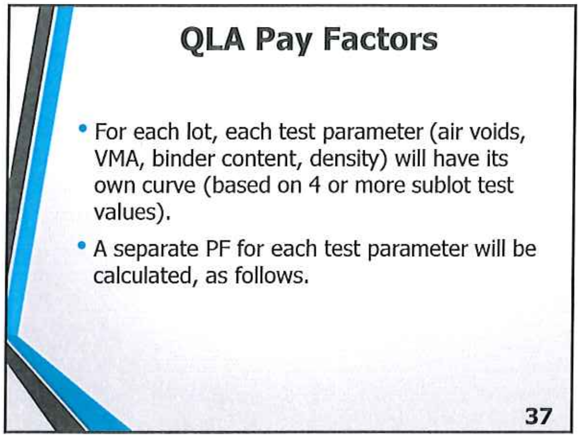
- Let's examine 2 different operations.
- Lot 2's mean is crowding the Lower Spec Limit much closer than the data in lot 1, but there is much less variability in the data of lot 2. The area (probability) in the left-hand tail is equal under both curves.





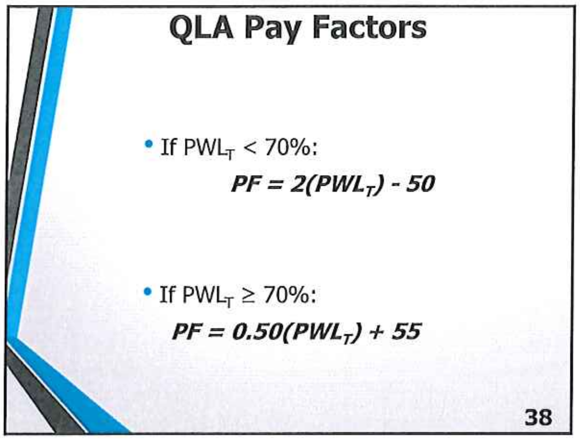
Percent Within Limits

- So, even though lot 2's mean was lower than that of lot 1, lot 2 had the same PWL because it had less variability (taller, slenderer curve).
- The smaller the standard deviation, the slenderer the curve.
- This illustrates that consistency of results is very important.



QLA Pay Factors

- For each lot, each test parameter (air voids, VMA, binder content, density) will have its own curve (based on 4 or more sublot test values).
- A separate PF for each test parameter will be calculated, as follows.



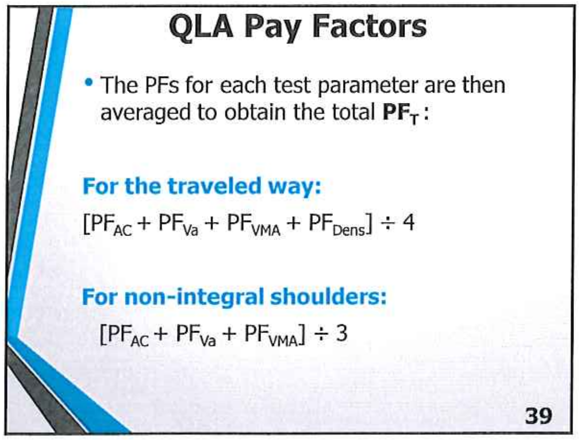
QLA Pay Factors

- If $PWL_T < 70\%$:

  $PF = 2(PWL_T) - 50$

- If $PWL_T \geq 70\%$:

  $PF = 0.50(PWL_T) + 55$



QLA Pay Factors

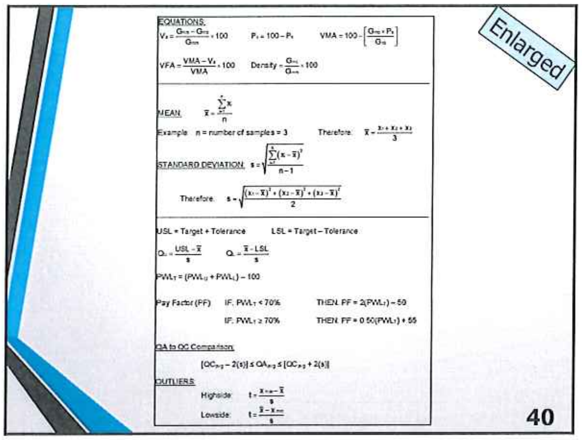
- The PFs for each test parameter are then averaged to obtain the total $\mathbf{PF_T}$:

For the traveled way:

$[PF_{AC} + PF_{Va} + PF_{VMA} + PF_{Dens}] \div 4$

For non-integral shoulders:

$[PF_{AC} + PF_{Va} + PF_{VMA}] \div 3$



Enlarged

EQUATIONS:

$V_a = \frac{G_{mm} - G_{mb}}{G_{mm}} \times 100$ $P_s = 100 - P_b$ $VMA = 100 - \left[\frac{G_{mb} \times P_s}{G_{sb}}\right]$

$VFA = \frac{VMA - V_a}{VMA} \times 100$ $Density = \frac{G_{mb}}{G_{mm}} \times 100$

MEAN: $\bar{x} = \frac{\sum_{i=1}^{n} x}{n}$

Example: n = number of samples = 3 Therefore: $\bar{x} = \frac{x_1 + x_2 + x_3}{3}$

STANDARD DEVIATION: $s = \sqrt{\frac{\sum_{i=1}^{n}(x - \bar{x})^2}{n-1}}$

Therefore: $s = \sqrt{\frac{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + (x_3 - \bar{x})^2}{2}}$

USL = Target + Tolerance LSL = Target – Tolerance

$Q_U = \frac{USL - \bar{x}}{s}$ $Q_L = \frac{\bar{x} - LSL}{s}$

$PWL_T = (PWL_U + PWL_L) - 100$

Pay Factor (PF) IF: $PWL_T < 70\%$ THEN: $PF = 2(PWL_T) - 50$

IF: $PWL_T \geq 70\%$ THEN: $PF = 0.50(PWL_T) + 55$

QA to QC Comparison:

$[QC_{x_3} - 2(s)] \leq QA_{x_3} \leq [QC_{x_3} + 2(s)]$

OUTLIERS:

Highside: $t = \frac{x_{high} - \bar{x}}{s}$

Lowside: $t = \frac{\bar{x} - x_{low}}{s}$

QLA Pay Factors

- So, back to our original example, if the average of the 4-test parameter PFs is 105%, then the contract price of $43.50 per ton per 4000-ton lot is adjusted by:

(1.05-1.00)(4000)($43.50) = $8700

The maximum PF is **105%.**

Example

- See handout of MoDOT spreadsheet.
- The Q table is in Section 403, Standard Specifications (Link to 502.15.8).
- Note: density is now 94.5 ± 2.5%.

EQUATIONS:

$$V_a = \frac{G_{mm} - G_{mb}}{G_{mm}} \times 100 \qquad P_s = 100 - P_b \qquad VMA = 100 - \left[\frac{G_{mb} \times P_s}{G_{sb}}\right]$$

$$VFA = \frac{VMA - V_a}{VMA} \times 100 \qquad Density = \frac{G_{mc}}{G_{mm}} \times 100$$

MEAN:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

Example: n = number of samples = 3 Therefore: $\bar{x} = \frac{x_1 + x_2 + x_3}{3}$

STANDARD DEVIATION:

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

Therefore: $s = \sqrt{\frac{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + (x_3 - \bar{x})^2}{2}}$

USL = Target + Tolerance LSL = Target – Tolerance

$$Q_U = \frac{USL - \bar{x}}{s} \qquad Q_L = \frac{\bar{x} - LSL}{s}$$

$PWL_T = (PWL_U + PWL_L) - 100$

Pay Factor (PF): IF: $PWL_T < 70\%$ THEN: $PF = 2(PWL_T) - 50$

IF: $PWL_T \geq 70\%$ THEN: $PF = 0.50(PWL_T) + 55$

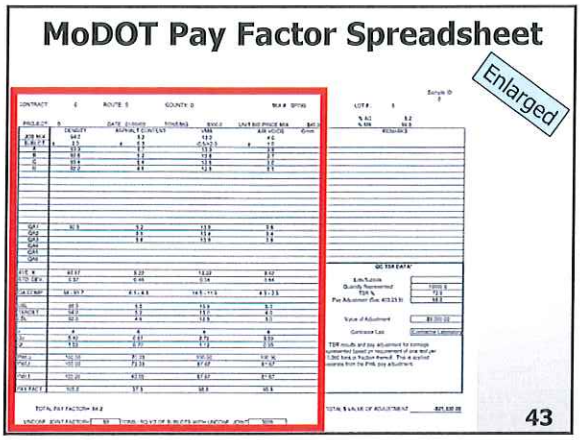
QA to QC Comparison:

$$[QC_{avg} - 2(s)] \leq QA_{avg} \leq [QC_{avg} + 2(s)]$$

OUTLIERS:

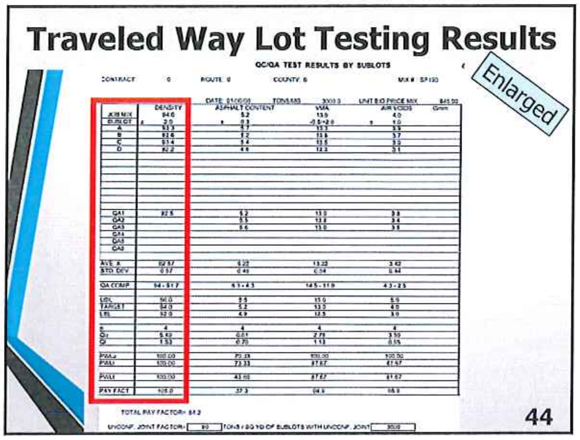
Highside: $t = \frac{x_{max} - \bar{x}}{s}$

Lowside: $t = \frac{\bar{x} - x_{min}}{s}$



MoDOT Pay Factor Spreadsheet

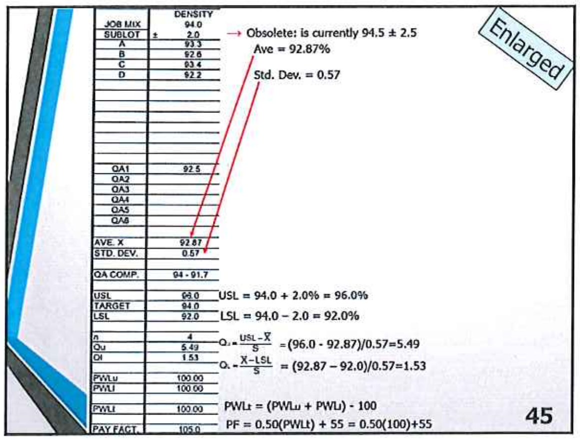
Enlarged



Traveled Way Lot Testing Results

QC/QA TEST RESULTS BY SUBLOTS

Enlarged



		DENSITY
JOB MIX		94.0
SUBLOT	±	2.0
A		93.3
B		92.6
C		93.4
D		92.2
QA1		92.5
QA2		
QA3		
QA4		
QA5		
QA6		
AVE. X		92.87
STD. DEV.		0.57
QA COMP.		94 - 91.7
USL		96.0
TARGET		94.0
LSL		92.0
n		4
Qu		5.49
Ql		1.53
PWLu		100.00
PWLl		100.00
PWLt		100.00
PAY FACT.		105.0

→ Obsolete: is currently 94.5 ± 2.5

Ave = 92.87%

Std. Dev. = 0.57

USL = 94.0 + 2.0% = 96.0%

LSL = 94.0 – 2.0 = 92.0%

$Q_u = \frac{USL - \bar{X}}{S}$ =(96.0 - 92.87)/0.57=5.49

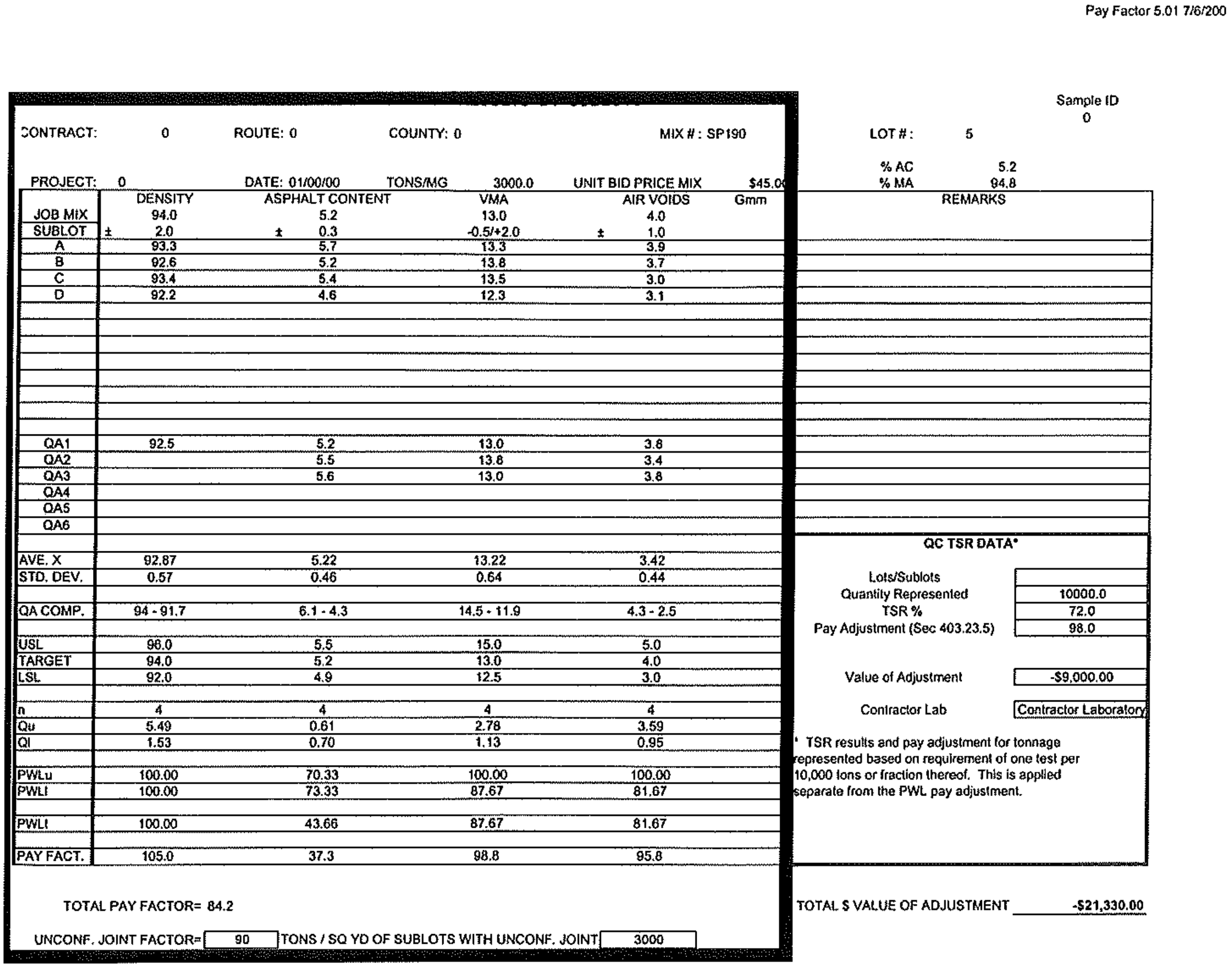
$Q_l = \frac{\bar{X} - LSL}{S}$ = (92.87 – 92.0)/0.57=1.53

$PWL_t = (PWL_u + PWL_l) - 100$

PF = 0.50(PWLt) + 55 = 0.50(100)+55

Enlarged

MoDOT Pay Factor Spreadsheet



Pay Factor 5.01 7/6/200

Sample ID
0

CONTRACT: 0 ROUTE: 0 COUNTY: 0 MIX # : SP190 LOT # : 5

% AC 5.2
PROJECT: 0 DATE: 01/00/00 TONS/MG 3000.0 UNIT BID PRICE MIX $45.0 % MA 94.8

	DENSITY	ASPHALT CONTENT	VMA	AIR VOIDS	Gmm
JOB MIX	94.0	5.2	13.0	4.0	
SUBLOT	± 2.0	± 0.3	-0.5/+2.0	± 1.0	
A	93.3	5.7	13.3	3.9	
B	92.6	5.2	13.8	3.7	
C	93.4	5.4	13.5	3.0	
D	92.2	4.6	12.3	3.1	
QA1	92.5	5.2	13.0	3.8	
QA2		5.5	13.8	3.4	
QA3		5.6	13.0	3.8	
QA4					
QA5					
QA6					
AVE. X	92.87	5.22	13.22	3.42	
STD. DEV.	0.57	0.46	0.64	0.44	
QA COMP.	94 - 91.7	6.1 - 4.3	14.5 - 11.9	4.3 - 2.5	
USL	96.0	5.5	15.0	5.0	
TARGET	94.0	5.2	13.0	4.0	
LSL	92.0	4.9	12.5	3.0	
n	4	4	4	4	
Qu	5.49	0.61	2.78	3.59	
Ql	1.53	0.70	1.13	0.95	
PWLu	100.00	70.33	100.00	100.00	
PWLl	100.00	73.33	87.67	81.67	
PWLt	100.00	43.66	87.67	81.67	
PAY FACT.	105.0	37.3	98.8	95.8	

REMARKS

TOTAL PAY FACTOR= 84.2

UNCONF. JOINT FACTOR= 90 TONS / SQ YD OF SUBLOTS WITH UNCONF. JOINT 3000

QC TSR DATA*

Lots/Sublots	
Quantity Represented	10000.0
TSR %	72.0
Pay Adjustment (Sec 403.23.5)	98.0
Value of Adjustment	-$9,000.00
Contractor Lab	Contractor Laboratory

* TSR results and pay adjustment for tonnage represented based on requirement of one test per 10,000 tons or fraction thereof. This is applied separate from the PWL pay adjustment.

TOTAL $ VALUE OF ADJUSTMENT -$21,330.00

Traveled Way Lot Testing Results

QC/QA TEST RESULTS BY SUBLOTS

CONTRACT: 0 ROUTE: 0 COUNTY: 0 MIX # : SP190

PROJECT: 0 DATE: 01/00/00 TONS/MG 3000.0 UNIT BID PRICE MIX $45.00

	DENSITY	ASPHALT CONTENT	VMA	AIR VOIDS	Gmm
JOB MIX	94.0	5.2	13.0	4.0	
SUBLOT	± 2.0	± 0.3	-0.5/+2.0	± 1.0	
A	93.3	5.7	13.3	3.9	
B	92.6	5.2	13.8	3.7	
C	93.4	5.4	13.5	3.0	
D	92.2	4.6	12.3	3.1	
QA1	92.5	5.2	13.0	3.8	
QA2		5.5	13.8	3.4	
QA3		5.6	13.0	3.8	
QA4					
QA5					
QA6					
AVE. X	92.87	5.22	13.22	3.42	
STD. DEV.	0.57	0.46	0.64	0.44	
QA COMP.	94 - 91.7	6.1 - 4.3	14.5 - 11.9	4.3 - 2.5	
USL	96.0	5.5	15.0	5.0	
TARGET	94.0	5.2	13.0	4.0	
LSL	92.0	4.9	12.5	3.0	
n	4	4	4	4	
Qu	5.49	0.61	2.78	3.59	
Ql	1.53	0.70	1.13	0.95	
PWLu	100.00	70.33	100.00	100.00	
PWLl	100.00	73.33	87.67	81.67	
PWLt	100.00	43.66	87.67	81.67	
PAY FACT.	105.0	37.3	98.8	95.8	

TOTAL PAY FACTOR= 84.2

UNCONF. JOINT FACTOR= 90 TONS / SQ YD OF SUBLOTS WITH UNCONF. JOINT 3000

		DENSITY
JOB MIX		94.0
SUBLOT	±	2.0
A		93.3
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C		93.4
D		92.2
QA1		92.5
QA2		
QA3		
QA4		
QA5		
QA6		
AVE. X		92.87
STD. DEV.		0.57
QA COMP.		94 - 91.7
USL		96.0
TARGET		94.0
LSL		92.0
n		4
Qu		5.49
Ql		1.53
PWLu		100.00
PWLl		100.00
PWLt		100.00
PAY FACT.		105.0

→ Obsolete: is currently 94.5 ± 2.5

Ave = 92.87%

Std. Dev. = 0.57

USL = 94.0 + 2.0% = 96.0%

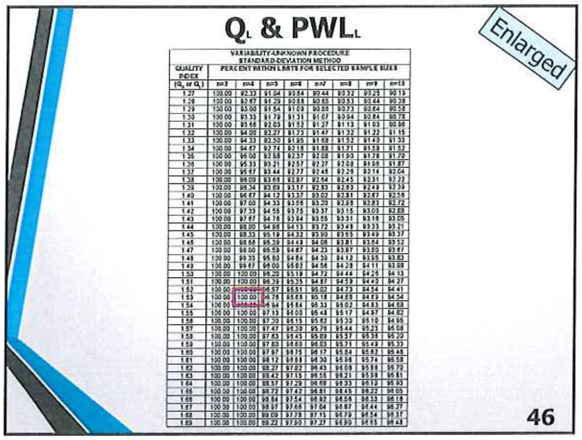
LSL = 94.0 - 2.0 = 92.0%

$$Q_U = \frac{USL - \overline{X}}{S} = (96.0 - 92.87)/0.57 = 5.49$$

$$Q_L = \frac{\overline{X} - LSL}{S} = (92.87 - 92.0)/0.57 = 1.53$$

$$PWL_T = (PWL_U + PWL_L) - 100$$

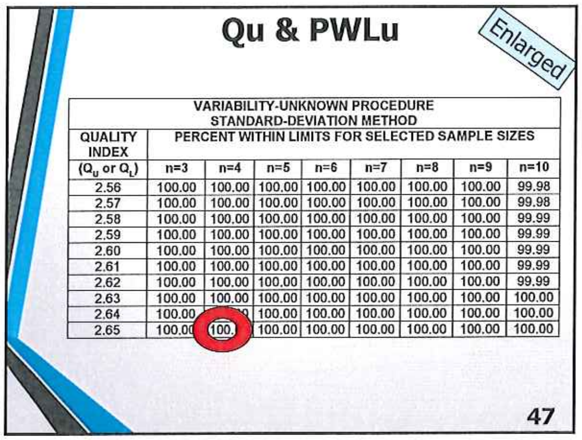
$$PF = 0.50(PWL_T) + 55 = 0.50(100) + 55$$



Q_L & PWL_L

Enlarged

VARIABILITY-UNKNOWN PROCEDURE
STANDARD-DEVIATION METHOD

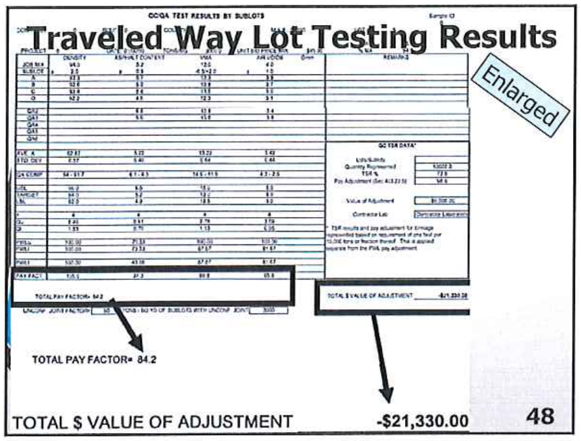


Qu & PWLu

Enlarged

VARIABILITY-UNKNOWN PROCEDURE
STANDARD-DEVIATION METHOD

QUALITY INDEX	PERCENT WITHIN LIMITS FOR SELECTED SAMPLE SIZES							
(Q_u or Q_L)	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
2.56	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98
2.57	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98
2.58	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.59	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.60	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.61	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.62	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.63	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2.64	100.00	[illegible]	100.00	100.00	100.00	100.00	100.00	100.00
2.65	100.0	100.	100.00	100.00	100.00	100.00	100.00	100.00



Traveled Way Lot Testing Results

Enlarged

TOTAL PAY FACTOR= 84.2

TOTAL $ VALUE OF ADJUSTMENT -$21,330.00

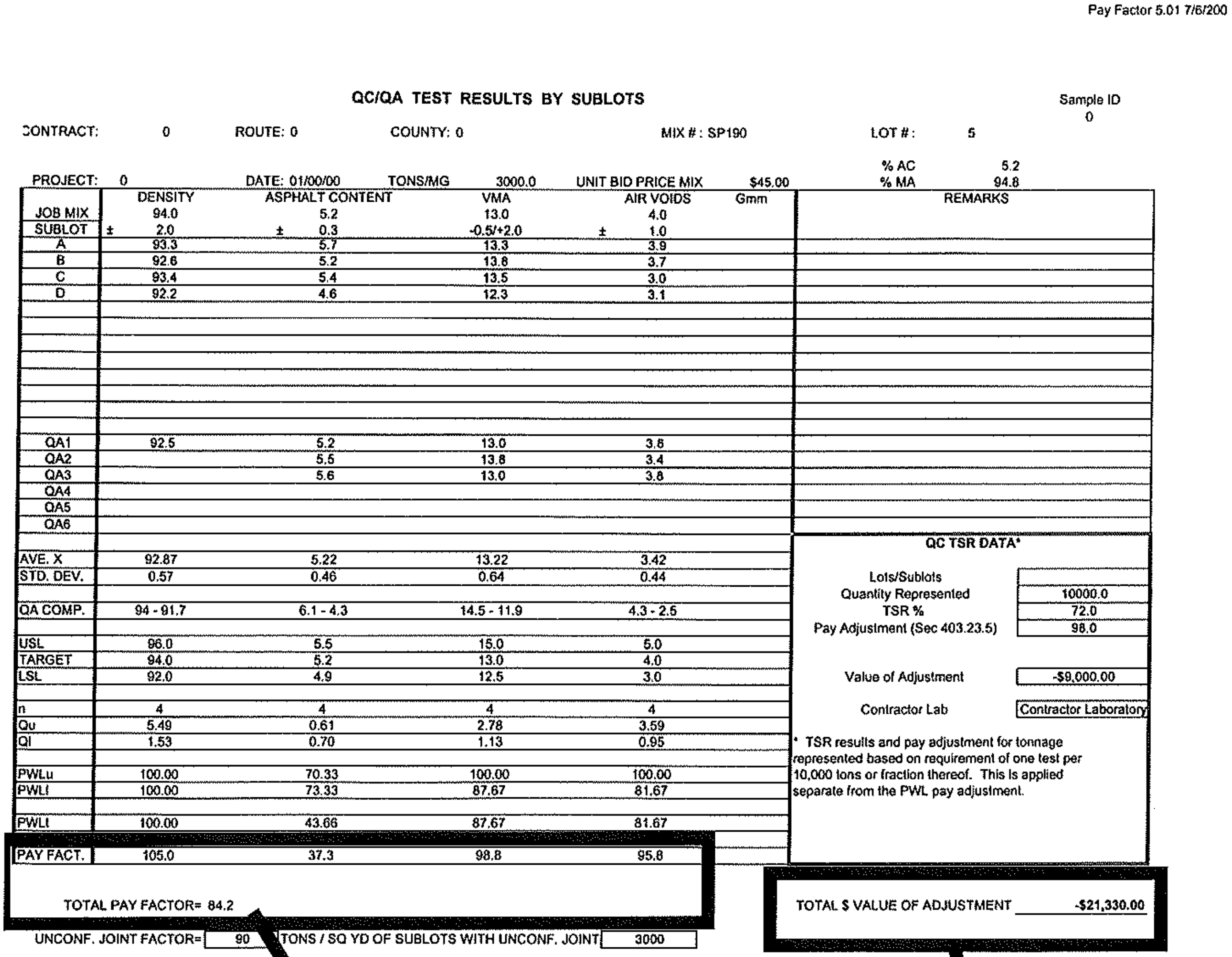
Q_L & PWL_L

VARIABILITY-UNKNOWN PROCEDURE STANDARD-DEVIATION METHOD								
QUALITY INDEX (Q_U or Q_L)	PERCENT WITHIN LIMITS FOR SELECTED SAMPLE SIZES							
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
1.27	100.00	92.33	91.04	90.64	90.44	90.32	90.25	90.19
1.28	100.00	92.67	91.29	90.86	90.65	90.53	90.44	90.38
1.29	100.00	93.00	91.54	91.09	90.86	90.73	90.64	90.58
1.30	100.00	93.33	91.79	91.31	91.07	90.94	90.84	90.78
1.31	100.00	93.66	92.03	91.52	91.27	91.13	91.03	90.96
1.32	100.00	94.00	92.27	91.73	91.47	91.32	91.22	91.15
1.33	100.00	94.33	92.50	91.95	91.68	91.52	91.40	91.33
1.34	100.00	94.67	92.74	92.16	91.88	91.71	91.59	91.52
1.35	100.00	95.00	92.98	92.37	92.08	91.90	91.78	91.70
1.36	100.00	95.33	93.21	92.57	92.27	92.08	91.96	91.87
1.37	100.00	95.67	93.44	92.77	92.46	92.26	92.14	92.04
1.38	100.00	96.00	93.66	92.97	92.64	92.45	92.31	92.22
1.39	100.00	96.34	93.89	93.17	92.83	92.63	92.49	92.39
1.40	100.00	96.67	94.12	93.37	93.02	92.81	92.67	92.56
1.41	100.00	97.00	94.33	93.56	93.20	92.98	92.83	92.72
1.42	100.00	97.33	94.55	93.75	93.37	93.15	93.00	92.88
1.43	100.00	97.67	94.76	93.94	93.55	93.31	93.16	93.05
1.44	100.00	98.00	94.98	94.13	93.72	93.48	93.33	93.21
1.45	100.00	98.33	95.19	94.32	93.90	93.65	93.49	93.37
1.46	100.00	98.66	95.39	94.49	94.06	93.81	93.64	93.52
1.47	100.00	99.00	95.59	94.67	94.23	93.97	93.80	93.67
1.48	100.00	99.33	95.80	94.84	94.39	94.12	93.95	93.83
1.49	100.00	99.67	96.00	95.02	94.56	94.28	94.11	93.98
1.50	100.00	100.00	96.20	95.19	94.72	94.44	94.26	94.13
1.51	100.00	100.00	96.39	95.35	94.87	94.59	94.40	94.27
1.52	100.00	100.00	96.57	95.51	95.02	94.73	94.54	94.41
1.53	100.00	100.00	96.76	95.68	95.18	94.88	94.69	94.54
1.54	100.00	100.00	96.94	95.84	95.33	95.02	94.83	94.68
1.55	100.00	100.00	97.13	96.00	95.48	95.17	94.97	94.82
1.56	100.00	100.00	97.30	96.15	95.62	95.30	95.10	94.95
1.57	100.00	100.00	97.47	96.30	95.76	95.44	95.23	95.08
1.58	100.00	100.00	97.63	96.45	95.89	95.57	95.36	95.20
1.59	100.00	100.00	97.80	96.60	96.03	95.71	95.49	95.33
1.60	100.00	100.00	97.97	96.75	96.17	95.84	95.62	95.46
1.61	100.00	100.00	98.12	96.88	96.30	95.96	95.74	95.58
1.62	100.00	100.00	98.27	97.02	96.43	96.08	95.86	95.70
1.63	100.00	100.00	98.42	97.15	96.55	96.21	95.98	95.81
1.64	100.00	100.00	98.57	97.29	96.68	96.33	96.10	95.93
1.65	100.00	100.00	98.72	97.42	96.81	96.45	96.22	96.05
1.66	100.00	100.00	98.84	97.54	96.92	96.56	96.33	96.16
1.67	100.00	100.00	98.97	97.66	97.04	96.67	96.44	96.27
1.68	100.00	100.00	99.09	97.78	97.15	96.79	96.54	96.37
1.69	100.00	100.00	99.22	97.90	97.27	96.90	96.65	96.48

Qu & PWLu

VARIABILITY-UNKNOWN PROCEDURE STANDARD-DEVIATION METHOD								
QUALITY INDEX	PERCENT WITHIN LIMITS FOR SELECTED SAMPLE SIZES							
(Q_U or Q_L)	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
2.56	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98
2.57	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98
2.58	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.59	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.60	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.61	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.62	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.63	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2.64	100.00	[illegible]	100.00	100.00	100.00	100.00	100.00	100.00
2.65	100.00	100.0	100.00	100.00	100.00	100.00	100.00	100.00

Traveled Way Lot Testing Results



Pay Factor 5.01 7/6/200

QC/QA TEST RESULTS BY SUBLOTS

Sample ID
0

CONTRACT: 0 ROUTE: 0 COUNTY: 0 MIX # : SP190 LOT # : 5

% AC 5.2
% MA 94.8

PROJECT: 0 DATE: 01/00/00 TONS/MG 3000.0 UNIT BID PRICE MIX $45.00

	DENSITY	ASPHALT CONTENT	VMA	AIR VOIDS	Gmm	REMARKS
JOB MIX	94.0	5.2	13.0	4.0		
SUBLOT	± 2.0	± 0.3	-0.5/+2.0	± 1.0		
A	93.3	5.7	13.3	3.9		
B	92.6	5.2	13.8	3.7		
C	93.4	5.4	13.5	3.0		
D	92.2	4.6	12.3	3.1		
QA1	92.5	5.2	13.0	3.8		
QA2		5.5	13.8	3.4		
QA3		5.6	13.0	3.8		
QA4						
QA5						
QA6						
AVE. X	92.87	5.22	13.22	3.42		
STD. DEV.	0.57	0.46	0.64	0.44		
QA COMP.	94 - 91.7	6.1 - 4.3	14.5 - 11.9	4.3 - 2.5		
USL	96.0	5.5	15.0	5.0		
TARGET	94.0	5.2	13.0	4.0		
LSL	92.0	4.9	12.5	3.0		
n	4	4	4	4		
Qu	5.49	0.61	2.78	3.59		
Ql	1.53	0.70	1.13	0.95		
PWLu	100.00	70.33	100.00	100.00		
PWLl	100.00	73.33	87.67	81.67		
PWLt	100.00	43.66	87.67	81.67		
PAY FACT.	105.0	37.3	98.8	95.8		

TOTAL PAY FACTOR= 84.2

UNCONF. JOINT FACTOR= 90 TONS / SQ YD OF SUBLOTS WITH UNCONF. JOINT 3000

QC TSR DATA*

Lots/Sublots	
Quantity Represented	10000.0
TSR %	72.0
Pay Adjustment (Sec 403.23.5)	98.0
Value of Adjustment	-$9,000.00
Contractor Lab	Contractor Laboratory

* TSR results and pay adjustment for tonnage represented based on requirement of one test per 10,000 tons or fraction thereof. This is applied separate from the PWL pay adjustment.

TOTAL $ VALUE OF ADJUSTMENT -$21,330.00

TOTAL PAY FACTOR= 84.2

TOTAL $ VALUE OF ADJUSTMENT -$21,330.00

Unconfined Joint Deductions

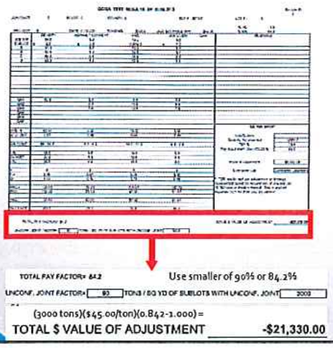
- Pay reduction applied to full width of lane for a given lot.
- The lowest adjustment factor (PF_{total} or the PAF for average unconfined joint density) will apply to the lot.
- Exception: If the PAF = 100% and the PF_{total} is over 100 (use the PF_{total})
- PF_{total} includes PFs for binder content, air voids, VMA, and density)

Unconfined Joint Deductions

- **Example**: For a given lot, if
  PF_{total} = 95% and PAF = 90%
  The 90% controls the whole lot.
- **Example**: For a given lot, if
  PF_{total} = 105% and PAF = 100%
  The 105% controls the whole lot.
- 403.23.6 and EPG 403.1.21

Unconfined Joint Factor

Enlarged



TOTAL PAY FACTOR= 84.2

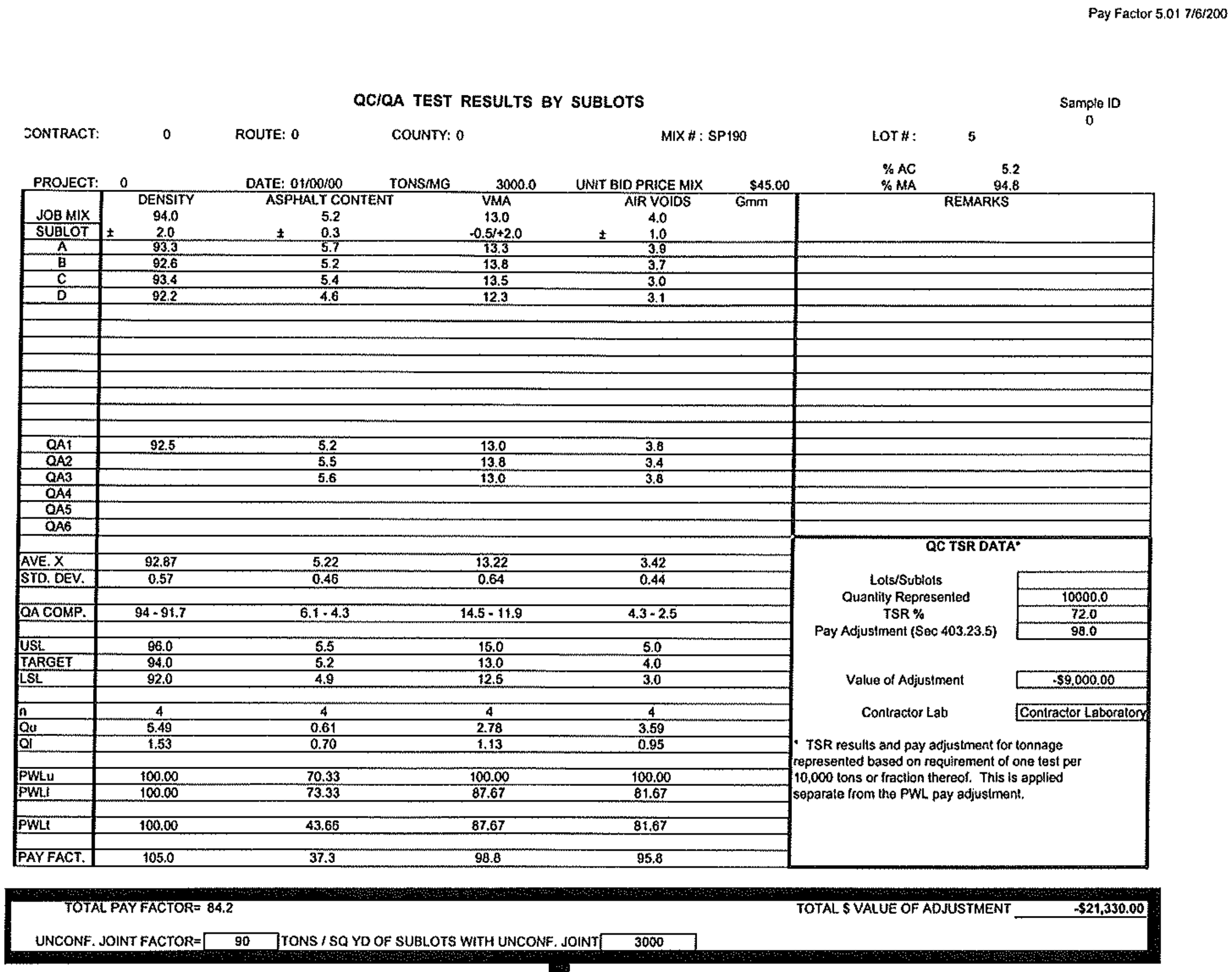
Use smaller of 90% or 84.2%

UNCONF. JOINT FACTOR= 90 TONS / SQ YD OF SUBLOTS WITH UNCONF. JOINT 3000

(3000 tons)($45.00/ton)(0.842-1.000) =

TOTAL $ VALUE OF ADJUSTMENT -$21,330.00

Unconfined Joint Factor



Pay Factor 5.01 7/6/200

QC/QA TEST RESULTS BY SUBLOTS

Sample ID
0

CONTRACT: 0 ROUTE: 0 COUNTY: 0 MIX # : SP190 LOT # : 5

% AC 5.2
% MA 94.8

PROJECT: 0 DATE: 01/00/00 TONS/MG 3000.0 UNIT BID PRICE MIX $45.00

	DENSITY	ASPHALT CONTENT	VMA	AIR VOIDS	Gmm	REMARKS
JOB MIX	94.0	5.2	13.0	4.0		
SUBLOT	± 2.0	± 0.3	-0.5/+2.0	± 1.0		
A	93.3	5.7	13.3	3.9		
B	92.6	5.2	13.8	3.7		
C	93.4	5.4	13.5	3.0		
D	92.2	4.6	12.3	3.1		
QA1	92.5	5.2	13.0	3.8		
QA2		5.5	13.8	3.4		
QA3		5.6	13.0	3.8		
QA4						
QA5						
QA6						
AVE. X	92.87	5.22	13.22	3.42		
STD. DEV.	0.57	0.46	0.64	0.44		
QA COMP.	94 - 91.7	6.1 - 4.3	14.5 - 11.9	4.3 - 2.5		
USL	96.0	5.5	15.0	5.0		
TARGET	94.0	5.2	13.0	4.0		
LSL	92.0	4.9	12.5	3.0		
n	4	4	4	4		
Qu	5.49	0.61	2.78	3.59		
Ql	1.53	0.70	1.13	0.95		
PWLu	100.00	70.33	100.00	100.00		
PWLl	100.00	73.33	87.67	81.67		
PWLt	100.00	43.66	87.67	81.67		
PAY FACT.	105.0	37.3	98.8	95.8		

QC TSR DATA*

Lots/Sublots	
Quantity Represented	10000.0
TSR %	72.0
Pay Adjustment (Sec 403.23.5)	98.0
Value of Adjustment	-$9,000.00
Contractor Lab	Contractor Laboratory

* TSR results and pay adjustment for tonnage represented based on requirement of one test per 10,000 tons or fraction thereof. This is applied separate from the PWL pay adjustment.

TOTAL PAY FACTOR= 84.2

TOTAL $ VALUE OF ADJUSTMENT -$21,330.00

UNCONF. JOINT FACTOR= 90 TONS / SQ YD OF SUBLOTS WITH UNCONF. JOINT 3000

TOTAL PAY FACTOR= 84.2

Use smaller of 90% or 84.2%

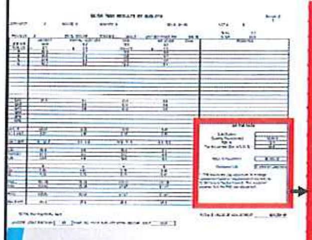
UNCONF. JOINT FACTOR= 90 TONS / SQ YD OF SUBLOTS WITH UNCONF. JOINT 3000

(3000 tons)($45.00/ton)(0.842-1.000) =

TOTAL $ VALUE OF ADJUSTMENT -$21,330.00

TSR Results

Enlarged



QC TSR DATA*

Lots/Sublots	
Quantity Represented	10,000.0
TSR %	72.0
Pay Adjustment (Sec 403.23.5)	98.0
Value of adjustment	− $9000.00
Contractor Lab	Contractor Laboratory

*TSR results and pay adjustment for tonnage Repressed based on requirement of one test per 10,000 tons or fraction thereof. This is applied Separate from the PWL pay adjustment.

(0.98-1.00)(10,000 tons)($45/ ton)= -$9000

52

Superpave TSR Pay Adjustment

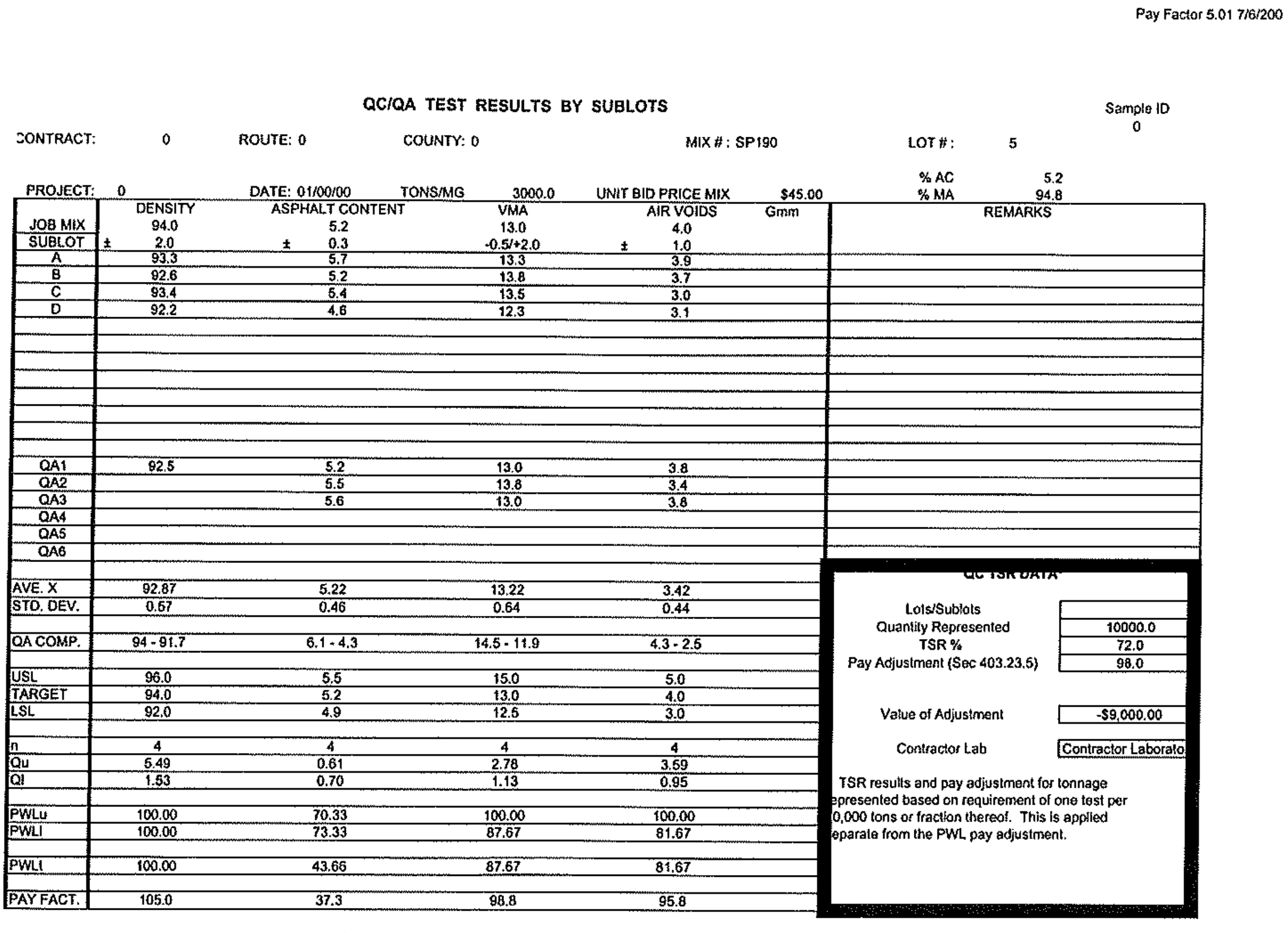
TSR	% of Contract price
≥90	103
75-89	100
70-74	98
65-69	97
<65	Remove

53

New Spreadsheets
2016

54

TSR Results



Pay Factor 5.01 7/6/200

QC/QA TEST RESULTS BY SUBLOTS

Sample ID
0

CONTRACT: 0 ROUTE: 0 COUNTY: 0 MIX # : SP190 LOT # : 5

% AC 5.2
% MA 94.8

PROJECT: 0 DATE: 01/00/00 TONS/MG 3000.0 UNIT BID PRICE MIX $45.00

	DENSITY	ASPHALT CONTENT	VMA	AIR VOIDS	Gmm	REMARKS
JOB MIX	94.0	5.2	13.0	4.0		
SUBLOT	± 2.0	± 0.3	-0.5/+2.0	± 1.0		
A	93.3	5.7	13.3	3.9		
B	92.6	5.2	13.8	3.7		
C	93.4	5.4	13.5	3.0		
D	92.2	4.6	12.3	3.1		
QA1	92.5	5.2	13.0	3.8		
QA2		5.5	13.8	3.4		
QA3		5.6	13.0	3.8		
QA4						
QA5						
QA6						
AVE. X	92.87	5.22	13.22	3.42		
STD. DEV.	0.67	0.46	0.64	0.44		
QA COMP.	94 - 91.7	6.1 - 4.3	14.5 - 11.9	4.3 - 2.5		
USL	96.0	5.5	15.0	5.0		
TARGET	94.0	5.2	13.0	4.0		
LSL	92.0	4.9	12.6	3.0		
n	4	4	4	4		
Qu	5.49	0.61	2.78	3.59		
Ql	1.53	0.70	1.13	0.95		
PWLu	100.00	70.33	100.00	100.00		
PWLl	100.00	73.33	87.67	81.67		
PWLt	100.00	43.66	87.67	81.67		
PAY FACT.	105.0	37.3	98.8	95.8		

QC TSR DATA

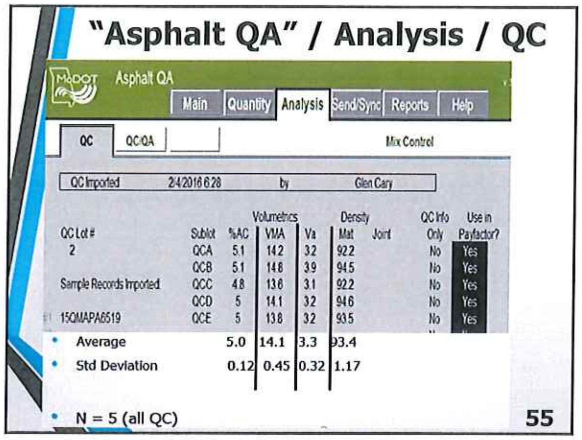
Lots/Sublots	
Quantity Represented	10000.0
TSR %	72.0
Pay Adjustment (Sec 403.23.5)	98.0
Value of Adjustment	-$9,000.00
Contractor Lab	Contractor Laborato

TSR results and pay adjustment for tonnage epresented based on requirement of one test per 0,000 tons or fraction thereof. This is applied eparate from the PWL pay adjustment.

TOTAL PAY FACTOR= 84.2

UNCONF. JOINT FACTOR= 90 TONS / S

(0.98-1.00)(10,000 tons)($45/ ton)= -$9000



"Asphalt QA" / Analysis / QC

QC Imported 2/4/2016 6:28 by Glen Cary

QC Lot # 2

Sample Records Imported

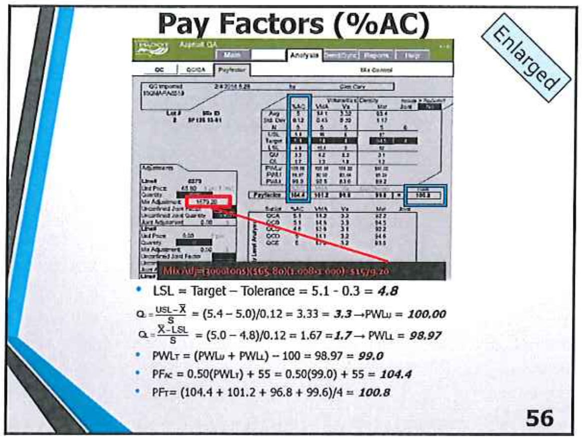
15QMAPA6519

	Volumetrics			Density		QC Info	Use in
Sublot	%AC	VMA	Va	Mat	Joint	Only	Payfactor?
QCA	5.1	14.2	3.2	92.2		No	Yes
QCB	5.1	14.8	3.9	94.5		No	Yes
QCC	4.8	13.6	3.1	92.2		No	Yes
QCD	5	14.1	3.2	94.6		No	Yes
QCE	5	13.8	3.2	93.5		No	Yes

	%AC	VMA	Va	Mat
Average	5.0	14.1	3.3	93.4
Std Deviation	0.12	0.45	0.32	1.17

- N = 5 (all QC)

55



Pay Factors (%AC)

Enlarged

Mix Adj=(3000tons)($65.80)(1.008-1.000)=$1579.20

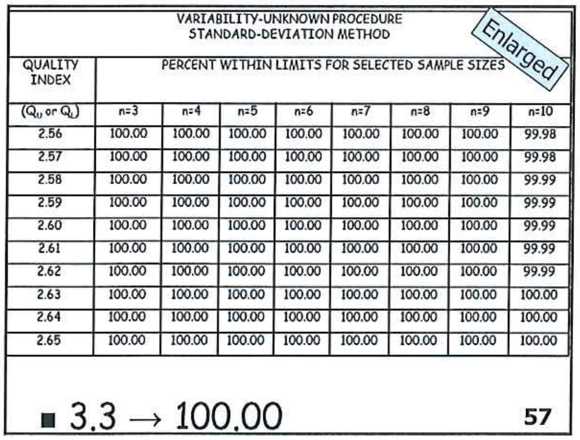
- LSL = Target – Tolerance = 5.1 - 0.3 = ***4.8***

$Q_U = \frac{USL - \overline{X}}{S}$ = (5.4 – 5.0)/0.12 = 3.33 = ***3.3*** → PWL_U = ***100.00***

$Q_L = \frac{\overline{X} - LSL}{S}$ = (5.0 – 4.8)/0.12 = 1.67 = ***1.7*** → PWL_L = ***98.97***

- $PWL_T = (PWL_U + PWL_L) - 100$ = 98.97 = ***99.0***
- $PF_{AC} = 0.50(PWL_T) + 55$ = 0.50(99.0) + 55 = ***104.4***
- PF_T= (104.4 + 101.2 + 96.8 + 99.6)/4 = ***100.8***

56



VARIABILITY-UNKNOWN PROCEDURE
STANDARD-DEVIATION METHOD

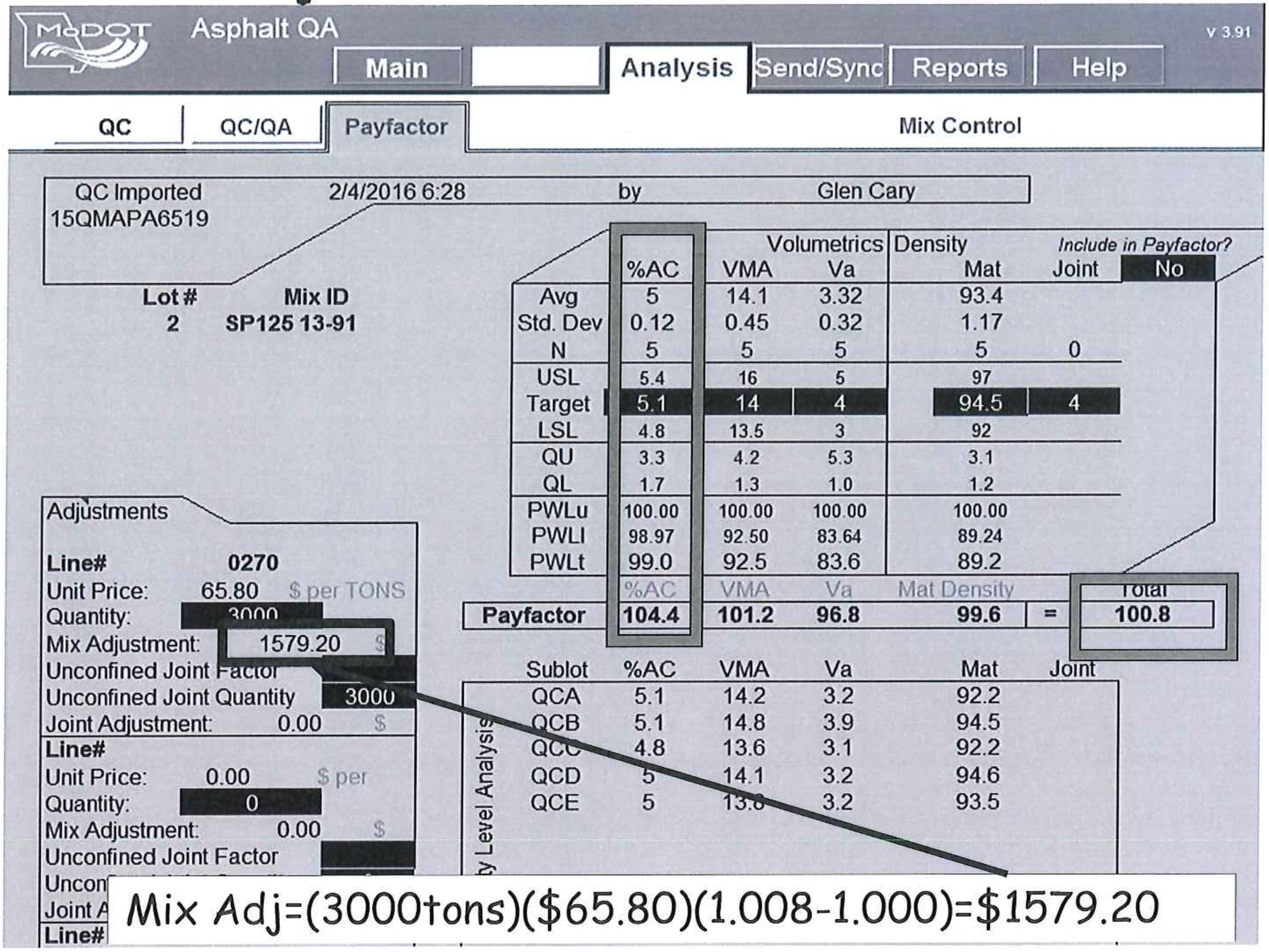
Enlarged

QUALITY INDEX	PERCENT WITHIN LIMITS FOR SELECTED SAMPLE SIZES							
(Q_U or Q_L)	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
2.56	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98
2.57	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98
2.58	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.59	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.60	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.61	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.62	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.63	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2.64	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2.65	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

- 3.3 → 100.00

57

Pay Factors (%AC)



QC Imported 2/4/2016 6:28 by Glen Cary
15QMAPA6519

Lot # 2
Mix ID SP125 13-91

	Volumetrics			Density	
	%AC	VMA	Va	Mat	Joint
Avg	5	14.1	3.32	93.4	
Std. Dev	0.12	0.45	0.32	1.17	
N	5	5	5	5	0
USL	5.4	16	5	97	
Target	5.1	14	4	94.5	4
LSL	4.8	13.5	3	92	
QU	3.3	4.2	5.3	3.1	
QL	1.7	1.3	1.0	1.2	
PWLu	100.00	100.00	100.00	100.00	
PWLl	98.97	92.50	83.64	89.24	
PWLt	99.0	92.5	83.6	89.2	

Include in Payfactor? Joint No

	%AC	VMA	Va	Mat Density	=	Total
Payfactor	**104.4**	**101.2**	**96.8**	**99.6**	=	**100.8**

Sublot	%AC	VMA	Va	Mat	Joint
QCA	5.1	14.2	3.2	92.2	
QCB	5.1	14.8	3.9	94.5	
QCC	4.8	13.6	3.1	92.2	
QCD	5	14.1	3.2	94.6	
QCE	5	13.8	3.2	93.5	

Adjustments

Line# **0270**
Unit Price: 65.80 $ per TONS
Quantity: 3000
Mix Adjustment: 1579.20 $
Unconfined Joint Factor
Unconfined Joint Quantity 3000
Joint Adjustment: 0.00 $
Line#
Unit Price: 0.00 $ per
Quantity: 0
Mix Adjustment: 0.00 $
Unconfined Joint Factor
Uncon
Joint A
Line#

Mix Adj=(3000tons)($65.80)(1.008-1.000)=$1579.20

- USL = Target + Tolerance = 5.1 + 0.3 = ***5.4***
- LSL = Target - Tolerance = 5.1 - 0.3 = ***4.8***

$$Q_U = \frac{USL - \bar{X}}{S} = (5.4 - 5.0)/0.12 = 3.33 = \mathbf{3.3} \rightarrow PWL_U = \mathbf{100.00}$$

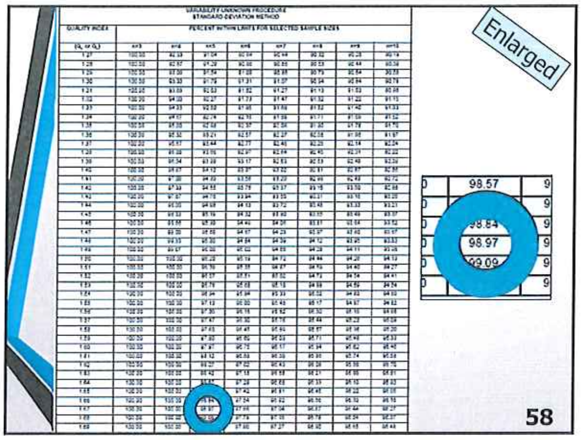
$$Q_L = \frac{\bar{X} - LSL}{S} = (5.0 - 4.8)/0.12 = 1.67 = \mathbf{1.7} \rightarrow PWL_L = \mathbf{98.97}$$

- $PWL_T = (PWL_U + PWL_L) - 100 = 98.97 = \mathbf{99.0}$
- $PF_{AC} = 0.50(PWL_T) + 55 = 0.50(99.0) + 55 = \mathbf{104.4}$
- $PF_T = (104.4 + 101.2 + 96.8 + 99.6)/4 = \mathbf{100.8}$

VARIABILITY-UNKNOWN PROCEDURE
STANDARD-DEVIATION METHOD

QUALITY INDEX	PERCENT WITHIN LIMITS FOR SELECTED SAMPLE SIZES							
(Q_U or Q_L)	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
2.56	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98
2.57	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98
2.58	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.59	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.60	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.61	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.62	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
2.63	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2.64	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2.65	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

- 3.3 → 100.00



Shoulders

- In the case of a ***non-integral shoulder,*** there is no QLA pay factor for density.
- Thus, the total PF is the ***average of the PFs for binder content, air voids, and VMA.***

VARIABILITY-UNKNOWN PROCEDURE STANDARD-DEVIATION METHOD								
QUALITY INDEX	PERCENT WITHIN LIMITS FOR SELECTED SAMPLE SIZES							
(Q_U or Q_L)	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
1.27	100.00	92.33	91.04	90.64	90.44	90.32	90.25	90.19
1.28	100.00	92.67	91.29	90.86	90.65	90.53	90.44	90.38
1.29	100.00	93.00	91.54	91.09	90.86	90.73	90.64	90.58
1.30	100.00	93.33	91.79	91.31	91.07	90.94	90.84	90.78
1.31	100.00	93.66	92.03	91.52	91.27	91.13	91.03	90.96
1.32	100.00	94.00	92.27	91.73	91.47	91.32	91.22	91.15
1.33	100.00	94.33	92.50	91.95	91.68	91.52	91.40	91.33
1.34	100.00	94.67	92.74	92.16	91.88	91.71	91.59	91.52
1.35	100.00	95.00	92.98	92.37	92.08	91.90	91.78	91.70
1.36	100.00	95.33	93.21	92.57	92.27	92.08	91.96	91.87
1.37	100.00	95.67	93.44	92.77	92.46	92.26	92.14	92.04
1.38	100.00	96.00	93.66	92.97	92.64	92.45	92.31	92.22
1.39	100.00	96.34	93.89	93.17	92.83	92.63	92.49	92.39
1.40	100.00	96.67	94.12	93.37	93.02	92.81	92.67	92.56
1.41	100.00	97.00	94.33	93.56	93.20	92.98	92.83	92.72
1.42	100.00	97.33	94.55	93.75	93.37	93.15	93.00	92.88
1.43	100.00	97.67	94.76	93.94	93.55	93.31	93.16	93.05
1.44	100.00	98.00	94.98	94.13	93.72	93.48	93.33	93.21
1.45	100.00	98.33	95.19	94.32	93.90	93.65	93.49	93.37
1.46	100.00	98.66	95.39	94.49	94.06	93.81	93.64	93.52
1.47	100.00	99.00	95.59	94.67	94.23	93.97	93.80	93.67
1.48	100.00	99.33	95.80	94.84	94.39	94.12	93.95	93.83
1.49	100.00	99.67	96.00	95.02	94.56	94.28	94.11	93.98
1.50	100.00	100.00	96.20	95.19	94.72	94.44	94.26	94.13
1.51	100.00	100.00	96.39	95.35	94.87	94.59	94.40	94.27
1.52	100.00	100.00	96.57	95.51	95.02	94.73	94.54	94.41
1.53	100.00	100.00	96.76	95.68	95.18	94.88	94.69	94.54
1.54	100.00	100.00	96.94	95.84	95.33	95.02	94.83	94.68
1.55	100.00	100.00	97.13	96.00	95.48	95.17	94.97	94.82
1.56	100.00	100.00	97.30	96.15	95.62	95.30	95.10	94.95
1.57	100.00	100.00	97.47	96.30	95.76	95.44	95.23	95.08
1.58	100.00	100.00	97.63	96.45	95.89	95.57	95.36	95.20
1.59	100.00	100.00	97.80	96.60	96.03	95.71	95.49	95.33
1.60	100.00	100.00	97.97	96.75	96.17	95.84	95.62	95.46
1.61	100.00	100.00	98.12	96.88	96.30	95.96	95.74	95.58
1.62	100.00	100.00	98.27	97.02	96.43	96.08	95.86	95.70
1.63	100.00	100.00	98.42	97.15	96.55	96.21	95.98	95.81
1.64	100.00	100.00	98.57	97.29	96.68	96.33	96.10	95.93
1.65	100.00	100.00	[illegible]	97.42	96.81	96.45	96.22	96.05
1.66	100.00	100.00	98.84	97.54	96.92	96.56	96.33	96.16
1.67	100.00	100.00	98.97	97.66	97.04	96.67	96.44	96.27
1.68	100.00	100.00	99.09	97.78	97.15	96.79	96.54	96.37
1.69	100.00	100.00	[illegible]	97.90	97.27	96.90	96.65	96.48

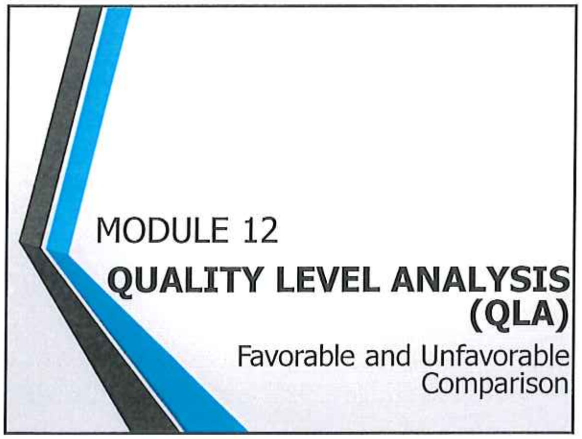
TAB

Module 12

Module 12

Quality Level Analysis (QLA)

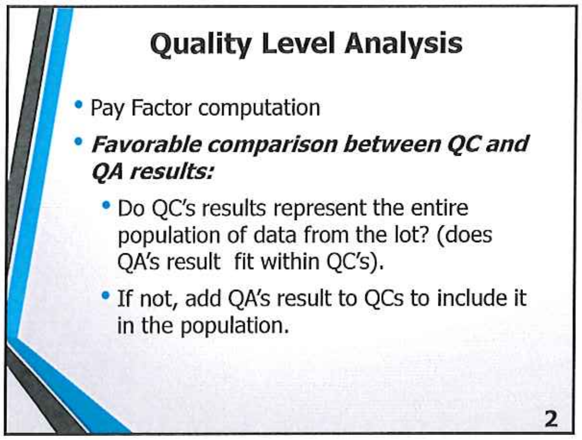
MoDOT



MODULE 12

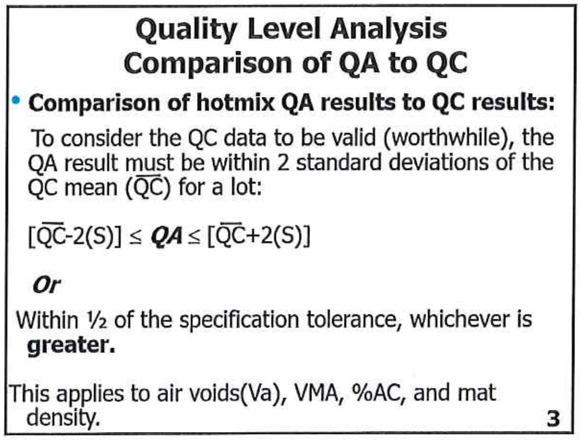
QUALITY LEVEL ANALYSIS (QLA)

Favorable and Unfavorable Comparison



Quality Level Analysis

- Pay Factor computation
- ***Favorable comparison between QC and QA results:***
  - Do QC's results represent the entire population of data from the lot? (does QA's result fit within QC's).
  - If not, add QA's result to QCs to include it in the population.



Quality Level Analysis
Comparison of QA to QC

- **Comparison of hotmix QA results to QC results:**

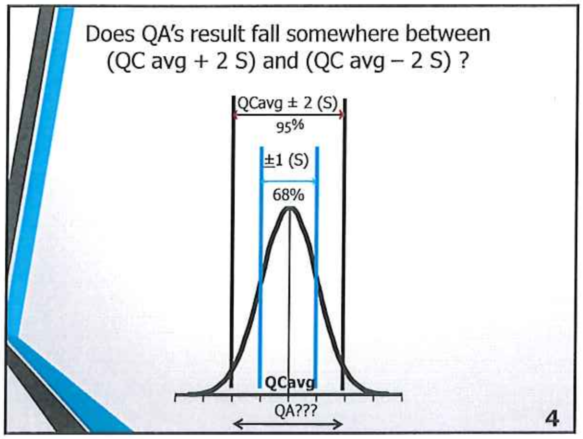
To consider the QC data to be valid (worthwhile), the QA result must be within 2 standard deviations of the QC mean ($\overline{QC}$) for a lot:

$$[\overline{QC}-2(S)] \leq \boldsymbol{QA} \leq [\overline{QC}+2(S)]$$

Or

Within ½ of the specification tolerance, whichever is **greater.**

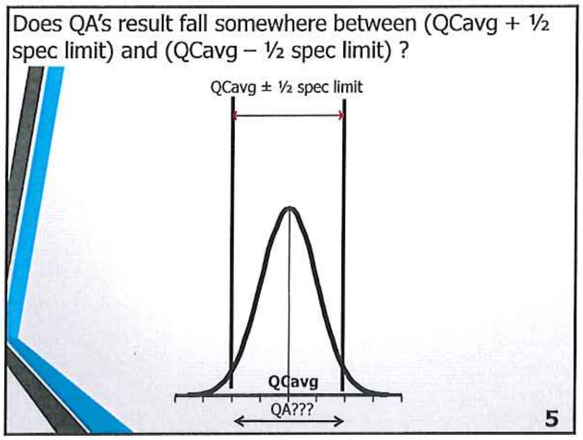
This applies to air voids(Va), VMA, %AC, and mat density.



Does QA's result fall somewhere between (QC avg + 2 S) and (QC avg – 2 S) ?

4

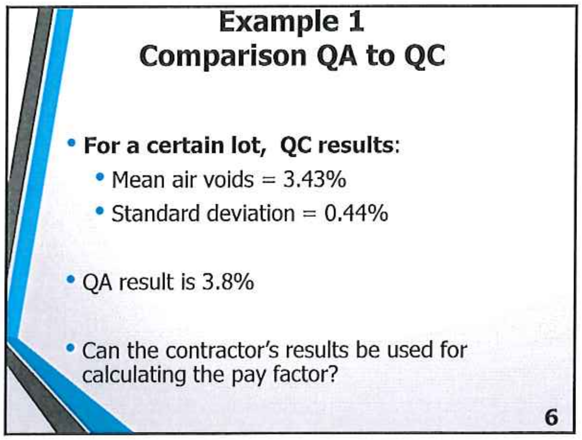
4



Does QA's result fall somewhere between (QCavg + ½ spec limit) and (QCavg – ½ spec limit) ?

5

5



Example 1
Comparison QA to QC

- **For a certain lot, QC results:**
  - Mean air voids = 3.43%
  - Standard deviation = 0.44%
- QA result is 3.8%
- Can the contractor's results be used for calculating the pay factor?

6

6

Comparison QA to QC, cont'd.

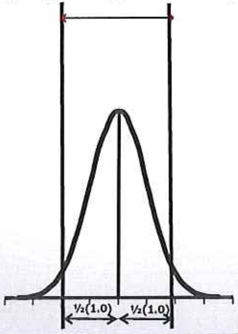
First, should you use **2 (S)** or **½ the spec.** tolerance to establish the acceptable range??

- Allowable range is -1.0% to + 1.0%, so the spec tolerance is 1.0%.
- Half of this is **0.5%.**

On the other hand:

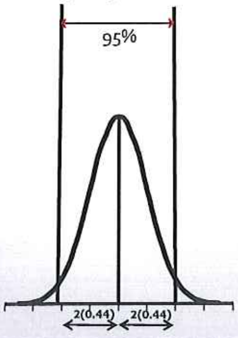
- 2(S) = 2(0.44) = **0.88**

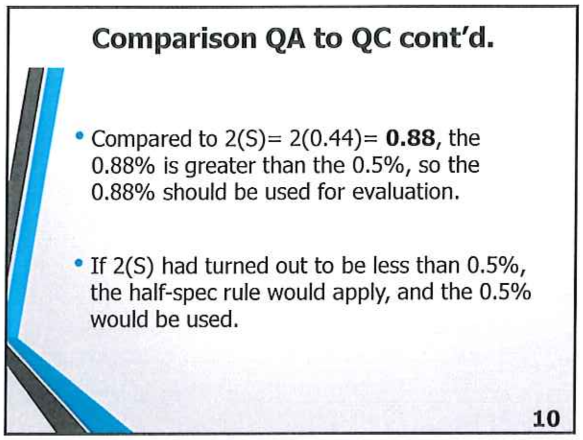
QC avg. ± ½ (spec tolerance)



So, use the 2(S) criteria for establishing the allowable range.

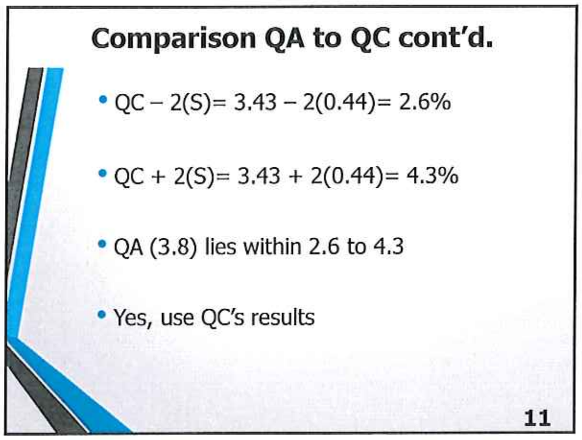
QC avg. ± 2 S





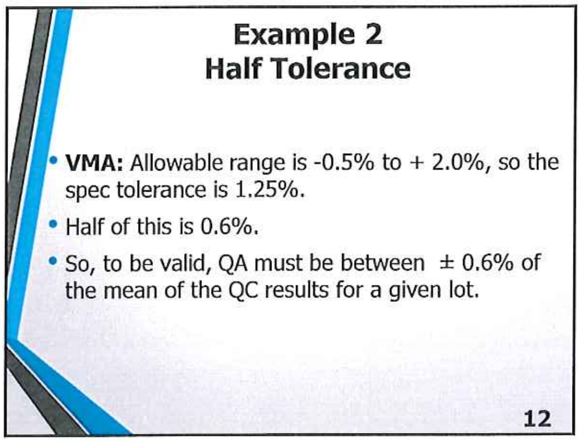
Comparison QA to QC cont'd.

- Compared to 2(S)= 2(0.44)= **0.88**, the 0.88% is greater than the 0.5%, so the 0.88% should be used for evaluation.
- If 2(S) had turned out to be less than 0.5%, the half-spec rule would apply, and the 0.5% would be used.



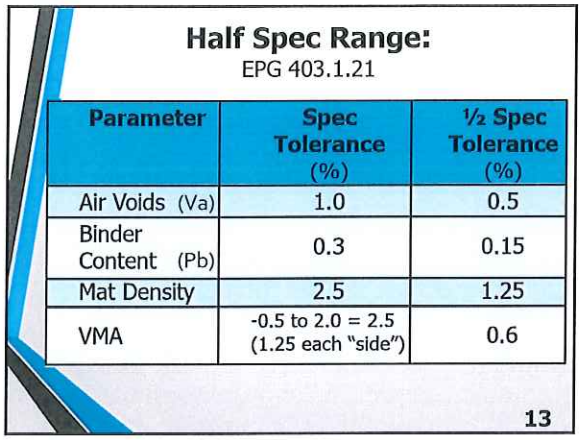
Comparison QA to QC cont'd.

- QC – 2(S)= 3.43 – 2(0.44)= 2.6%
- QC + 2(S)= 3.43 + 2(0.44)= 4.3%
- QA (3.8) lies within 2.6 to 4.3
- Yes, use QC's results



Example 2
Half Tolerance

- **VMA:** Allowable range is -0.5% to + 2.0%, so the spec tolerance is 1.25%.
- Half of this is 0.6%.
- So, to be valid, QA must be between ± 0.6% of the mean of the QC results for a given lot.

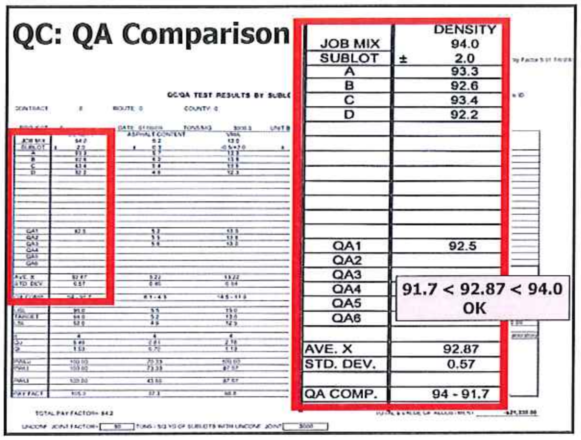


Half Spec Range:

EPG 403.1.21

Parameter	Spec Tolerance (%)	½ Spec Tolerance (%)
Air Voids (Va)	1.0	0.5
Binder Content (Pb)	0.3	0.15
Mat Density	2.5	1.25
VMA	-0.5 to 2.0 = 2.5 (1.25 each "side")	0.6

13

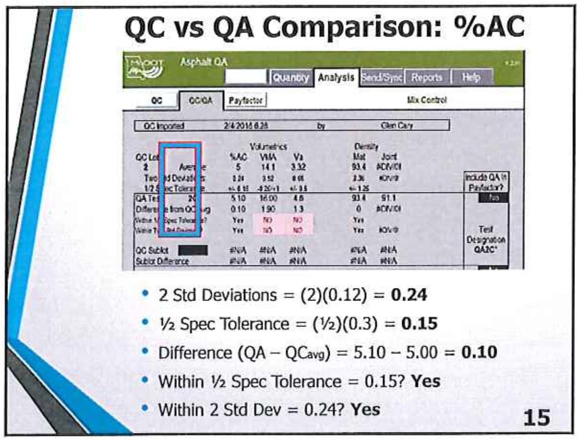


QC: QA Comparison

		DENSITY
JOB MIX		94.0
SUBLOT	±	2.0
A		93.3
B		92.6
C		93.4
D		92.2
QA1		92.5
QA2		
QA3		
QA4		
QA5		
QA6		
AVE. X		92.87
STD. DEV.		0.57
QA COMP.		94 - 91.7

91.7 < 92.87 < 94.0
OK

14

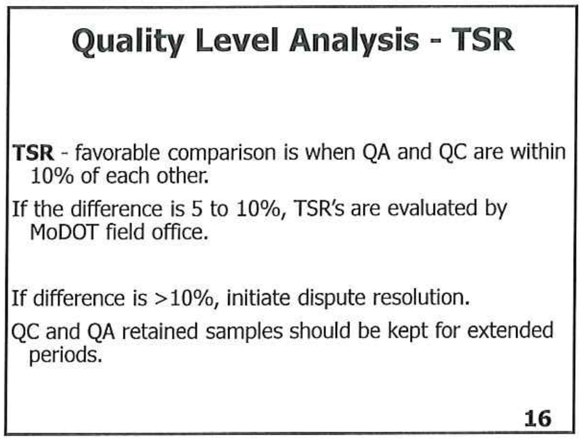


QC vs QA Comparison: %AC

QC Imported 2/4/2016 8:28 by Glen Cary

- 2 Std Deviations = (2)(0.12) = **0.24**
- ½ Spec Tolerance = (½)(0.3) = **0.15**
- Difference (QA – QCavg) = 5.10 – 5.00 = **0.10**
- Within ½ Spec Tolerance = 0.15? **Yes**
- Within 2 Std Dev = 0.24? **Yes**

15



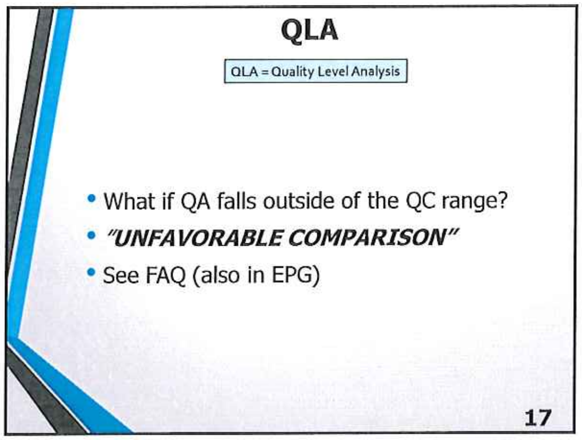
Quality Level Analysis - TSR

TSR - favorable comparison is when QA and QC are within 10% of each other.

If the difference is 5 to 10%, TSR's are evaluated by MoDOT field office.

If difference is >10%, initiate dispute resolution.

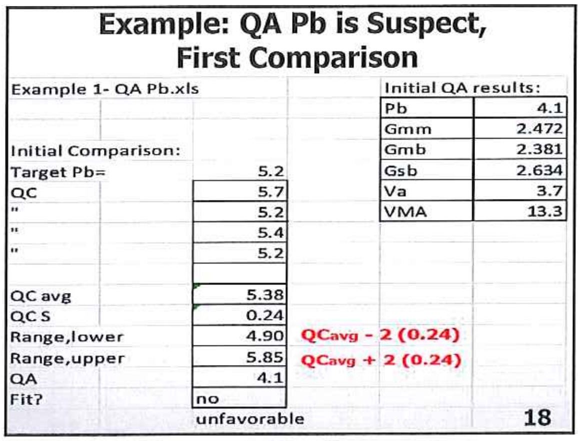
QC and QA retained samples should be kept for extended periods.



QLA

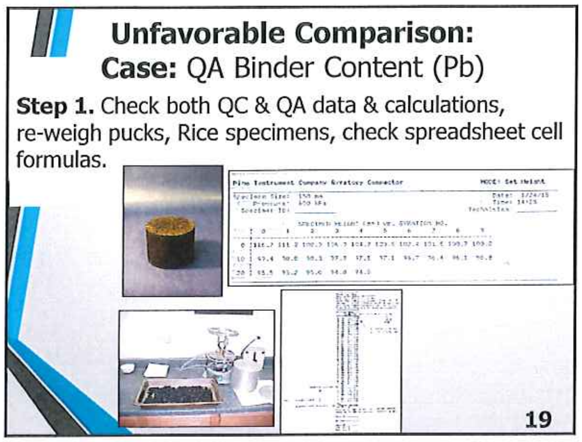
QLA = Quality Level Analysis

- What if QA falls outside of the QC range?
- ***"UNFAVORABLE COMPARISON"***
- See FAQ (also in EPG)



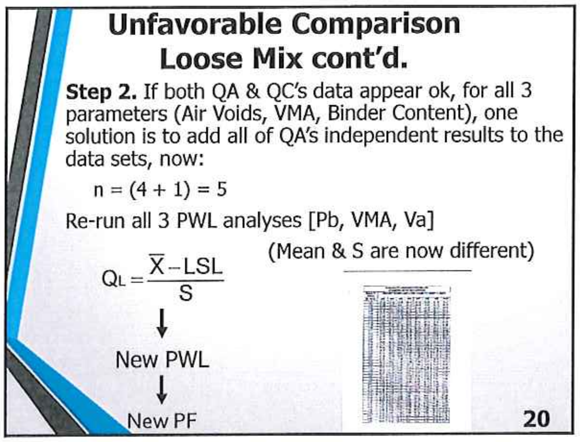
Example: QA Pb is Suspect, First Comparison

Example 1- QA Pb.xls			Initial QA results:	
			Pb	4.1
			Gmm	2.472
Initial Comparison:			Gmb	2.381
Target Pb=	5.2		Gsb	2.634
QC	5.7		Va	3.7
"	5.2		VMA	13.3
"	5.4			
"	5.2			
QC avg	5.38			
QC S	0.24			
Range,lower	4.90	QCavg - 2 (0.24)		
Range,upper	5.85	QCavg + 2 (0.24)		
QA	4.1			
Fit?	no			
	unfavorable			



Unfavorable Comparison: Case: QA Binder Content (Pb)

Step 1. Check both QC & QA data & calculations, re-weigh pucks, Rice specimens, check spreadsheet cell formulas.



Unfavorable Comparison Loose Mix cont'd.

Step 2. If both QA & QC's data appear ok, for all 3 parameters (Air Voids, VMA, Binder Content), one solution is to add all of QA's independent results to the data sets, now:

n = (4 + 1) = 5

Re-run all 3 PWL analyses [Pb, VMA, Va]

(Mean & S are now different)

$$Q_L = \frac{\overline{X} - LSL}{S}$$

$$\downarrow$$

New PWL

$$\downarrow$$

New PF

Add QA P_b, VMA, Air Voids to QC Sets Re-run PWL's with QA included

	Pb5	VMA5	Va5
n	5	5	5
QC	5.7	13.3	3.9
QC	5.2	13.8	3.7
QC	5.4	13.5	3.0
QC	5.2	12.3	3.1
QA	4.1	13.3	3.7
Avg, n=5	5.12	13.24	3.48
S	0.61	0.56	0.40
USL	5.5	15	5
LSL	4.9	12.5	3
Qu	0.63	3.12	3.78
QL	0.36	1.31	1.19
PWLu	71.95	100	100
PWLL	62.73	92.03	88.97
PWLt	34.68	92.03	88.97
PF	19	101	99

So, choose to re-run QA retained split.

Unfavorable Comparison Loose Mix cont'd.

Step 3a. Or could jointly test a retained loose mix sample (QA or QC on suspect sublot):

- Run whole suite of tests (G_{mm}, G_{mb}, P_b)

Unfavorable Comparison Loose Mix cont'd.

- Favorable comparisons between loose mix splits (original vs. retained) is defined as:
  - G_{mm}: within 0.005
  - G_{mb}: within 0.010
  - P_b: within 0.1%
- If this step verifies that all 3 ***original test results are valid***, keep using the original results.

Step 3a:	QA		
	Retained	Original:	Close?
Pb	4.1	4.1	yes
Gmm	2.475	2.472	yes
Gmb	2.388	2.381	yes

Unfavorable Comparison Loose Mix cont'd.

- Add QA's independent results to the 3 data sets (Pb, VMA, Va), now n = (4 + 1) = 5
- Re-run all 3 PWL analyses.

(This is shown in Step 2, previous slide 22)

$$Q_L = \frac{\overline{X} - LSL}{S}$$

Unfavorable Comparison Loose Mix cont'd.

Step 3b. Alternate outcome of Step 3a. If running the retained loose mix split shows the original to be invalid, substitute all results (Pb, Gmm, Gmb) from the retained split. Re-calculate Va and VMA.

Now you have new QA test values for each parameter (air voids, VMA, binder content).

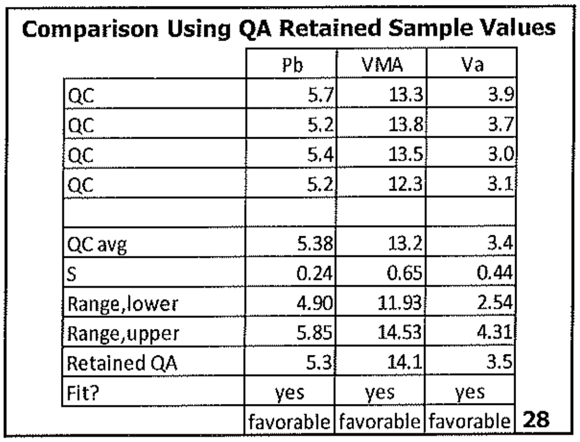
Step 3b: QA's Retained Pb Very Different

Step 3b:	QA		
	Retained	Original:	Close?
Pb	5.3	4.1	no
Gmm	2.475	2.472	yes
Gmb	2.388	2.381	yes
Va	3.5	3.7	
VMA	14.1	13.3	

Unfavorable Comparison, Loose Mix cont'd.

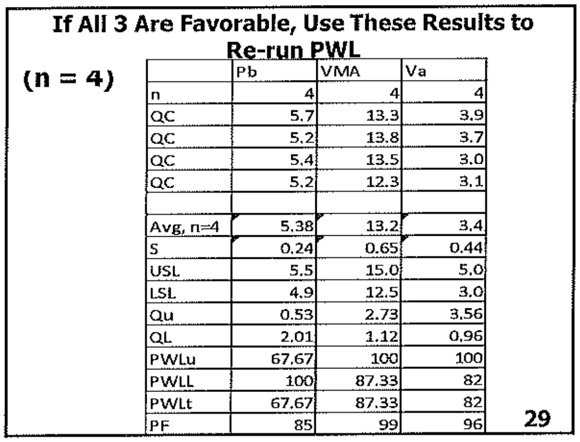
For each parameter (Pb, VMA, Va) , re-run the lot comparison of QA vs QC:

- If all 3 are favorable, use these results to re-run PWL (n = 4).



Comparison Using QA Retained Sample Values

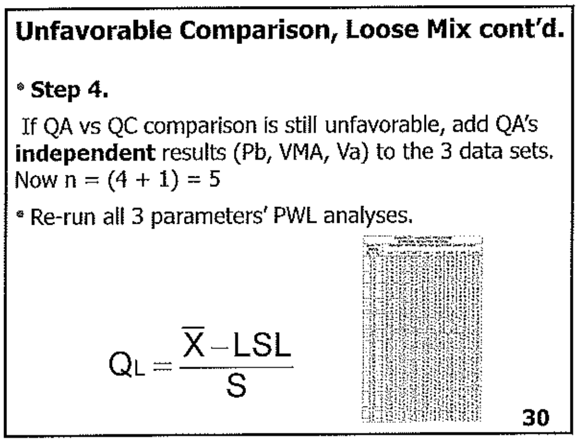
	Pb	VMA	Va
QC	5.7	13.3	3.9
QC	5.2	13.8	3.7
QC	5.4	13.5	3.0
QC	5.2	12.3	3.1
QC avg	5.38	13.2	3.4
S	0.24	0.65	0.44
Range,lower	4.90	11.93	2.54
Range,upper	5.85	14.53	4.31
Retained QA	5.3	14.1	3.5
Fit?	yes	yes	yes
	favorable	favorable	favorable



If All 3 Are Favorable, Use These Results to Re-run PWL

(n = 4)

	Pb	VMA	Va
n	4	4	4
QC	5.7	13.3	3.9
QC	5.2	13.8	3.7
QC	5.4	13.5	3.0
QC	5.2	12.3	3.1
Avg, n=4	5.38	13.2	3.4
S	0.24	0.65	0.44
USL	5.5	15.0	5.0
LSL	4.9	12.5	3.0
Qu	0.53	2.73	3.56
QL	2.01	1.12	0.96
PWLu	67.67	100	100
PWLL	100	87.33	82
PWLt	67.67	87.33	82
PF	85	99	96



Unfavorable Comparison, Loose Mix cont'd.

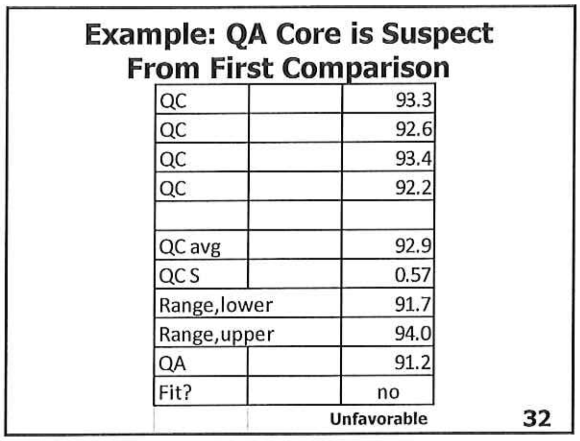
- **Step 4.**

If QA vs QC comparison is still unfavorable, add QA's **independent** results (Pb, VMA, Va) to the 3 data sets. Now n = (4 + 1) = 5

- Re-run all 3 parameters' PWL analyses.

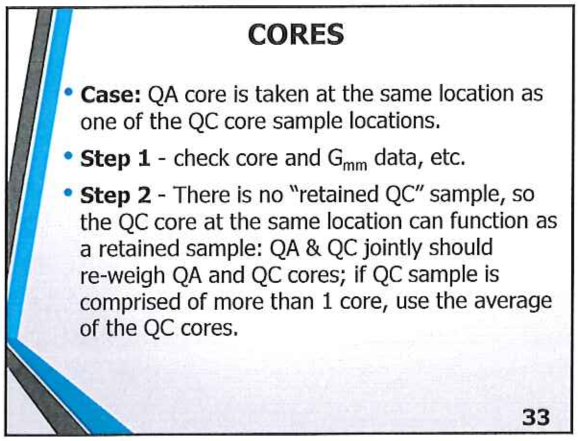
$$Q_L = \frac{\overline{X} - LSL}{S}$$

Unfavorable Core Comparison



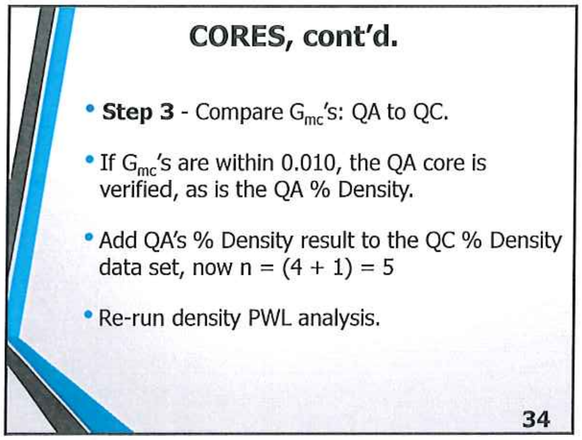
Example: QA Core is Suspect From First Comparison

QC		93.3
QC		92.6
QC		93.4
QC		92.2
QC avg		92.9
QC S		0.57
Range,lower		91.7
Range,upper		94.0
QA		91.2
Fit?		no
		Unfavorable



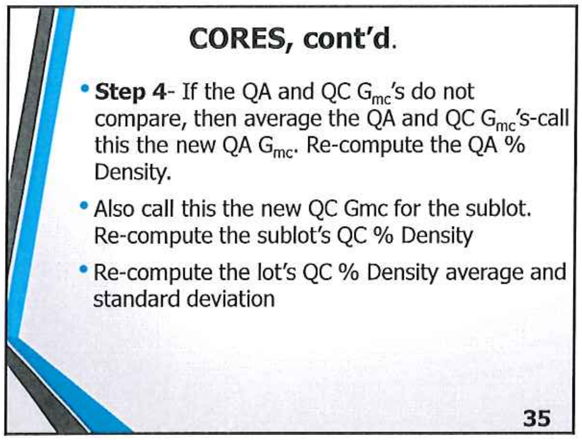
CORES

- **Case:** QA core is taken at the same location as one of the QC core sample locations.
- **Step 1** - check core and G_{mm} data, etc.
- **Step 2** - There is no "retained QC" sample, so the QC core at the same location can function as a retained sample: QA & QC jointly should re-weigh QA and QC cores; if QC sample is comprised of more than 1 core, use the average of the QC cores.



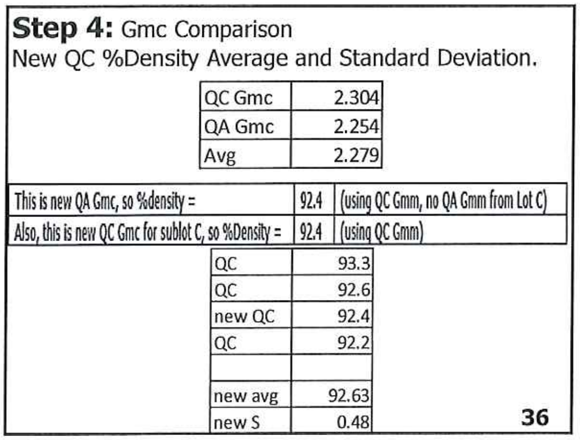
CORES, cont'd.

- **Step 3** - Compare G_{mc}'s: QA to QC.
- If G_{mc}'s are within 0.010, the QA core is verified, as is the QA % Density.
- Add QA's % Density result to the QC % Density data set, now n = (4 + 1) = 5
- Re-run density PWL analysis.



CORES, cont'd.

- **Step 4**- If the QA and QC G_{mc}'s do not compare, then average the QA and QC G_{mc}'s-call this the new QA G_{mc}. Re-compute the QA % Density.
- Also call this the new QC Gmc for the sublot. Re-compute the sublot's QC % Density
- Re-compute the lot's QC % Density average and standard deviation



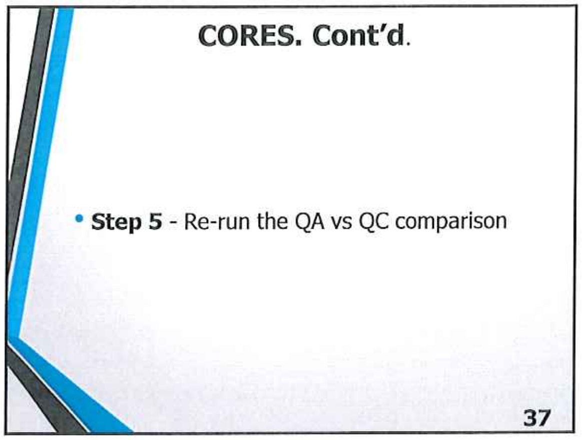
Step 4: Gmc Comparison

New QC %Density Average and Standard Deviation.

QC Gmc	2.304
QA Gmc	2.254
Avg	2.279

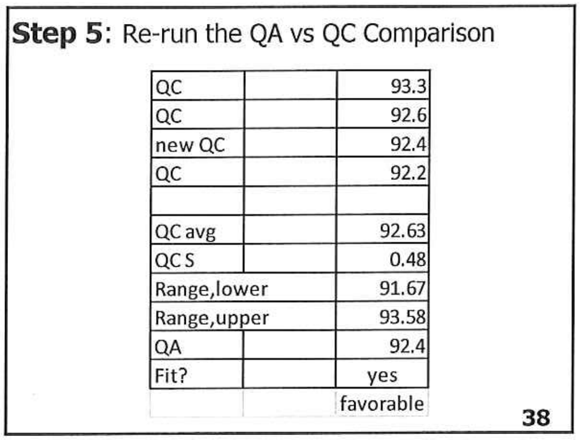
This is new QA Gmc, so %density =	92.4	(using QC Gmm, no QA Gmm from Lot C)
Also, this is new QC Gmc for sublot C, so %Density =	92.4	(using QC Gmm)

QC	93.3
QC	92.6
new QC	92.4
QC	92.2
new avg	92.63
new S	0.48



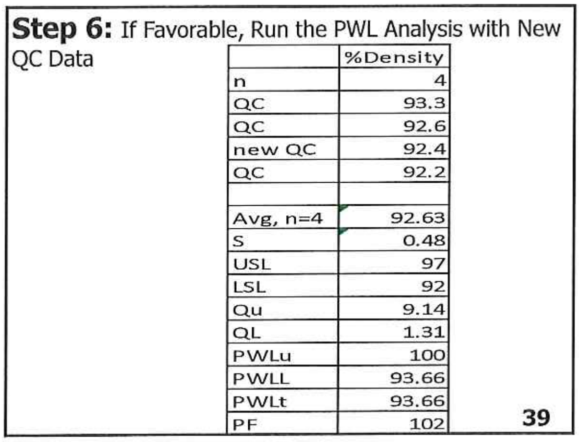
CORES. Cont'd.

- **Step 5** - Re-run the QA vs QC comparison



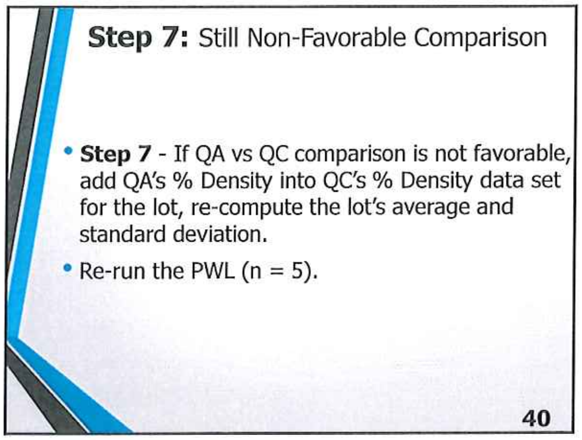
Step 5: Re-run the QA vs QC Comparison

QC		93.3
QC		92.6
new QC		92.4
QC		92.2
QC avg		92.63
QC S		0.48
Range,lower		91.67
Range,upper		93.58
QA		92.4
Fit?		yes
		favorable



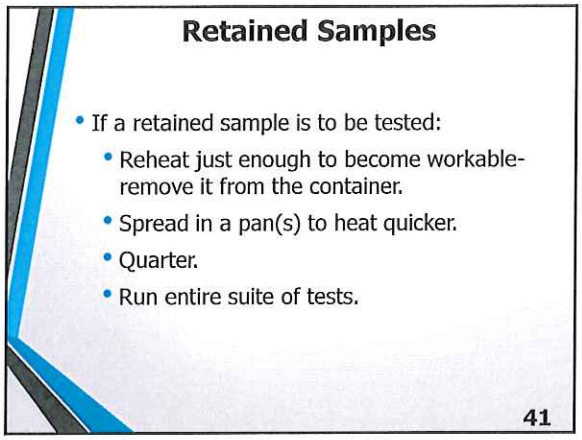
Step 6: If Favorable, Run the PWL Analysis with New QC Data

	%Density
n	4
QC	93.3
QC	92.6
new QC	92.4
QC	92.2
Avg, n=4	92.63
S	0.48
USL	97
LSL	92
Qu	9.14
QL	1.31
PWLu	100
PWLL	93.66
PWLt	93.66
PF	102



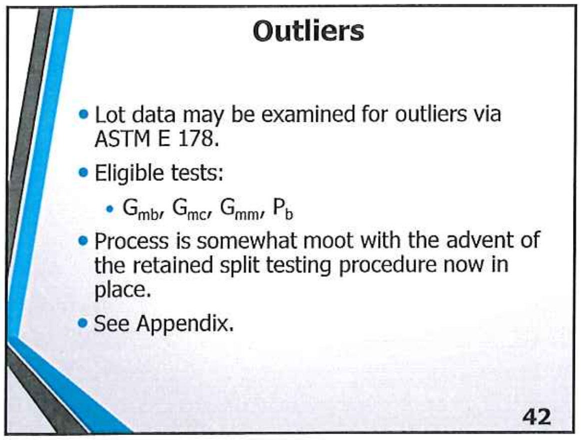
Step 7: Still Non-Favorable Comparison

- **Step 7** - If QA vs QC comparison is not favorable, add QA's % Density into QC's % Density data set for the lot, re-compute the lot's average and standard deviation.
- Re-run the PWL (n = 5).



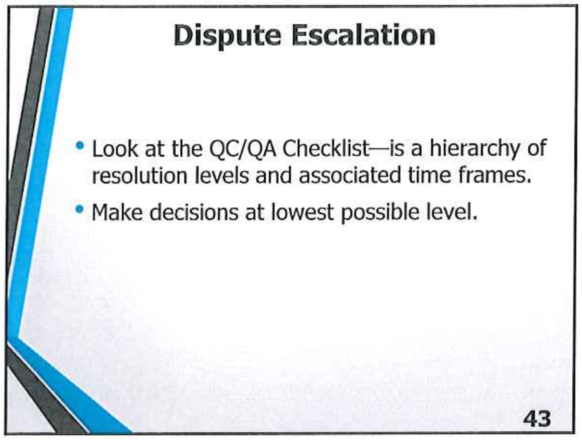
Retained Samples

- If a retained sample is to be tested:
  - Reheat just enough to become workable-remove it from the container.
  - Spread in a pan(s) to heat quicker.
  - Quarter.
  - Run entire suite of tests.



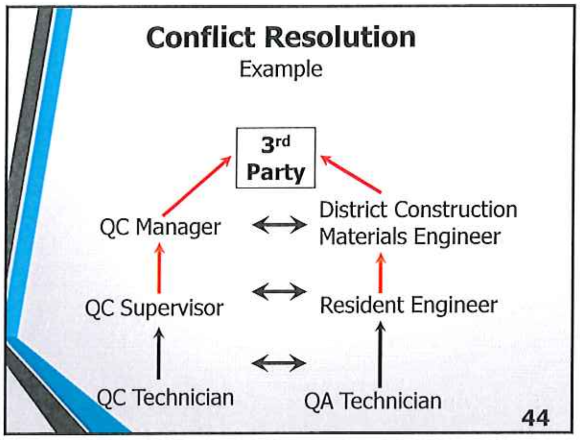
Outliers

- Lot data may be examined for outliers via ASTM E 178.
- Eligible tests:
  - G_{mb}, G_{mc}, G_{mm}, P_b
- Process is somewhat moot with the advent of the retained split testing procedure now in place.
- See Appendix.



Dispute Escalation

- Look at the QC/QA Checklist—is a hierarchy of resolution levels and associated time frames.
- Make decisions at lowest possible level.



Conflict Resolution

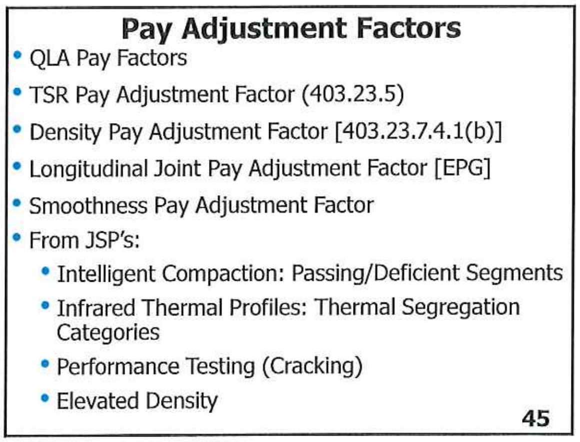
Example

3rd Party

QC Manager ↔ District Construction Materials Engineer

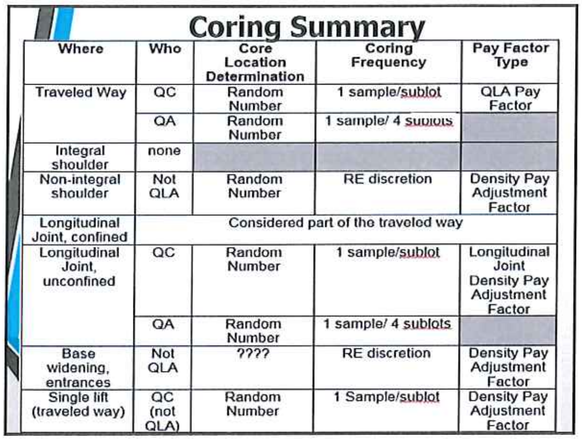
QC Supervisor ↔ Resident Engineer

QC Technician ↔ QA Technician



Pay Adjustment Factors

- QLA Pay Factors
- TSR Pay Adjustment Factor (403.23.5)
- Density Pay Adjustment Factor [403.23.7.4.1(b)]
- Longitudinal Joint Pay Adjustment Factor [EPG]
- Smoothness Pay Adjustment Factor
- From JSP's:
  - Intelligent Compaction: Passing/Deficient Segments
  - Infrared Thermal Profiles: Thermal Segregation Categories
  - Performance Testing (Cracking)
  - Elevated Density

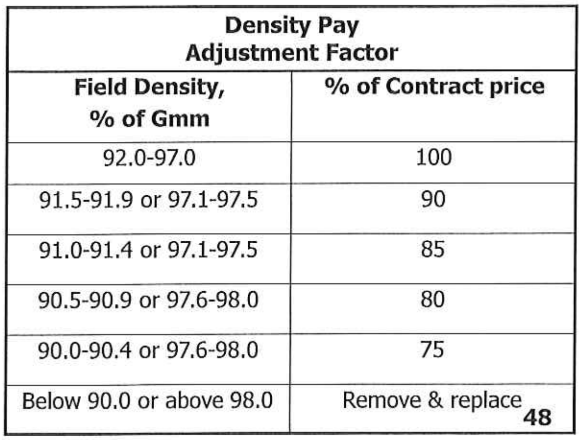


Coring Summary

Where	Who	Core Location Determination	Coring Frequency	Pay Factor Type
Traveled Way	QC	Random Number	1 sample/sublot	QLA Pay Factor
	QA	Random Number	1 sample/ 4 sublots	
Integral shoulder	none			
Non-integral shoulder	Not QLA	Random Number	RE discretion	Density Pay Adjustment Factor
Longitudinal Joint, confined	Considered part of the traveled way			
Longitudinal Joint, unconfined	QC	Random Number	1 sample/sublot	Longitudinal Joint Density Pay Adjustment Factor
	QA	Random Number	1 sample/ 4 sublots	
Base widening, entrances	Not QLA	????	RE discretion	Density Pay Adjustment Factor
Single lift (traveled way)	QC (not QLA)	Random Number	1 Sample/sublot	Density Pay Adjustment Factor

TSR
Pay Adjustment

TSR	% of Contract price
≥90	103
75-89	100
70-74	98
65-69	97
<65	Remove



Density Pay Adjustment Factor	
Field Density, % of Gmm	**% of Contract price**
92.0-97.0	100
91.5-91.9 or 97.1-97.5	90
91.0-91.4 or 97.1-97.5	85
90.5-90.9 or 97.6-98.0	80
90.0-90.4 or 97.6-98.0	75
Below 90.0 or above 98.0	Remove & replace

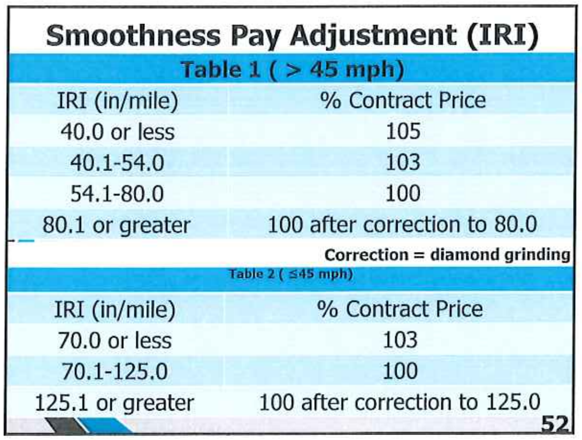
Longitudinal Joint Density Pay Adjustment Factor (PAF)	
Field Density, % of Gmm	**% of Contract Unit Price**
90.0 - 96.0	100
89.5 - 89.9 **or** 96.1 - 96.5	90
89.0 - 89.4 **or** 96.6 - 97.0	85
88.5 - 88.9 **or** 97.1 - 97.5	80
88.0 - 88.4 **or** 97.6 - 98.0	75
Below 88.0 **or** above 98.0	Remove & replace

Non-Integral shoulders & Small Quantities

- Use the Density Pay Adjustment Table
- Use of the factors for non-integral shoulders is at the Resident Engineer's discretion

Confined Longitudinal Joint Density Evaluation

- Density in confined joints is handled with the traveled way coring. Required density is same as for the traveled way (94.5 ± 2.5%).



Smoothness Pay Adjustment (IRI)

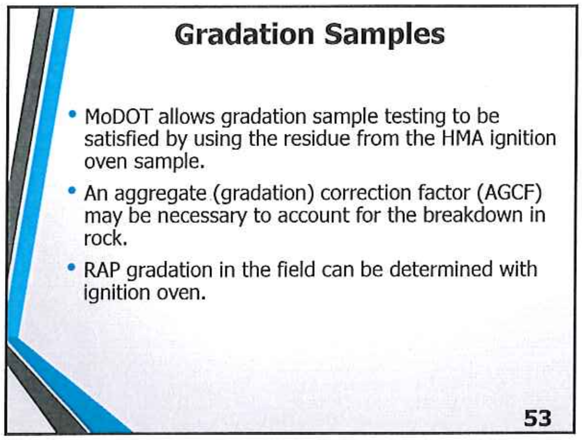
Table 1 (> 45 mph)

IRI (in/mile)	% Contract Price
40.0 or less	105
40.1-54.0	103
54.1-80.0	100
80.1 or greater	100 after correction to 80.0

Correction = diamond grinding

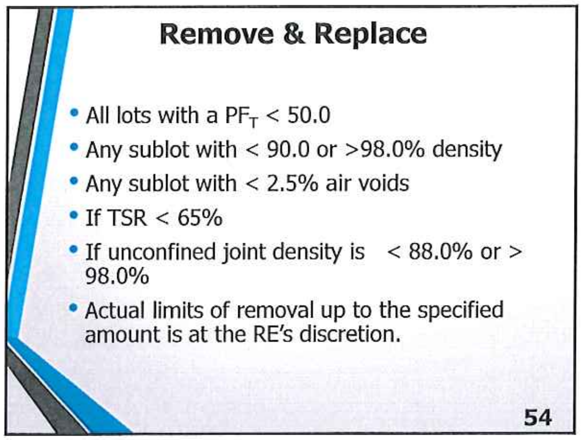
Table 2 (≤45 mph)

IRI (in/mile)	% Contract Price
70.0 or less	103
70.1-125.0	100
125.1 or greater	100 after correction to 125.0



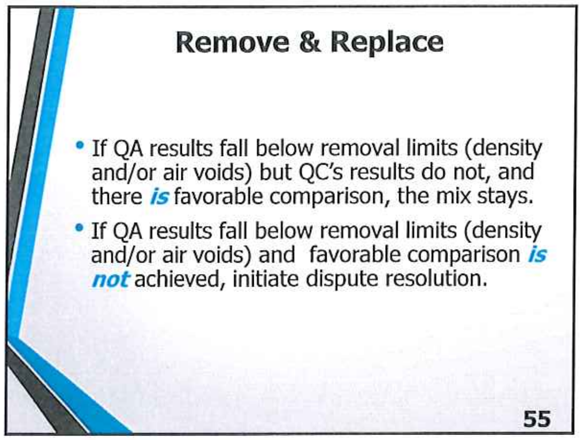
Gradation Samples

- MoDOT allows gradation sample testing to be satisfied by using the residue from the HMA ignition oven sample.
- An aggregate (gradation) correction factor (AGCF) may be necessary to account for the breakdown in rock.
- RAP gradation in the field can be determined with ignition oven.



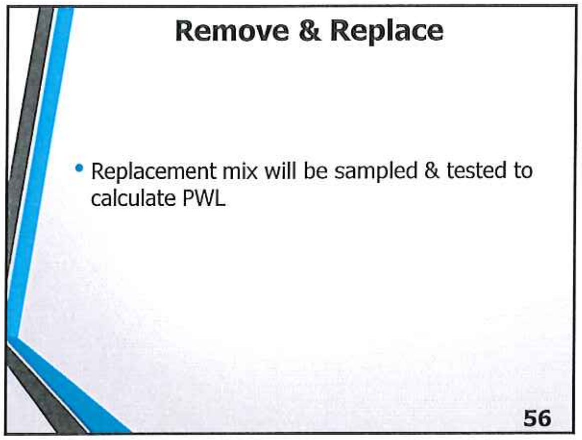
Remove & Replace

- All lots with a $PF_T < 50.0$
- Any sublot with < 90.0 or >98.0% density
- Any sublot with < 2.5% air voids
- If TSR < 65%
- If unconfined joint density is < 88.0% or > 98.0%
- Actual limits of removal up to the specified amount is at the RE's discretion.



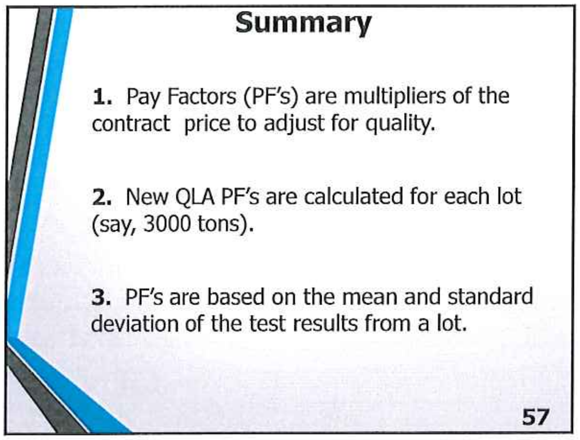
Remove & Replace

- If QA results fall below removal limits (density and/or air voids) but QC's results do not, and there ***is*** favorable comparison, the mix stays.
- If QA results fall below removal limits (density and/or air voids) and favorable comparison ***is not*** achieved, initiate dispute resolution.



Remove & Replace

- Replacement mix will be sampled & tested to calculate PWL

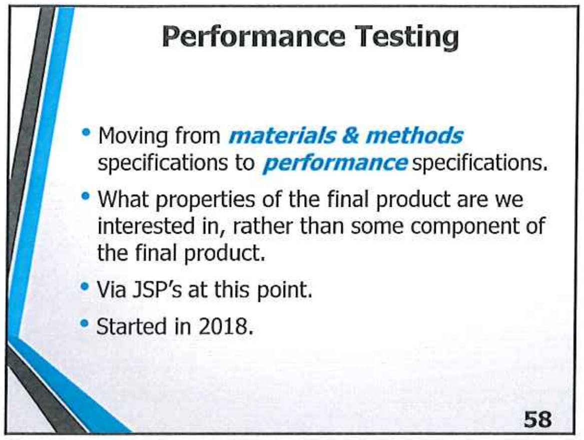


Summary

1. Pay Factors (PF's) are multipliers of the contract price to adjust for quality.

2. New QLA PF's are calculated for each lot (say, 3000 tons).

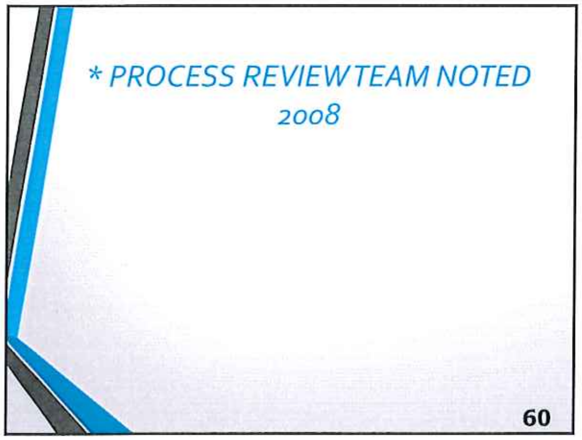
3. PF's are based on the mean and standard deviation of the test results from a lot.



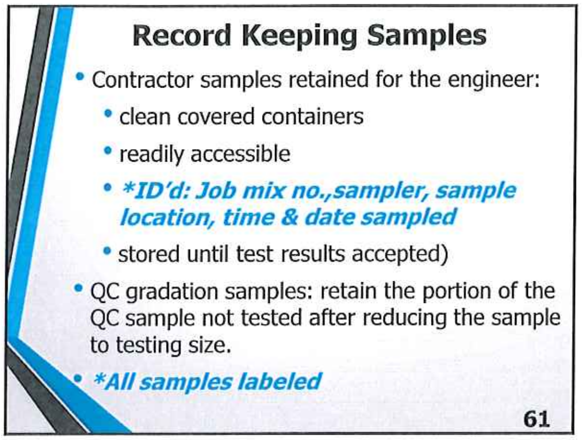
Performance Testing

- Moving from ***materials & methods*** specifications to ***performance*** specifications.
- What properties of the final product are we interested in, rather than some component of the final product.
- Via JSP's at this point.
- Started in 2018.

Record Keeping and Exchange of Data



** PROCESS REVIEW TEAM NOTED 2008*



Record Keeping Samples

- Contractor samples retained for the engineer:
  - clean covered containers
  - readily accessible
  - ****ID'd: Job mix no.,sampler, sample location, time & date sampled***
  - stored until test results accepted)
- QC gradation samples: retain the portion of the QC sample not tested after reducing the sample to testing size.
- ****All samples labeled***

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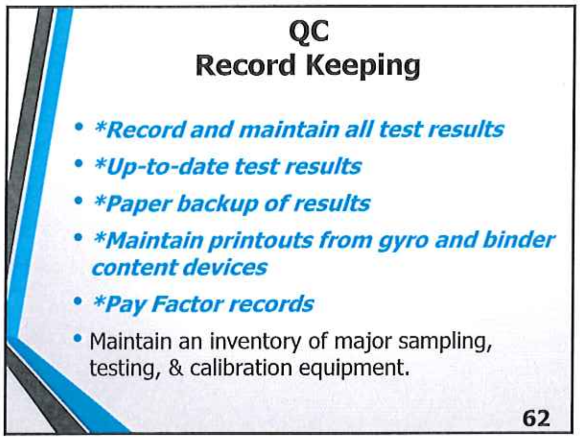
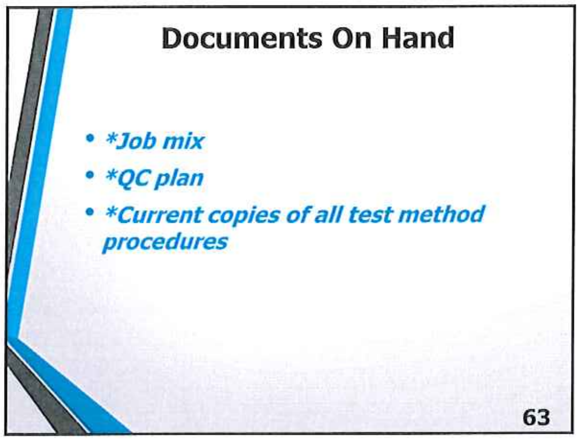


QC
Record Keeping

- ****Record and maintain all test results***
- ****Up-to-date test results***
- ****Paper backup of results***
- ****Maintain printouts from gyro and binder content devices***
- ****Pay Factor records***
- Maintain an inventory of major sampling, testing, & calibration equipment.

62



Documents On Hand

- ****Job mix***
- ****QC plan***
- ****Current copies of all test method procedures***

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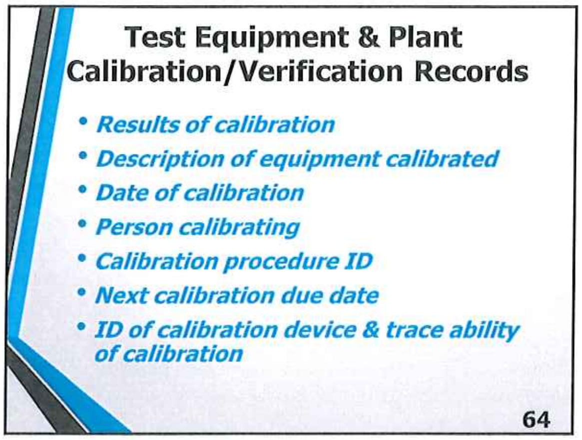

Test Equipment & Plant Calibration/Verification Records

- ***Results of calibration***
- ***Description of equipment calibrated***
- ***Date of calibration***
- ***Person calibrating***
- ***Calibration procedure ID***
- ***Next calibration due date***
- ***ID of calibration device & trace ability of calibration***

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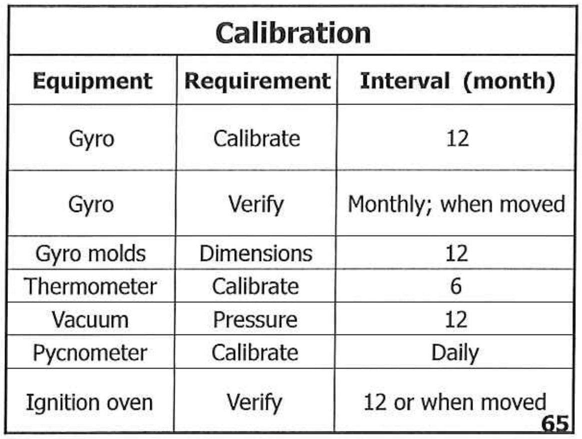
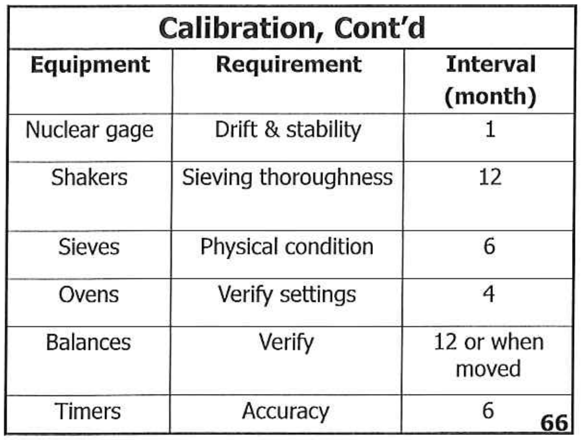


Calibration

Equipment	Requirement	Interval (month)
Gyro	Calibrate	12
Gyro	Verify	Monthly; when moved
Gyro molds	Dimensions	12
Thermometer	Calibrate	6
Vacuum	Pressure	12
Pycnometer	Calibrate	Daily
Ignition oven	Verify	12 or when moved

65



Calibration, Cont'd

Equipment	Requirement	Interval (month)
Nuclear gage	Drift & stability	1
Shakers	Sieving thoroughness	12
Sieves	Physical condition	6
Ovens	Verify settings	4
Balances	Verify	12 or when moved
Timers	Accuracy	6

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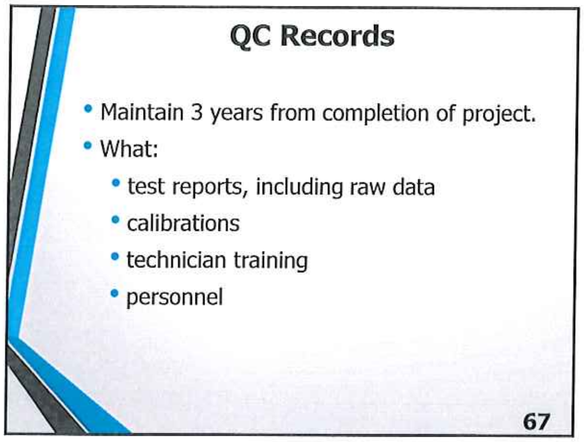
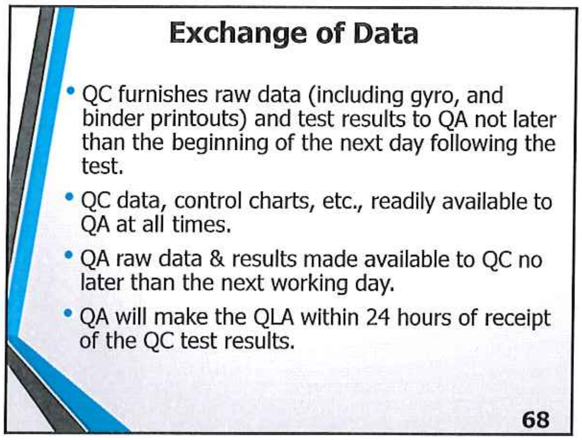


QC Records

- Maintain 3 years from completion of project.
- What:
  - test reports, including raw data
  - calibrations
  - technician training
  - personnel



Exchange of Data

- QC furnishes raw data (including gyro, and binder printouts) and test results to QA not later than the beginning of the next day following the test.
- QC data, control charts, etc., readily available to QA at all times.
- QA raw data & results made available to QC no later than the next working day.
- QA will make the QLA within 24 hours of receipt of the QC test results.

TAB

Module 13

Module 13

Performance Testing

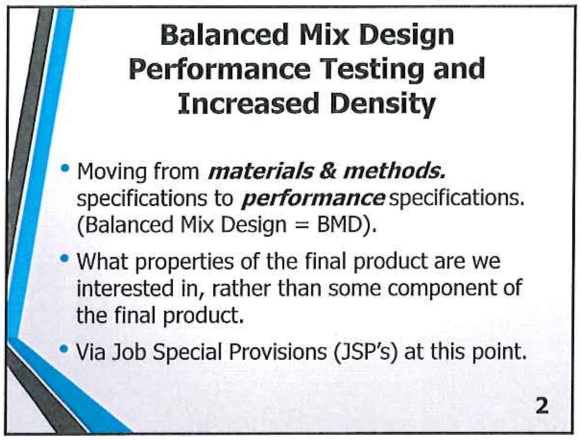
MoDOT

MoDOT SUPERPAVE QC/QA TRAINING/CERTIFICATION COURSE

MODULE 13

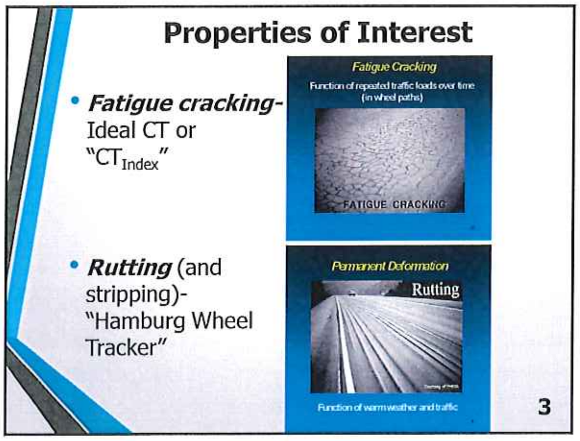
The Future?

Balanced Mix Design
Performance Testing



Balanced Mix Design Performance Testing and Increased Density

- Moving from ***materials & methods.*** specifications to ***performance*** specifications. (Balanced Mix Design = BMD).
- What properties of the final product are we interested in, rather than some component of the final product.
- Via Job Special Provisions (JSP's) at this point.



Properties of Interest

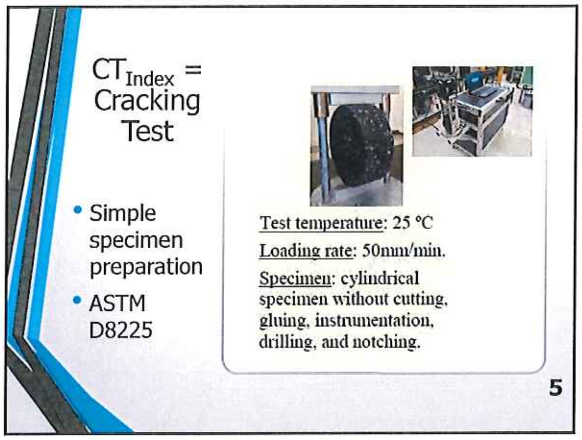
- ***Fatigue cracking***- Ideal CT or "CT_{Index}"
- ***Rutting*** (and stripping)- "Hamburg Wheel Tracker"

Performance Testing

- ***Fatigue Cracking***
- Rutting

Fatigue Cracking

Function of repeated traffic loads over time (in wheel paths)



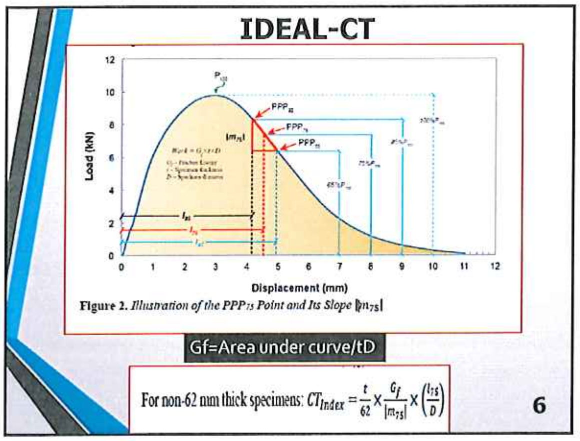
CT_{Index} = Cracking Test

- Simple specimen preparation
- ASTM D8225

Test temperature: 25 °C

Loading rate: 50mm/min.

Specimen: cylindrical specimen without cutting, gluing, instrumentation, drilling, and notching.

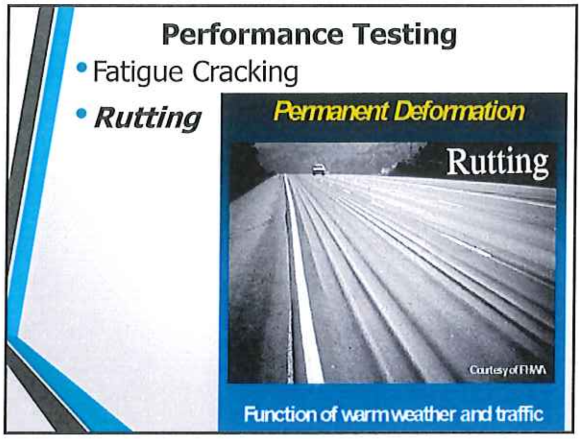


IDEAL-CT

Figure 2. *Illustration of the PPP75 Point and Its Slope* $|m_{75}|$

Gf=Area under curve/tD

For non-62 mm thick specimens: $CT_{Index} = \frac{t}{62} \times \frac{G_f}{|m_{75}|} \times \left(\frac{l_{75}}{D}\right)$



Performance Testing

- Fatigue Cracking
- ***Rutting***

Permanent Deformation

Rutting

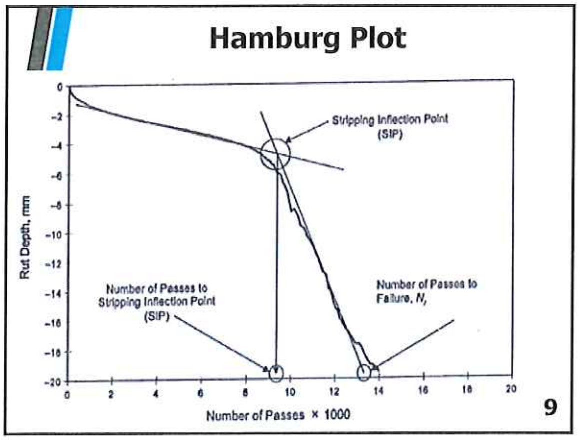
Courtesy of FHWA

Function of warm weather and traffic

Hamburg Wheel Tracker

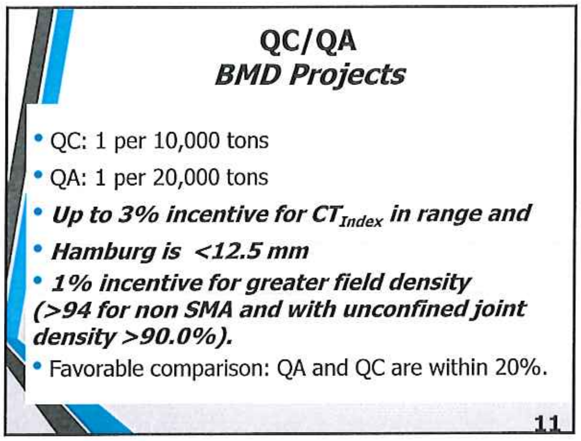
AASHTO T 324

- Capacity to resist rutting (and stripping)
- Warm temperatures
- Under water



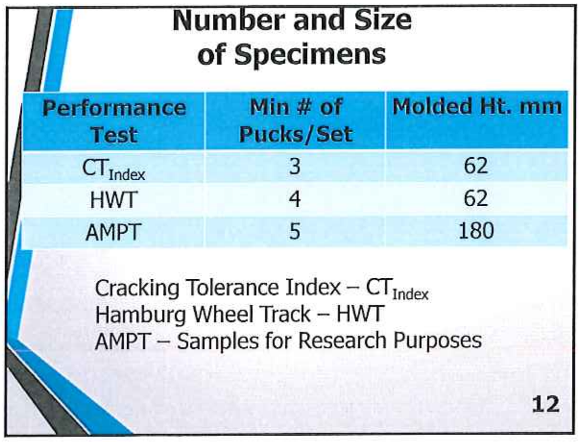
Hamburg Plot

Good Marginal (Barely In-Spec)
Poor (In-Tolerance/Out-of-Spec)



QC/QA
BMD Projects

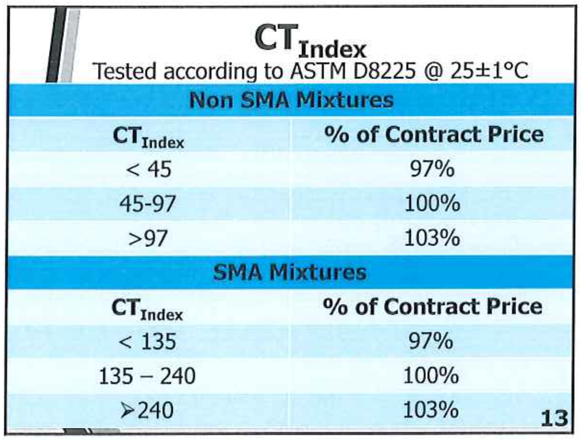
- QC: 1 per 10,000 tons
- QA: 1 per 20,000 tons
- ***Up to 3% incentive for CT_{Index} in range and***
- ***Hamburg is <12.5 mm***
- ***1% incentive for greater field density (>94 for non SMA and with unconfined joint density >90.0%).***
- Favorable comparison: QA and QC are within 20%.



Number and Size of Specimens

Performance Test	Min # of Pucks/Set	Molded Ht. mm
CT_{Index}	3	62
HWT	4	62
AMPT	5	180

Cracking Tolerance Index – CT_{Index}
Hamburg Wheel Track – HWT
AMPT – Samples for Research Purposes



CT_{Index}

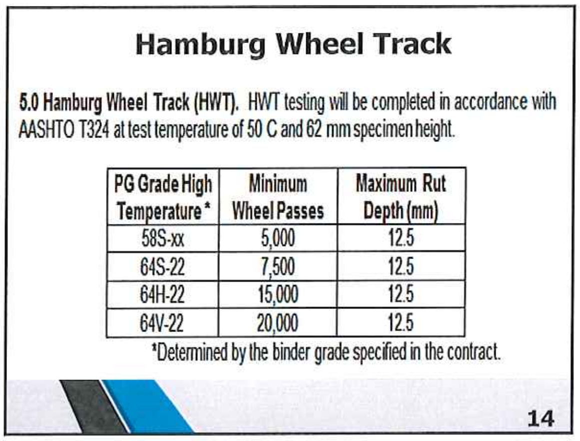
Tested according to ASTM D8225 @ 25±1°C

Non SMA Mixtures

CT_{Index}	% of Contract Price
< 45	97%
45-97	100%
>97	103%

SMA Mixtures

CT_{Index}	% of Contract Price
< 135	97%
135 – 240	100%
➢240	103%

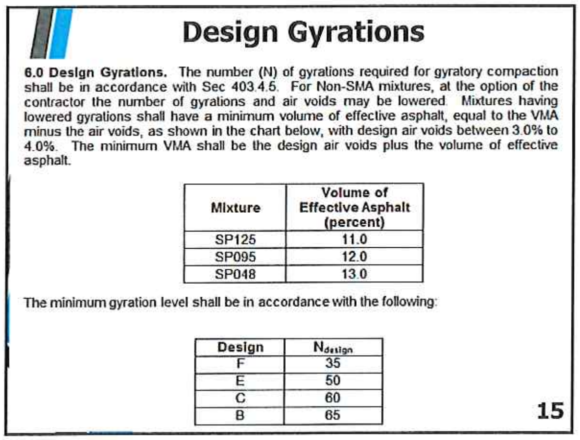


Hamburg Wheel Track

5.0 Hamburg Wheel Track (HWT). HWT testing will be completed in accordance with AASHTO T324 at test temperature of 50 C and 62 mm specimen height.

PG Grade High Temperature*	Minimum Wheel Passes	Maximum Rut Depth (mm)
58S-xx	5,000	12.5
64S-22	7,500	12.5
64H-22	15,000	12.5
64V-22	20,000	12.5

*Determined by the binder grade specified in the contract.



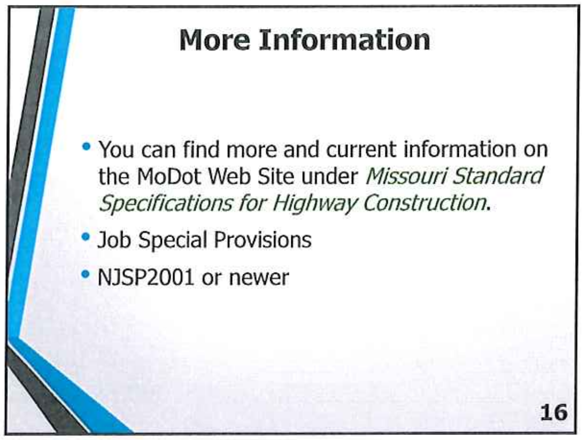
Design Gyrations

6.0 Design Gyrations. The number (N) of gyrations required for gyratory compaction shall be in accordance with Sec 403.4.5. For Non-SMA mixtures, at the option of the contractor the number of gyrations and air voids may be lowered. Mixtures having lowered gyrations shall have a minimum volume of effective asphalt, equal to the VMA minus the air voids, as shown in the chart below, with design air voids between 3.0% to 4.0%. The minimum VMA shall be the design air voids plus the volume of effective asphalt.

Mixture	Volume of Effective Asphalt (percent)
SP125	11.0
SP095	12.0
SP048	13.0

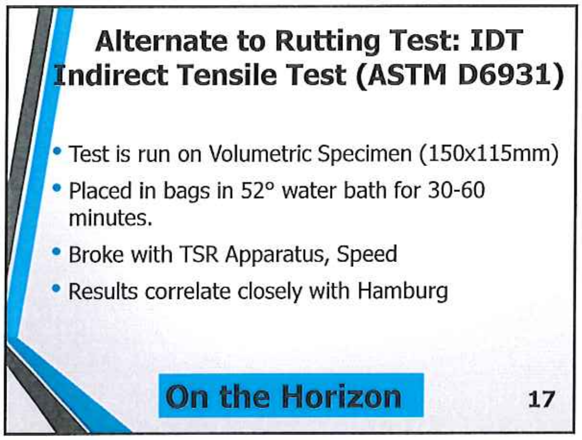
The minimum gyration level shall be in accordance with the following:

Design	N_{design}
F	35
E	50
C	60
B	65



More Information

- You can find more and current information on the MoDot Web Site under *Missouri Standard Specifications for Highway Construction*.
- Job Special Provisions
- NJSP2001 or newer



Alternate to Rutting Test: IDT Indirect Tensile Test (ASTM D6931)

- Test is run on Volumetric Specimen (150x115mm)
- Placed in bags in 52° water bath for 30-60 minutes.
- Broke with TSR Apparatus, Speed
- Results correlate closely with Hamburg

On the Horizon

Balanced Mix Design Performance Testing and Increased Density NJSP-20-01B

1.0 Description. This work shall consist of providing asphalt mixture in accordance with Sec 403 and meet the Balanced Mix Design (BMD) performance requirements of cracking and rutting resistant properties at an increased density level. The BMD performance requirements will be applied to SuperPave mainline wearing surface mixtures. Bituminous binder and base, level course, shoulder, and pavement repair mixtures are excluded from the BMD requirements.

2.0 Performance Testing. Acceptable test results meeting the 100% pay criteria for both Cracking Tolerance Index (CT_{Index}) and Hamburg Wheel Track (HWT) tests shall be submitted with the mix design for approval. The contractor shall conduct Quality Control (QC) testing for CT_{Index} and HWT tests at a frequency of 1/10,000 tons for the mainline pavement. The random testing location will be determined by the engineer.

Incentive/disincentive payment will be calculated based upon the mixture cost for the tonnage represented by each sample, generally 10,000 tons. An incentive of 3% of the asphalt mixture item cost will be paid if the CT_{Index} results are within the incentive range and HWT results are below 12.5 mm. The engineer will conduct performance testing at a frequency of 1/20,000 tons for Quality Assurance (QA). A favorable comparison will be achieved if the results for QA and QC are within 20%.

In addition, a 1% incentive is being offered for sublots with qualifying density results above 94% for non-SMA mixtures and with unconfined joint density of 90.0% or above.

Gyratory compacted samples for the Asphalt Material Performance Tester (AMPT) shall be fabricated at a minimum of once per project or as directed by the engineer and submitted to the MoDOT Central Laboratory for informational purposes only.

3.0 Mix Sampling and Preparation. Laboratory mixed samples for mix design submittal shall be short term conditioned in accordance with AASHTO R30 prior to conducting performance testing. Loose mix samples from the plant shall be taken during production in accordance with AASHTO R 97 and split to the appropriate size in accordance with AASHTO R 47. No conditioning is required on plant mixed samples. Samples shall then be heated to the compaction temperature +/- 3° C prior to compacting necessary samples for QA/QC testing. QA personnel shall be present during the sampling, splitting, and molding process. QC shall fabricate all test specimens. QA will randomly select the specimens to submit to the MoDOT Central Laboratory for performance testing. The following table details the minimum number of specimens required:

Performance Test	Minimum Number of Specimens per Set	Molded Specimen Height (mm)
Cracking Tolerance Index (CT_{Index})	3	62
Hamburg Wheel Track (HWT)	4	62
AMPT Samples for Research Purposes	5	180

When QA testing is to be performed, three sets shall be fabricated for CT_{Index} and HWT performance testing: QC, QA, and an additional set for QA retention.

AMPT samples for BMD research shall be fabricated in accordance with AASHTO PP 99-19, carefully following the exceptions noted herein:

1) Pour the mixture into the center of the mold to minimize air void variation between samples. Pouring material down the sides of the mold will result in lower air voids on that side of the mold.
2) Charge the mold in two equal lifts. After each lift, use the spatula to scrape the walls of the mold, inserting the spatula 8-10 times around the circumference of the mold. Insert the spatula into the center of the mixture 10-12 times in an evenly distributed pattern. Insert the spatula as far as possible into the mixture without damaging aggregates.

3.1 Molding Samples. The specimens shall be compacted to an air void content of 7.0 +/- 0.5% or 6.0 ± 0.5% for SMA mixtures. The gyratory specimen weight for each performance test shall be submitted with the mix design. The compacted test specimens shall be allowed to cool to 25 +/- 3° C prior to determining the air void content.

3.2 Determining Air Voids. The bulk specific gravity of the test specimen will be determined in accordance with AASHTO T166. Specimens shall be air dried for 24 +/- 3 hours before preconditioning the test specimens for CT_{Index} testing. Test specimens shall be preconditioned as specified in the test methods. If a water bath is utilized, it is critical that samples are kept dry.

3.3 Records. Compaction temperature, times in and out of the oven, gyratory specimen weight, and sample identification shall be recorded.

4.0 Cracking Tolerance Index (CT_{Index}) Testing. The CT_{Index} testing shall be completed in accordance with ASTM D8225 and at a test temperature of 25 C +/- 1° C. Incentive/disincentive payment will be calculated based upon the mixture cost for the tonnage represented by each sample, generally 10,000 tons. An incentive of 3% of the asphalt mixture item cost will be paid if the CT_{Index} results are within the incentive range and HWT results are below 12.5 mm.

Non SMA Mixtures	
Cracking Tolerance Index (CT_{Index})	**Percent of Contract Price**
< 45	97%
45 - 97	100%
> 97	103%

SMA Mixtures	
Cracking Tolerance Index (CT_{Index})	**Percent of Contract Price**
< 135	97%
135 - 240	100%
> 240	103%

5.0 Hamburg Wheel Track (HWT). HWT testing will be completed in accordance with AASHTO T324 at test temperature of 50 C and 62 mm specimen height.

PG Grade High Temperature *	Minimum Wheel Passes	Maximum Rut Depth (mm)
58S-xx	5,000	12.5
64S-22	7,500	12.5
64H-22	15,000	12.5
64V-22	20,000	12.5

*Determined by the binder grade specified in the contract.

6.0 Design Gyrations. The number (N) of gyrations required for gyratory compaction shall be in accordance with Sec 403.4.5. For Non-SMA mixtures, at the option of the contractor the number of gyrations and air voids may be lowered. Mixtures having lowered gyrations shall have a minimum volume of effective asphalt, equal to the VMA minus the air voids, as shown in the chart below, with design air voids between 3.0% to 4.0%. The minimum VMA shall be the design air voids plus the volume of effective asphalt.

Mixture	Volume of Effective Asphalt (percent)
SP125	11.0
SP095	12.0
SP048	13.0

The minimum gyration level shall be in accordance with the following:

Design	N_{design}
F	35
E	50
C	60
B	65

7.0 VFA Requirements. Section 403.4.6.3 Voids Filled with Asphalt shall be omitted provided that the HWT requirements described above are satisfied and the CT_{Index} is 45 or greater.

8.0 Sec 403 Revisions.

Delete Section 403.5.2 and replace with the following…

403.5.2 Density. The final, in-place density of the mixture shall be between 92.0 and 97.5 percent of the theoretical maximum specific gravity for all mixtures except SMA. SMA mixtures shall have a minimum density of 94.0 percent of the theoretical maximum specific gravity. The theoretical maximum specific gravity shall be determined from a sample representing the material being tested. Tests shall be taken not later than the day following placement of the mixture. The engineer will randomly determine test locations.

Delete Section 403.23.7.3 and replace with the following…

403.23.7.3 Removal of Material. All lots of material with a PFT less than 50.0 shall be removed and replaced with acceptable material by the contractor. Any sublot of material with a percent of theoretical maximum density of less than 90.0 percent or greater than 98.0 percent shall be removed and replaced with acceptable material by the contractor. For SMA mixtures, any sublot of material with a percent of theoretical maximum density of less than 92.0 percent shall be removed and replaced with acceptable material by the contractor. Any sublot of material with air voids in the compacted specimens less than 2.0 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 at the designated number of wheel passes above. No additional payment will be made for such removal and replacement. The replaced material will be tested at the frequencies listed in Sec 403.19. Pay for the material will be determined in accordance with the applicable portions of Sec 403.23 based on the replacement material.

Delete Section 403.23.7.4.1 and replace with the following…

403.23.7.4.1 Small Quantities. Small quantities are defined in Sec 403.19.3.2.1. Unless the contractor has elected to use the normal evaluation in the Bituminous QC Plan for small quantities, the following shall apply for each separate mixture qualifying as a small quantity

(a) QLA and PWL will not be required.

(b) Mixtures shall be within the specified limits for VMA, V_a, AC and density. In addition to any adjustments in pay due to profile, the contract unit price for the mixture represented by each set of cores will be adjusted based on actual field density above or below the specified density using the following schedule:

Field Density (Percent of Laboratory Max. Theoretical Density)			**Pay Factor (Percent of Contract Unit Price)**
For all SP mixtures other than SMA:			
		92.0 to 97.5 inclusive	100
97.6 to 98.0	or	91.5 to 91.9 inclusive	90
	or	91.0 to 91.4 inclusive	85
	or	90.5 to 90.9 inclusive	80
	or	90.0 to 90.4 inclusive	75
Above 98.0	or	Below 90.0	Remove and Replace
For SMA mixtures:			
		>94.0	100

		93.5 to 93.9 inclusive	90
		93.0 to 93.4 inclusive	85
		92.5 to 92.9 inclusive	80
		92.0 to 92.4 inclusive	75
		Below 92.0	Remove and Replace

9.0 Elevated Density. Sublots with a QC density test result which compares favorably with QA, has a density result of 97% – 94% and have unconfined joint densities of 90% or greater shall receive a 1% incentive based on the bituminous mixture unit price for non-SMA mixtures.

10.0 Basis of Pavement. Payment for compliance with this provision will be made at the contract unit price for Item No. 403-10.56, Asphalt Performance Testing, lump sum.

TAB

Module 14

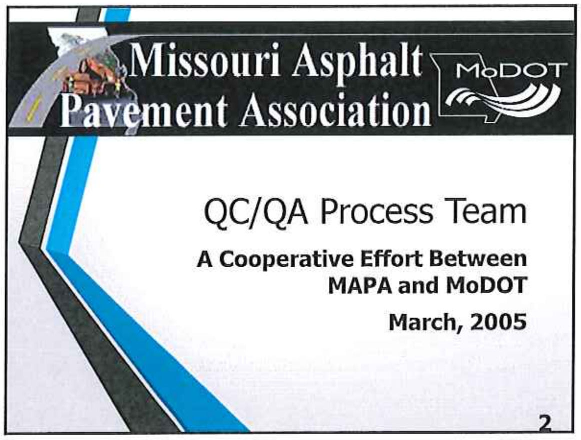
Module 14

Contract Administration

MoDOT

MODULE 14

CONTRACT ADMINISTRATION



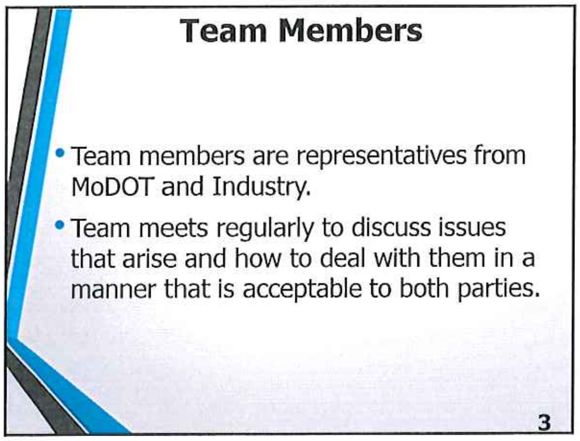
Missouri Asphalt Pavement Association

MoDOT

QC/QA Process Team

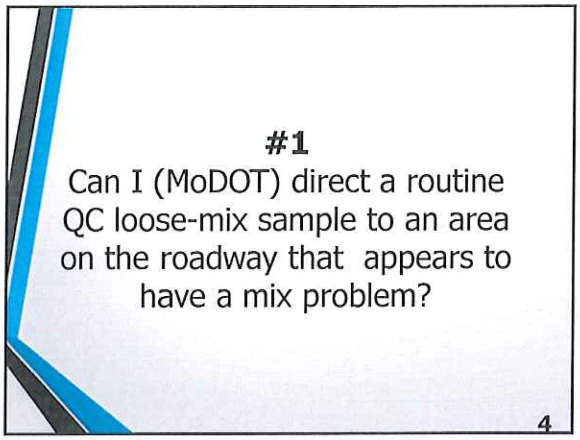
A Cooperative Effort Between MAPA and MoDOT

March, 2005



Team Members

- Team members are representatives from MoDOT and Industry.
- Team meets regularly to discuss issues that arise and how to deal with them in a manner that is acceptable to both parties.



#1

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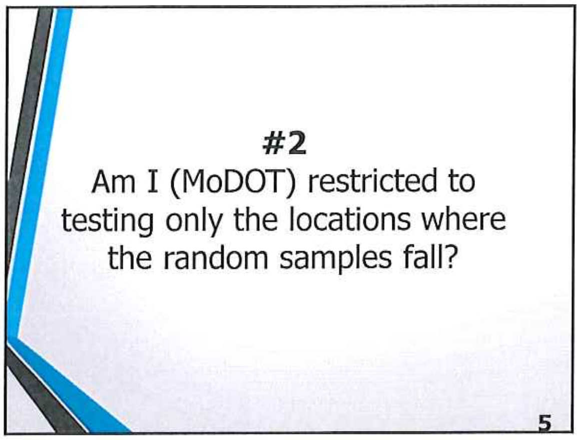

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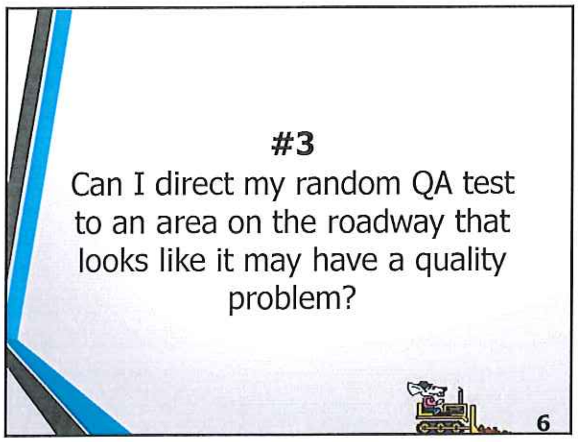
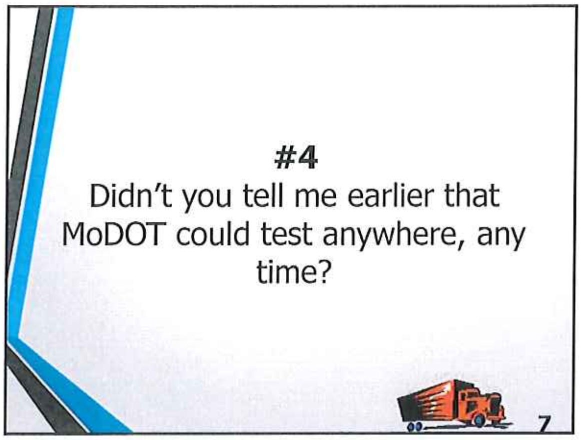


#3

Can I direct my random QA test to an area on the roadway that looks like it may have a quality problem?



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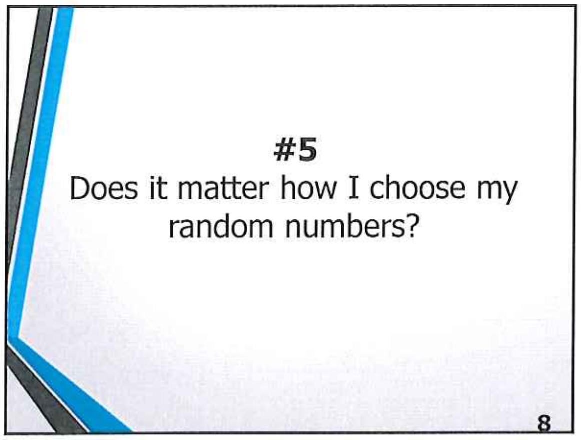
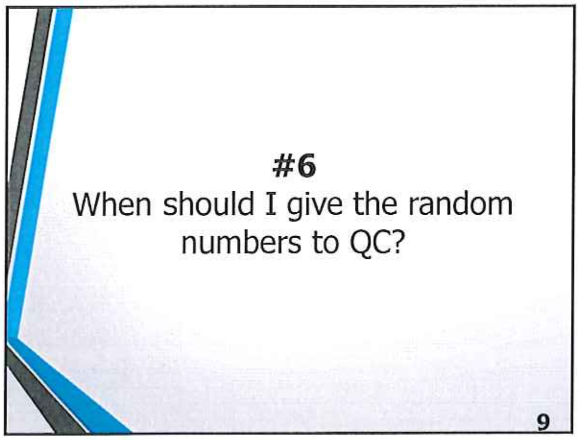


#5

Does it matter how I choose my random numbers?



#6

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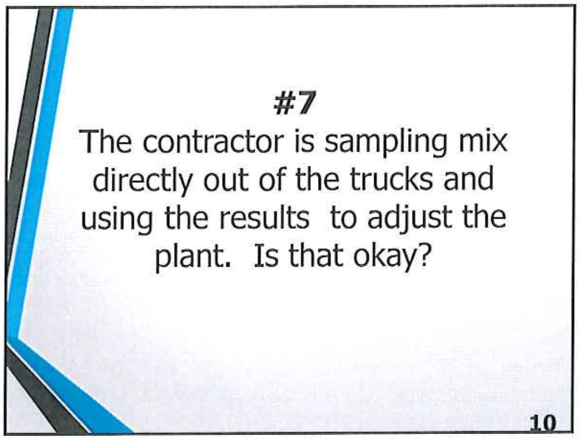

#7

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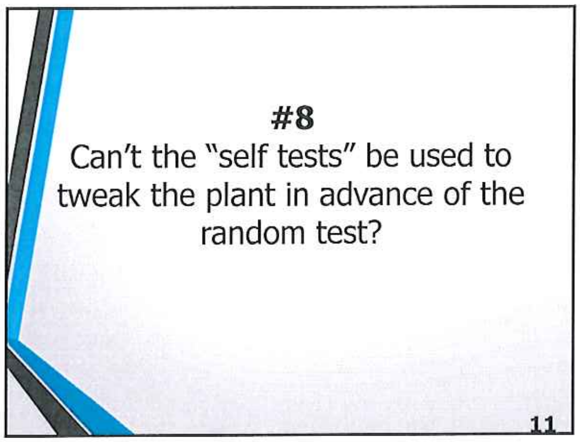

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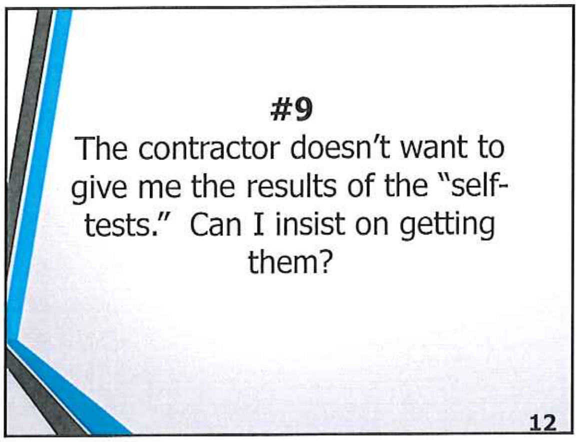
Can't the "self tests" be used to tweak the plant in advance of the random test?



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The contractor doesn't want to give me the results of the "self-tests." Can I insist on getting them?

#10

Can "self-test" results be used to determine removal limits?

#11

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#12

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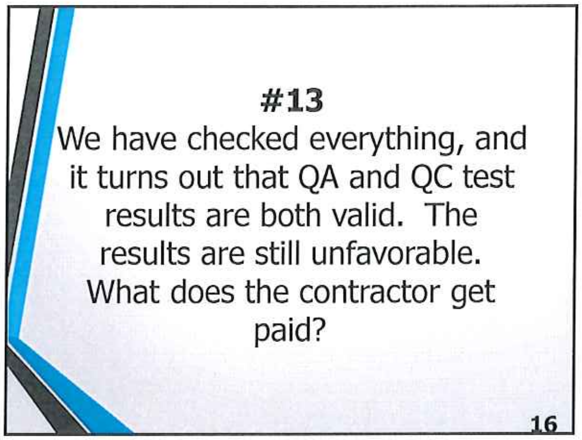
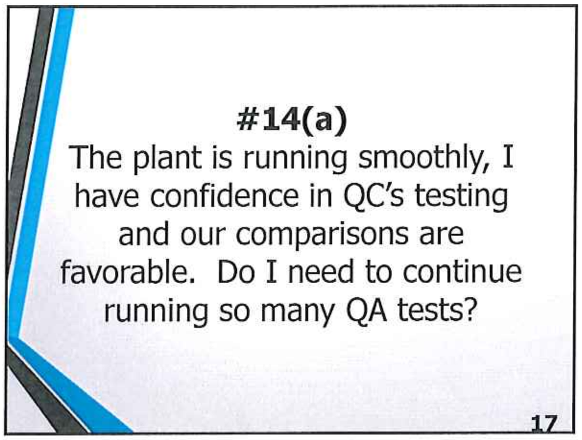


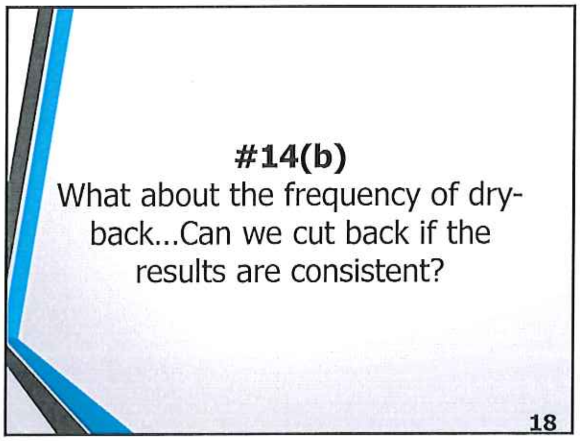
#13

We have checked everything, and it turns out that QA and QC test results are both valid. The results are still unfavorable. What does the contractor get paid?



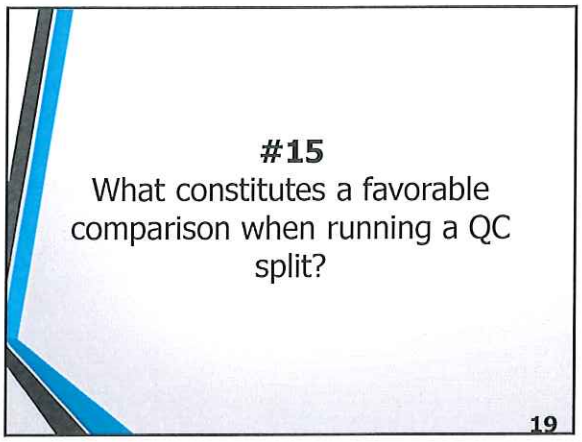
#14(a)

The plant is running smoothly, I have confidence in QC's testing and our comparisons are favorable. Do I need to continue running so many QA tests?



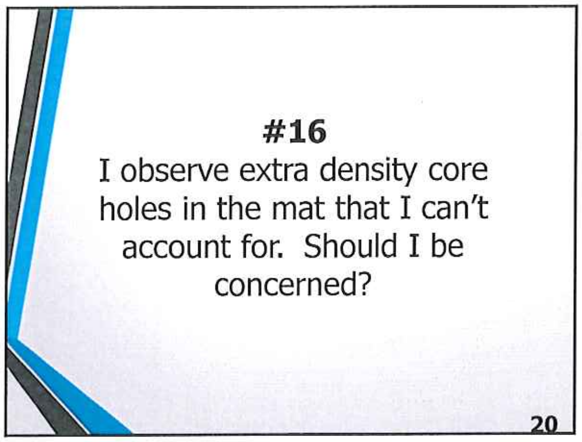
#14(b)

What about the frequency of dry-back…Can we cut back if the results are consistent?



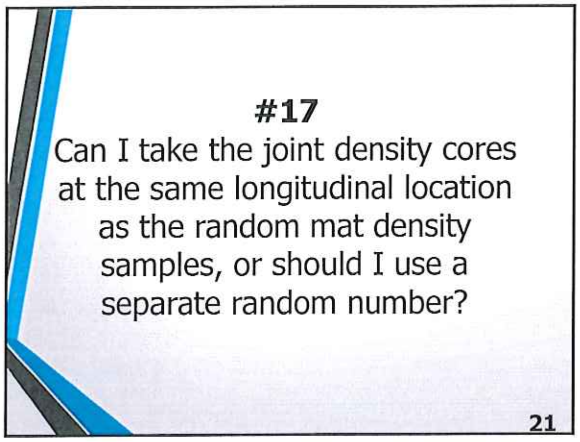
#15

What constitutes a favorable comparison when running a QC split?



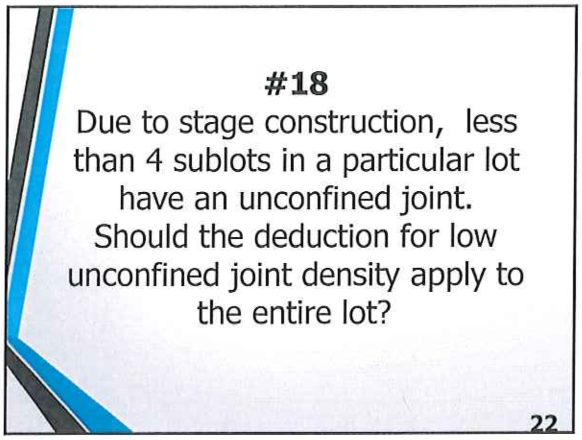
#16

I observe extra density core holes in the mat that I can't account for. Should I be concerned?



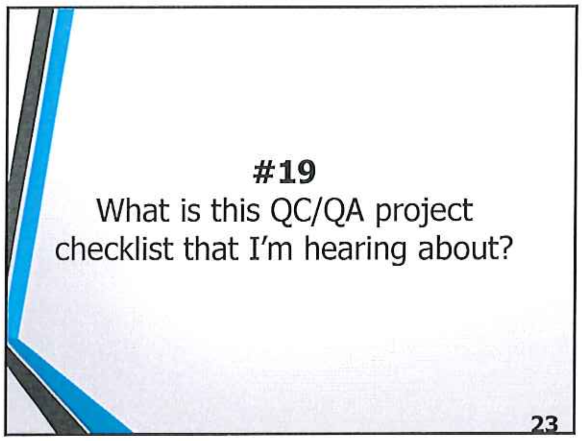
#17

Can I take the joint density cores at the same longitudinal location as the random mat density samples, or should I use a separate random number?



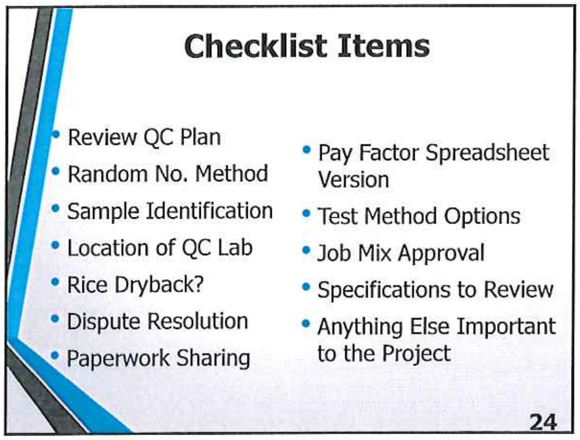
#18

Due to stage construction, less than 4 sublots in a particular lot have an unconfined joint. Should the deduction for low unconfined joint density apply to the entire lot?



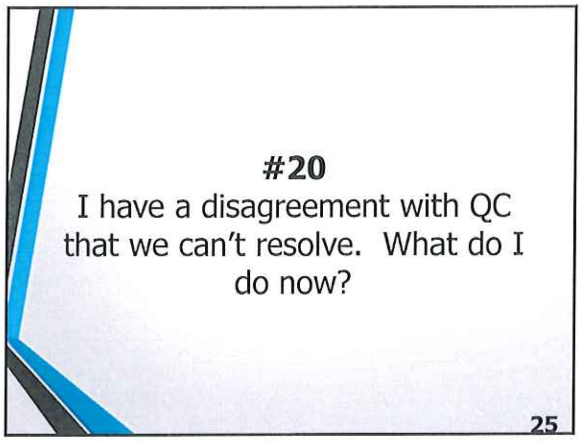
#19

What is this QC/QA project checklist that I'm hearing about?



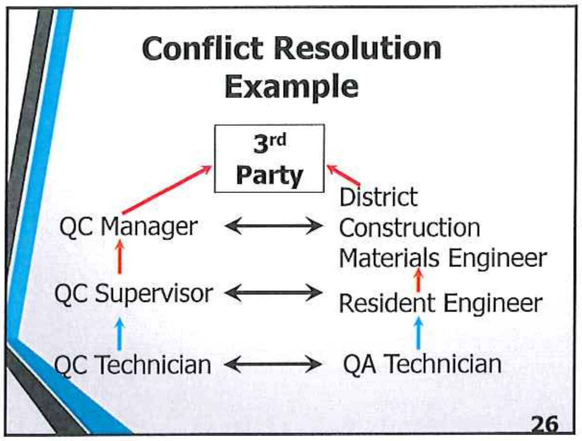
Checklist Items

- Review QC Plan
- Random No. Method
- Sample Identification
- Location of QC Lab
- Rice Dryback?
- Dispute Resolution
- Paperwork Sharing
- Pay Factor Spreadsheet Version
- Test Method Options
- Job Mix Approval
- Specifications to Review
- Anything Else Important to the Project



#20

I have a disagreement with QC that we can't resolve. What do I do now?



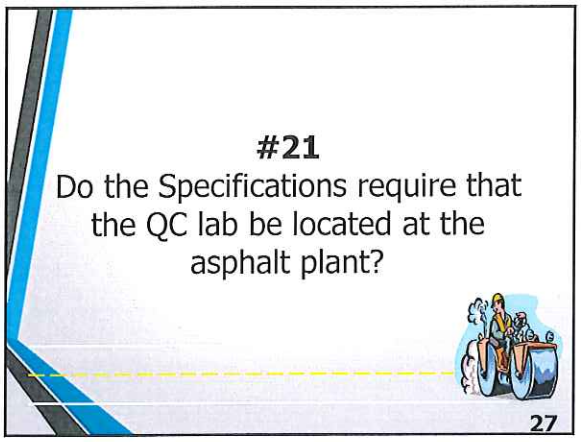
Conflict Resolution Example

3rd Party

QC Manager ⟷ District Construction Materials Engineer

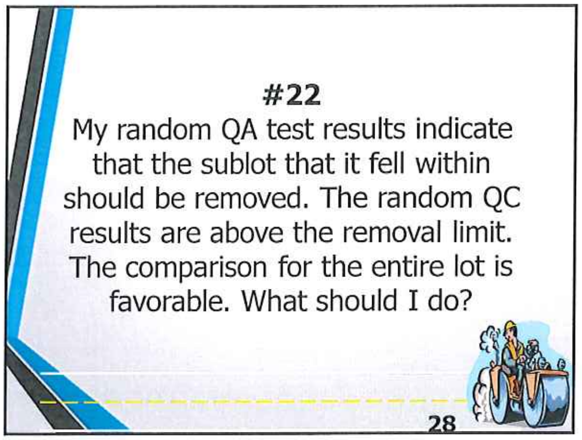
QC Supervisor ⟷ Resident Engineer

QC Technician ⟷ QA Technician



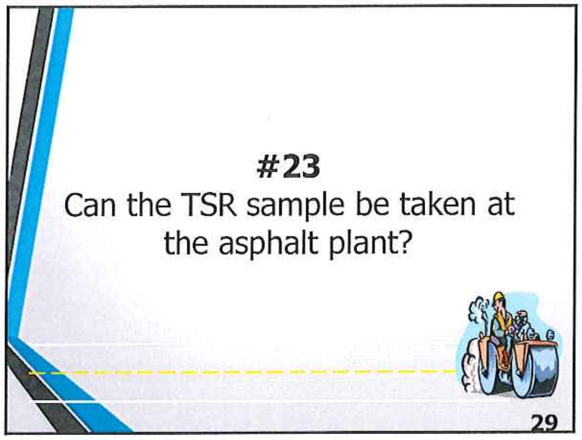
#21

Do the Specifications require that the QC lab be located at the asphalt plant?



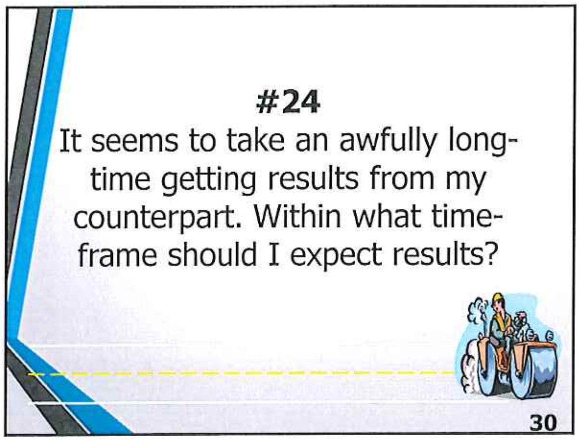
#22

My random QA test results indicate that the sublot that it fell within should be removed. The random QC results are above the removal limit. The comparison for the entire lot is favorable. What should I do?



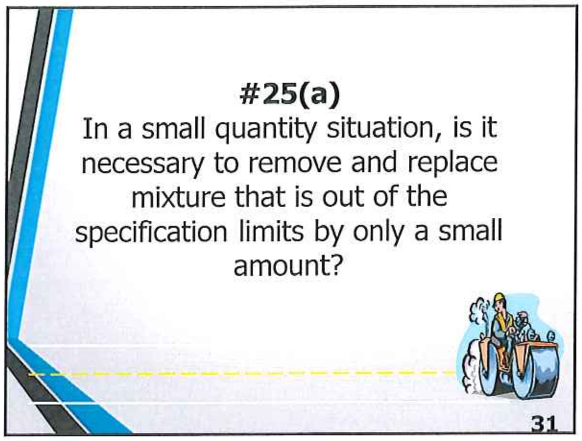
#23

Can the TSR sample be taken at the asphalt plant?



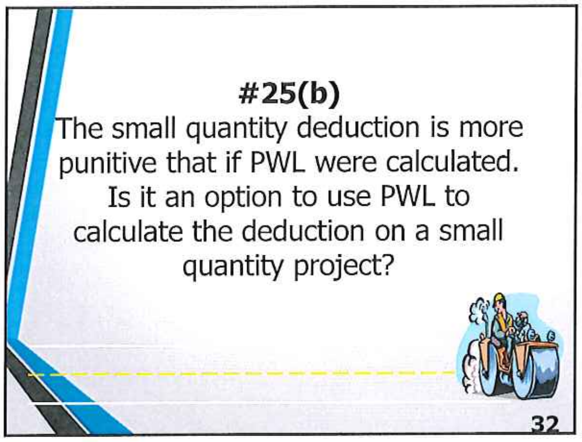
#24

It seems to take an awfully long-time getting results from my counterpart. Within what time-frame should I expect results?



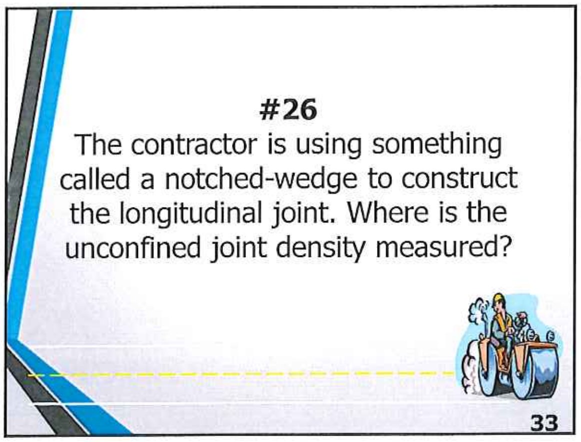
#25(a)

In a small quantity situation, is it necessary to remove and replace mixture that is out of the specification limits by only a small amount?



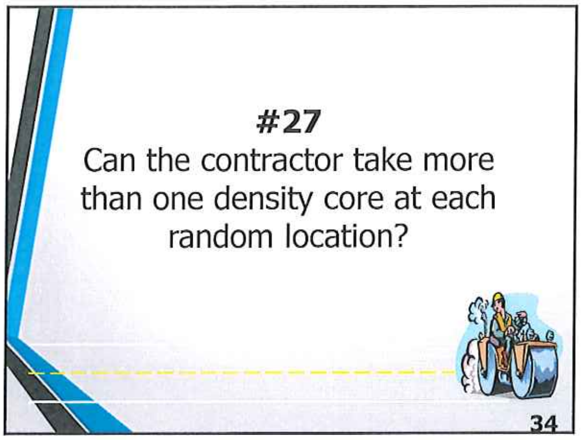
#25(b)

The small quantity deduction is more punitive that if PWL were calculated. Is it an option to use PWL to calculate the deduction on a small quantity project?



#26

The contractor is using something called a notched-wedge to construct the longitudinal joint. Where is the unconfined joint density measured?



#27

Can the contractor take more than one density core at each random location?

SECTION 403 FAQ

(Revised 5-29-18)

INTRODUCTION

This document was developed, and will be maintained, to clarify the intent of the specifications, reduce conflict in the QC/QA environment and improve uniformity of contract administration across the state.

This is not a contract document and cannot be enforced as such. The Resident Engineer always has the latitude to react in an appropriate way to job specific circumstances, but decisions should be consistent with the underlying intent of guiding specifications and policies.

For this discussion, QC refers to the contractor's representative performing Quality Control testing. QA refers to MoDOT's representative performing Quality Assurance testing.

QUESTIONS AND ANSWERS

#1

Can I direct a routine QC loose-mix sample to an area on the roadway that appears to have a mix problem?

It is critical that routine tests, as defined in the contractor's QC plan, be at random locations. It is critical because any manipulation of the random numbers introduces bias. Keep in mind that the QC test results are used to statistically define a population of data. Bias causes inaccuracy in that statistical calculation.

#2

Am I restricted to testing only the locations where the random samples fall?

No. QA can take a sample anywhere, at any time if there is concern about a problem area, but this should be treated as an "extra" sample. These "extra" samples are used to determine if problem areas are acceptable, or to help define limits of a problem.

#3

Can I direct my random QA test to an area on the roadway that looks like it may have a quality problem?

No. The QA random test that will be used for comparison to QC should be taken at a random location unless adjusted for a specific reason. For example, a test should not be taken in the middle of a busy intersection because that would be contrary to public interest. Also, Sec 403.23.7.1.5 allows samples to be separated by a minimum of 200 tons. Remember, bias causes problems with our statistics and is not in the interest of either MoDOT or the contractor.

#4

Didn't you tell me earlier that QA could test anywhere any time?

Yes. The test frequencies listed in the specifications are minimums. QA always has the option to take additional tests. The random QA sample is used for comparison to QC and determines whether QC tests adequately define the characteristics of the entire lot. The "extra" QA test is used only to determine if an isolated area has a problem, or to help define the limits of a problem.

#5

Does it matter how I choose my random numbers?

Generate random numbers by using the Asphalt Random Locations spreadsheet, because that eliminates any question of bias.

QA can locate the sheet on the internal site at the following link:

http://eprojects/Templates/Forms/AllItems.aspx

Sheet Name: Asphalt_Random_Locations

A random number chart is okay, but be sure to choose random number pairs either row by row, or column by column. In other words, don't jump around on the chart, because that can introduce unintentional bias. Random number generators on a calculator are satisfactory as long as the selections aren't intentionally biased.

When using any method other than the spreadsheet to generate random numbers for roadway density cores, the pairs should be recorded once at the beginning of the lot and provided to QC at the completion of the lot. This will assure transparency of the random number selection process. Drawing a number from a hat can be used if no other options are available.

#6

When should I give the random numbers to QC?

This issue has caused a great deal of conflict statewide. To restore confidence in the process, the following procedures will be used:

Random numbers will be generated in advance, by lot, and a printout of those numbers will be sealed in an envelope. At least one lot should be prepared in advance and kept in a secure location. The QA inspector will also keep a copy in his possession. A best practice is to generate all of the random numbers prior to the start of the project. Both QA and QC parties sign and date the seal and then QA delivers the envelopes at the end of each lot. Random numbers will be given to QC between 100 and 150 tons in advance of the test. The intent is to give QC enough time to get any ongoing tests to a stopping point and to get out to the roadway in time. This should not give the plant operator enough time to adjust production and work any resulting change through the silo. When the sampling for a lot is completed, the envelope for that lot will be opened to demonstrate that the random numbers were not manipulated during production.

Random numbers for density cores should also be generated in advance. They can be provided to QC when rolling is complete.

QC and QA need to work together in good faith to make this process run smoothly. Occasionally random tests will fall close together. If QC is at a critical point in a test when the next random number comes up, QA should make an adjustment QA should be aware that this policy creates some real challenges for QC and use appropriate judgment.

Loose mix samples should not be collected from the roadway in handwork areas. Random cores should not be taken in areas where handwork is required due to adjacent obstructions, they should instead be moved 10 feet ahead of the affected area. Extra QA cores may be taken to monitor these areas, but should not be part of the PWL.

As a professional courtesy, QA should give QC a reasonable opportunity to witness random QA roadway sampling.

#7

The contractor is sampling mix directly out of the trucks and using the results to adjust the plant. Is that okay?

Yes, but the samples should be marked as such if they are tested in the field laboratory. The contractor has the option of doing extra testing. These "self-tests" or "truck tests" are used to see how the mix is doing between random tests. Only the random QC tests are used to calculate pay.

#8

Can't the "self tests" be used to tweak the plant in advance of the random test?

Not if the random test locations are given 100 to 150 tons in advance as outlined earlier. There would be no way to complete a test and adjust the plant in time.

#9

The contractor doesn't want to give me the results of the "self-tests." Can I insist on getting them?

There is no reason to demand "self-test" results. If the random testing is being done correctly, the results will accurately define general production characteristics. If there is reason to be concerned about an isolated area, take an extra QA test.

#10

Can "self-test" results be used to determine removal limits?

EPG 403 reads as follows: "*QC self-test results may be used to help define the limits of removal as long as the self-test(s) are well documented*".

A self-test will be considered well documented if the following minimum criteria are met:

1. The puck is available and is clearly labeled
2. The gyratory printout is made available
3. The printout from the AC test is made available

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

#11

There are test specimens in the field laboratory that I can't identify. I can't be there all the time to witness all the testing. How do I know that the correct samples are used to determine payment?

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.

#12

My QA sample does not compare favorably with QC. QC says my testing is in error. Now what do I do?

QA and QC should be given the opportunity to witness each other's sampling and testing. Doing so will head off a lot of conflict.

Copies of all test methods should be readily available in the field laboratory. Testing procedure must follow an approved test method. If either party has an issue with the other's test procedure, 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 testing procedure is taken off the table as a variable.

EPG 403 reads as follows: "*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.*"

#13

We have checked everything and it turns out that QA and QC test results are both valid. The results are still unfavorable. What does the contractor get paid?

EPG 403 reads as follows: "*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 & VA) for that sample will be used, even if only one of the three properties has an unfavorable comparison.

#14

The plant is running smoothly, I have confidence in QC's testing and our comparisons are favorable. Do I need to continue running so many QA tests?

The minimum testing frequencies are shown in section 403.19.3 of the specification. The following table illustrates the differences. The frequency of testing of QC splits can be reduced when QC and QA become confident with each other's sampling and testing procedures, frequencies for evaluating the retained sample are outlined in section 403.18.1.

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

What about the frequency of dry-back. Can we cut back if the results are consistent?

Section 403.19.3.1.2 explains the dry-back requirement

"The dry-back may be reduced to once per 4 sublots if the difference of the Gmm and Dry-back Gmm of the first 4 samples are within 0.002 of each other."

#15

What constitutes a favorable comparison when running a QC split?

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 and testing procedures to identify the cause of the difference.

Isn't that a pretty tight comparison range for Gmb?

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.

#16

I observe extra density core holes in the mat that I can't account for. Should I be concerned?

The roadway inspector should assure that the 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. This needs to be done promptly so that testing of the density cores can proceed without delay. When specific job circumstances make this procedure impractical, the roadway inspector may dry the core with a paper towel and mark the side using a permanent felt-tipped marker, then place and seal the core or cores in a tamper proof bag. The identifying mark should be unique and readily identifiable when the sample arrives at the plant. A signature, along with lot and sublot, is one example of an identifying mark. When marked in this fashion, it is acceptable for the contractor to deliver the QC cores to the lab.

The roadway inspector will select one QC core roadway location per lot to cut a QA core. The QA core should be taken at the same offset as the QC core and within 6 inches longitudinally. The roadway inspector will take possession of the QA core and deliver it directly to the lab. When calculating the Gmb for the QA core, the Gmm will be the same as that used for the corresponding QC Core. The comparison will be favorable when the Gmb of the QA core and the QC core at that same location (or the average of the QC cores if specified in the QC plan) is within 0.010.

If the comparison is not immediately favorable, QC and QA will rerun both cores in each other's presence to check for testing errors. If the comparison is still outside the acceptable limit, the resident engineer will determine if either core is non-representative due to damage, roadway surface irregularities etc. If both cores are representative, an average of QC and QA will be used for that sublot.

#17

Can I take the joint density cores at the same longitudinal location as the random mat density samples or should I use a separate random number?
Either way is acceptable. If QC prefers to take the joint cores at a separate random number it should be indicated in the QC plan.

#18

Due to stage construction, less than 4 sublots in a particular lot have an unconfined joint. Should the deduction for low unconfined joint density apply to the entire lot?
No. The deduction should only apply to those sublots which have an unconfined joint density sample, the spread sheet will assist with this determination.

#19

What is this QC/QA project checklist that I'm hearing about?
A checklist was developed for QC and QA to run through before work begins. It is intended to reduce conflict by working out the day to day details of how to conduct business in advance of the production pressures. A Industry/MoDOT task force developed a checklist but any other that accomplishes the same thing is acceptable.
One of the key elements is to clearly define a conflict escalation procedure. Far too many conflicts lay unresolved for too long. Conflicts that QC and QA cannot resolve between themselves should be promptly escalated.

#20

I have a disagreement with QC that we can't resolve. What do I do now?
The vast majority of issues between QC and QA can be resolved by consulting the QC Plan, the Test Method or the contract documents. If a dispute cannot be resolved within a few hours of taking these initial steps, it should be escalated.
Time frames and escalation levels (including the names of the individuals) should be discussed when going through the checklist. Unresolved issues lead to an atmosphere of mistrust in the QC/QA environment.
Decisions should always be timely and made at the lowest **appropriate** level.

#21

Do the Specifications require that the QC lab be located at the asphalt plant?
No. The contractor is required to provide an appropriately equipped QC laboratory. 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 2 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 a location appropriate to the work under progress. For example, the contractor may elect to place the laboratory at a location between the jobsite and the plant.

#22

My random QA test results indicate that the sublot that it fell within should be removed. The random QC results are above the removal limit. The comparison for the entire lot is favorable. What should I do?

EPG 403 under Removal of Material reads as follows: "*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 whether or not the mix should stay in place.*"

#23

Can the TSR sample be taken at the asphalt plant?

Yes, the test method allows that. Since it is easier to take a larger sample at the plant, the QA sample should be at least 250 pounds. 125 pounds should be sent to the Central Laboratory for testing and the other half kept by the RE as a retained sample. The inspector should write the Mix Number and sample ID on the box. TSR samples need to be taken at random locations but can be taken when it is convenient to production.

#24

It seems to take an awfully long time getting results from my counterpart. Within what time-frame should I expect results?

Sec 403.17.1.1 of the Standard Specifications requires QC to provide all **raw** data to the engineer no later than the beginning of the day following the test. Raw data, of course, is subject to revision.

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

These should be adhered to unless there is a compelling reason to do otherwise. If problems are persistent they should be escalated quickly for resolution. In general, it is a good practice to provide PWL calculations to the contractor for work that is paid for on each estimate.

#25

In a small quantity situation is it necessary to remove and replace mixture that is out of the specification limits by only a small amount?

In Section 403 of the EPG under Removal of the Material the following guidance exists; "The resident engineer should use engineering judgment when mixture placed under this section fails to meet specifications. 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. Mixture that is out of specification by a minor amount may be left in place with no deduction"

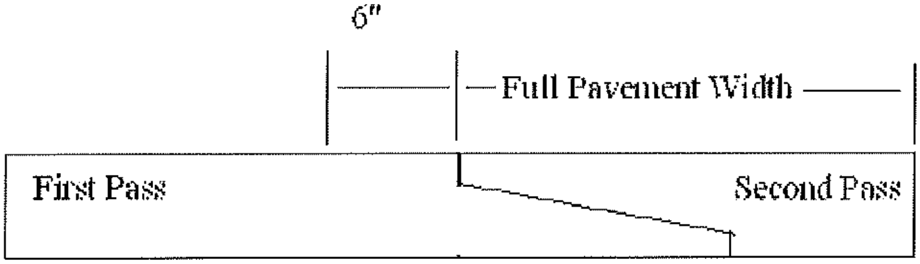
The small quantity deduction is more punitive than if PWL were calculated. Is it an option to use PWL to calculate the deduction on a small quantity project?

Yes, if the contractor has it spelled out in the quality control plan.

26

The contractor is using something called a notched-wedge to construct the longitudinal joint. Where is the unconfined joint density measured?

The notch wedge generally looks like the sketch below:



Unconfined joint density should be measured on the first pass in the 6 inches adjacent to the vertical notch (if the contractor is taking 6 inch density cores the location should be adjusted as necessary to avoid the vertical face of the notch.) On the second pass, the entire width of the lane is fair game for random density testing, including the entire wedge section.

TAB

APPENDIX

Appendix

Items:

1. Outlier Evaluation ASTM E178
2. ASTM E178 Dealing with Outlying Observations
3. Mix Design Overview Binder, Rap, Shingles Module 2C(1)
4. Mix Design Overview Testing and Evaluation Module 2C(2)
5. Ignition Oven Test Cookbook
6. Rice Test (Maximum Specific Gravity) Cookbook

Appendix Item #1.

OUTLIER EVALUATION

ASTM E 178

Applies to test values: G_{mm}, G_{mb}, % binder, core sp. gravity

1. **If the largest test value (x_{max}) in the set is suspected to be an outlier, calculate the t-statistic:**

$$t = \frac{(x_{max}-x_{avg})}{S}$$

Where X_{avg}=average
S = standard deviation

2. **If the smallest test value (x_{min}) in the set is suspected to be an outlier, calculate the t-statistic:**

$$t = \frac{(x_{avg}-x_{min})}{S}$$

3. **Compare the largest *calculated t-statistic* to the *critical t-statistic*. The *critical t-statistic* depends on the desired significance level and the number of test results in the set. MoDOT has set the significance level at 5%. If the evaluation is of an outlier either being too high, or too low, the following is a table of t-critical values. Typically, there are 4 sublots per lot, with one test per sublot:**

No. of tests	t @ 5% in tail
3	1.153
4	1.463
5	1.672
6	1.822
7	1.938
8	2.032
9	2.110
10	2.176

If the *calculated t-statistic* is greater than $t_{critical\,(\alpha=5\%)}$, consider the test result to be an outlier. Material from the retained QA or QC sample may be tested to determine a replacement value.

QCQA/OutlierEvalE178.doc (12-18-02; revised 9-23-03; revised 3-2-09; 4-24-09))

Appendix Item #2.

ASTM E-178 Dealing with Outlying Observations

Example

G_{mm} – 2.474, 2.478, 2.484, 2.522

$\bar{x} = 2.490$

$s = 0.022$

$$T_n = \frac{(x_n - \bar{x})}{s} = \frac{(\overset{\text{max}}{2.522} - 2.490)}{0.022} = 1.455 \quad < 1.463$$

$$T_1 = \frac{(\bar{x} - x_1)}{s} = \frac{(2.490 - \overset{\text{min}}{2.474})}{0.022} = 0.727 \quad < 1.463$$

From Table 1, 5% Significance at 4 observations the limit is 1.463. Therefore, there are no outlying data.

For specific gravity determinations, standard deviation (s) should be to the thousandth place, 0.XXX.

For asphalt content determinations, standard deviation (s) should be to the hundredth place, 0.XX.

MoDOT SUPERPAVE QC/QA
TRAINING/CERTIFICATION
COURSE

MODULE 2C(1)

MIX DESIGN OVERVIEW:

Binder
RAP & Shingles

11-24-06 Revision
11-9-07 Revision, 4-22-09 Revision
11-18-09 Revision, 12-29-09 Revision
11-17-10 Revision, 1-19-11 Revision
3-2-12 Revision, 2-26-13 Revision
12-18-13 Revision, 12-29-14 Revision
2-4-15 Revision, 12-28-16 Revision
2-16-18 Revision, 12-12-18 Revision
12-17-19 Revision, 1-30-20 Revision
1-20-21 Revision

OUTLINE

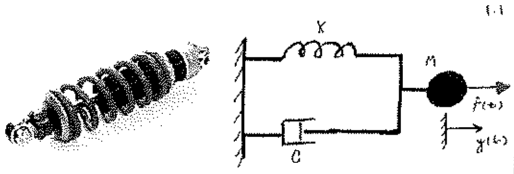
- ***Module 2c(1):***
  - ***Binder grading & selection***
  - M 332 grades
- Module 2c(2):
  - Testing & evaluation
  - RAP & shingles
  - Mixing & compaction temperatures

ASPHALT (BINDER) GRADING

- Binder produced in grades
- Grades based on viscosity-temperature behavior
- Choice of grade depends primarily on climate

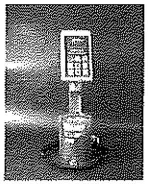
ASPHALT (BINDER) BEHAVIOR

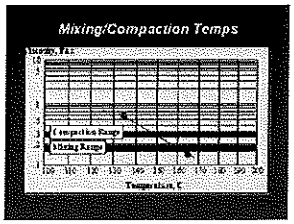
- Based on ***rheology***
  - Rheology: study of flow and deformation
- Asphalt cement is a ***viscoelastic*** material:
  - Elastic: spring
  - Viscous: dashpot (piston)



Binder Behavior

- Asphalt is a ***thermoplastic***
- Behavior depends on:
  - ***Temperature***





  - ***Duration of loading***

  - ***Aging*** (properties change with time)

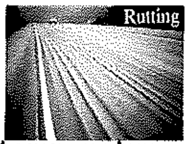
SELECTION OF PG BINDER GRADE

- Based on:
  - ***Climate***
  - Depth in pavement
  - Volume of traffic
  - Vehicle speed
  - Desired level of reliability
  - RAS (shingle) content
  - RAP content

SELECTION OF PG BINDER GRADE

Climate

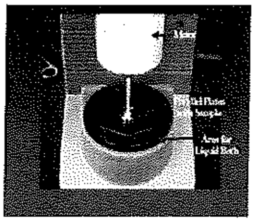
- Grade chosen primarily on temperature expected:
  - to prevent ***rutting***, based on cumulative hours at elevated temperatures



  - to prevent ***cold temperature cracking***, based on average single-day low temperature

CONDITIONING/TESTING

- Rutting: High temperature (DSR)



- Fatigue Cracking: Intermediate temperature (DSR)
- Cold-temperature cracking: cold temperature (BBR)

Superpave Asphalt Binder Specification

AASHTO M 320

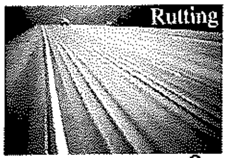
The grading system is based on Climate

PG 64 - 22

Performance Grade

Cold-temperature crack resistant down to -22 ° *C*
(-7.6° F)

Rut-resistant up to 64° C
(147° F)



AASHTO M320 PG GRADING SYSTEM

- 6 degree increments

Table 3.1 Superpave Binder Grades

High Temperature Grades (Degrees C)	Low Temperature Grades (Degrees C)
PG 46	-34, -40, -46
PG 52	-10, -16, -22, -28, -34, -40, -4
PG 58	-16, -22, -28, -34, -40
PG 64	-10, -16, -22, -28, -34, -40
PG 70	-10, -16, -22, -28, -34, -40
PG 76	-10, -16, -22, -28, -34
PG 82	-10, -16, -22, -28, -34

Choosing a PG Grade for a Climate

- Cleveland: say, get 30 years of weather data
- Convert air temperatures to pavement temperatures
- average high pavement temperature is *52 ° C*
- Average low pavement temperature is *-16 ° C*
- *A PG 52-16* will cover 50% of the data, thus will have a 50% Reliability
- *A PG 58-22* will cover ~98% of the data, thus will have a ~98% Reliability

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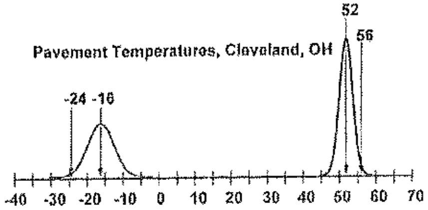


Figure 5.3 Example High and Low Pavement Temperature Variations

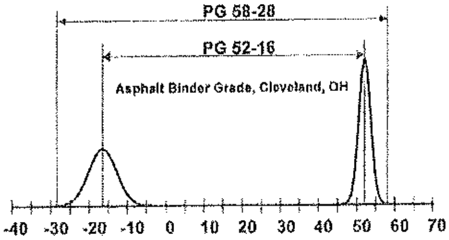


Figure 5.4 Superpave Binder Grade Selections for Cleveland

Rule-of-90 (or 92)

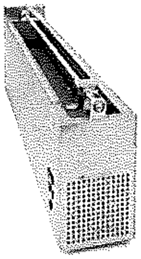
- If temperature range (absolute value high to low is less than 90° (or 92°), the binder is probably ***non-modified*** ("neat" asphalt)
- If range is ≥ 90°, probably is ***modified***
- Examples:
- *PG* 64-22, range = 86° non-modified
- *PG* 70-22, range = 92°, modified
- *PG* 76-22, range = 98°, modified

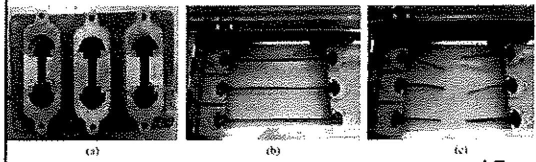
TO MODIFY
Optional Materials

- Polymer (eg. elastomeric polymer)
- Polyphosphoric acid (PPA)
- REOB = Re-refined engine oil bottoms
- Air-blown asphalt
- Others

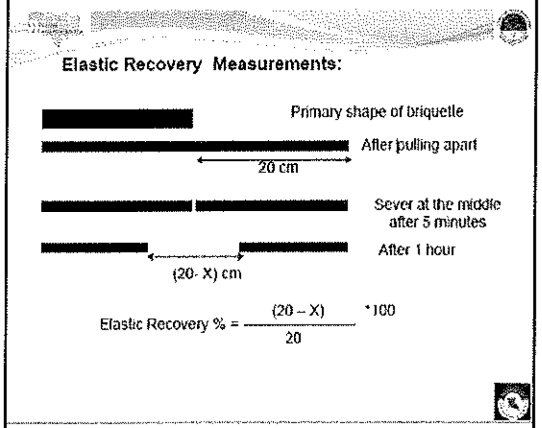
DO I REALLY HAVE POLYMER IN MY BINDER?

- M320 has the Elastic Recovery test- MoDOT has this in the 1015 spec





Elastic Recovery (%)



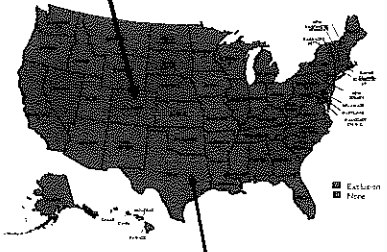
$$\text{Elastic Recovery \%} = \frac{(20 - X)}{20} * 100$$

- *Greater %ER is better*

Section 1015.10.3

Grade	ER, min. %
PG 64-22, 58-22, 58-28	--------
PG 70-22	55
PG 76-22	65

State DOTs with Binder "Exclusions" (don't allow): (PPA, REOB, Air Blown Asphalt, Other)



Other DOTs handle the problem in different ways

POLYPHOSPHORIC ACID (PPA)

- Can increase binder high-temp PG & performance without degrading low temp grade & performance
- Typically dosed at 0.25% to 1.5% by weight of asphalt

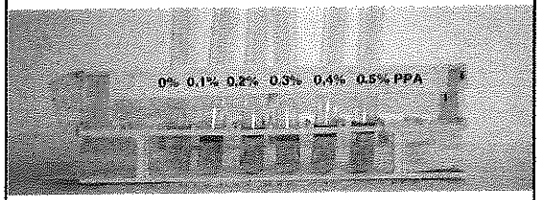
PPA
Possible Issues

- May make mix more prone to moisture sensitivity
- PPA may react with amine-based *Liquid Anti Strips (LAS)* & *Warm Mix Additives (WMA)* which will lead to a partial decrease in high-temp PG improvement
- Chemically compatible LAS and WMA function should not be inhibited. Performance testing such as AASHTO T283 (TSR) or T324 (HWT) are highly recommended
- LAS and WMA suppliers make PPA-compatible materials

PPA
Possible Issues, cont'd.

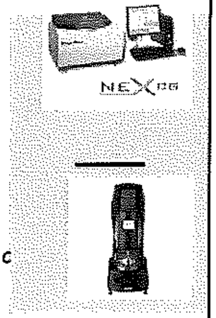
- Good communication with contractor regarding potential use of amine-based LAS
  - Ensure compatibility with WMA & LAS

Simple Test to Detect PPA in Asphalt



Other Analysis Methods

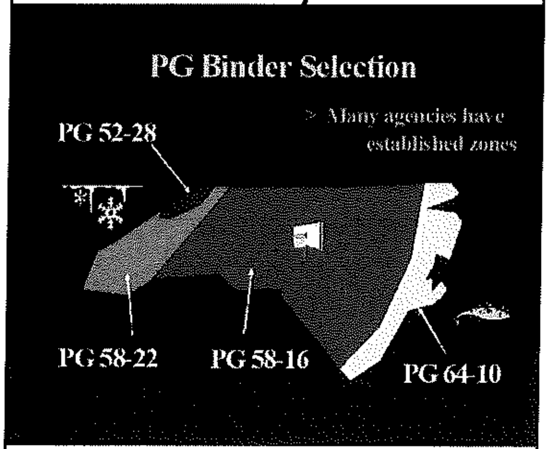
- To detect PPA in Asphalt
  - XRF - detect presence of phosphorous
  - DSR - detect drop in binder high PG stiffness
- Note - Just because binder contains Phosphorous does not mean it has been modified with phosphoric acid
- It could be Engine Oil Additives - REOBs can contain a heat stabilizing additives that can contain up 8% Phosphorous, 8.5% Zinc



SELECTION OF PG BINDER GRADE
Climate

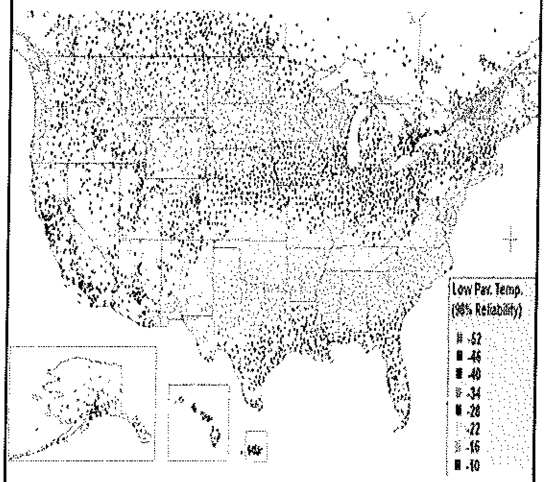
- Specify a higher upper number-grade to prevent rutting eg. 58→ 64
- Specify a lower number-grade to prevent cold temperature cracking, eg. -28 → -34

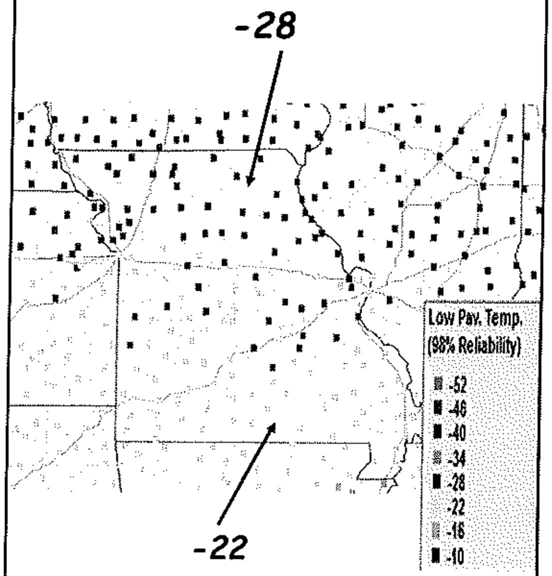
MATCH GRADE TO CLIMATE-
Example


PG Binder Selection

> Many agencies have established zones

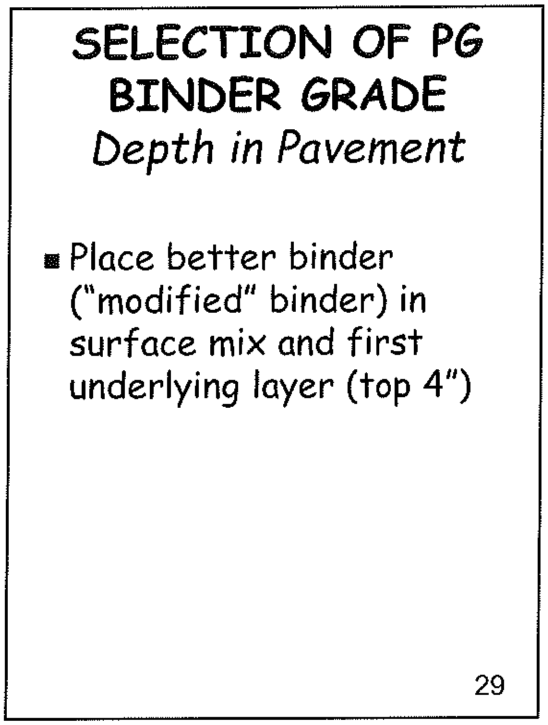
LTPPBind Program
Lower PG Number
(Low Temperature Values)





SELECTION OF PG BINDER GRADE

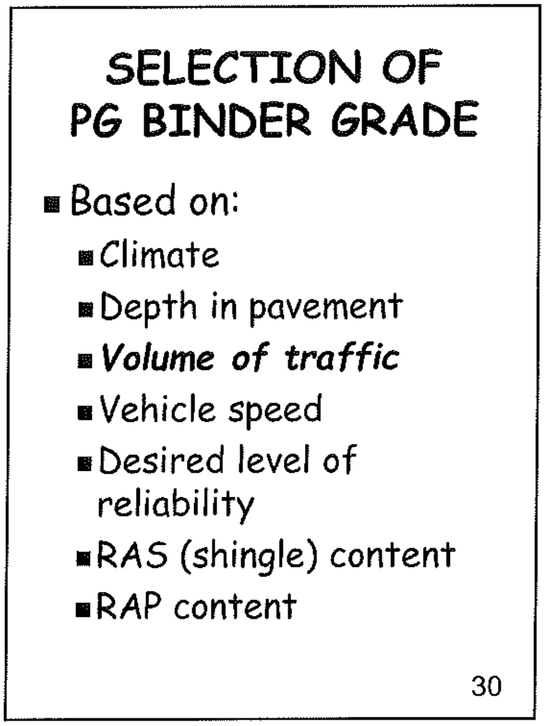
- Based on:
  - Climate
  - ***Depth in pavement***
  - Volume of traffic
  - Vehicle speed
  - Desired level of reliability
  - RAS (shingle) content
  - RAP content



SELECTION OF PG BINDER GRADE

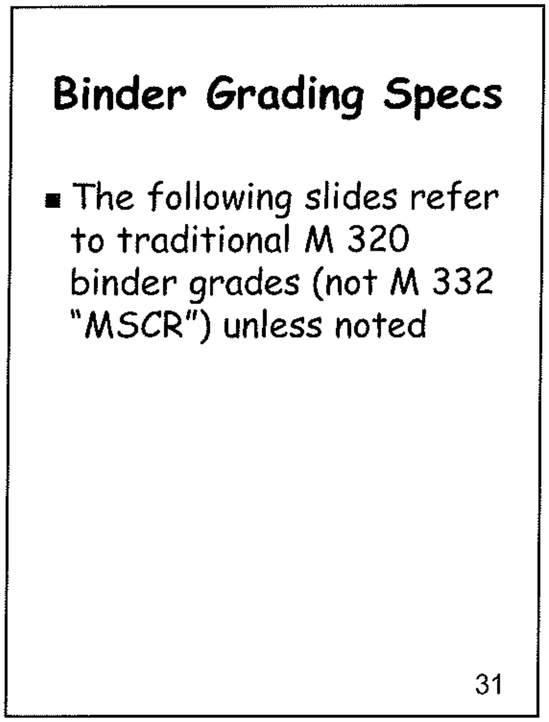
Depth in Pavement

- Place better binder ("modified" binder) in surface mix and first underlying layer (top 4")



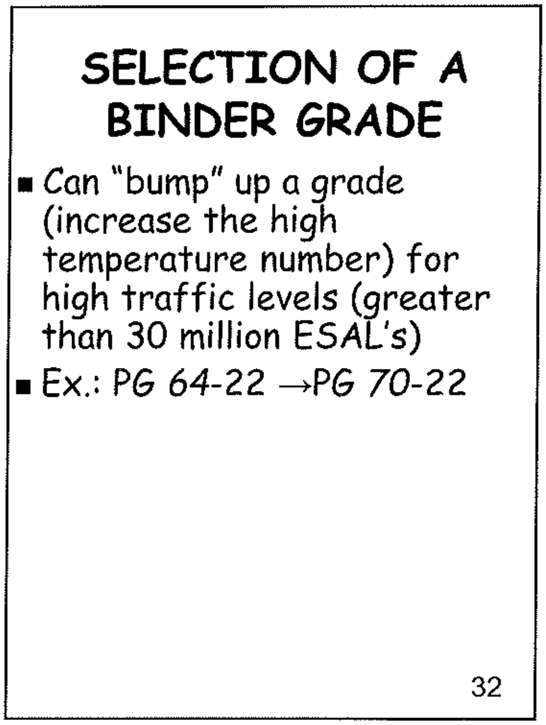
SELECTION OF PG BINDER GRADE

- Based on:
  - Climate
  - Depth in pavement
  - ***Volume of traffic***
  - Vehicle speed
  - Desired level of reliability
  - RAS (shingle) content
  - RAP content



Binder Grading Specs

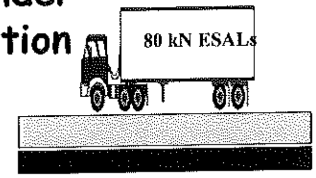
- The following slides refer to traditional M 320 binder grades (not M 332 "MSCR") unless noted



SELECTION OF A BINDER GRADE

- *Can "bump" up a grade (increase the high temperature number) for high traffic levels (greater than 30 million ESAL's)*
- Ex.: *PG 64-22 →PG 70-22*

Effect of Traffic Amount on Binder Selection



- 10 to 30 x 10^6 ESAL
  - Consider increasing - - one high temp grade
- ≥ 30 x 10^6+ ESAL
  - Recommend increasing - - one high temp grade

> **<u>E</u>quivalent <u>S</u>ingle <u>A</u>xle <u>L</u>oads**

SELECTION OF PG BINDER GRADE

- Based on:
  - Climate
  - Depth in pavement
  - Volume of traffic
  - ***Vehicle speed***
  - Desired level of reliability
  - RAS (shingle) content
  - RAP content

Vehicle Speed

- Slower → increased rutting
- Stopped → worst case for rutting

Why?

- Longer duration of load

Effect of Loading Rate (*Vehicle Speed*) on Binder Selection

- Can bump up a grade (increase high temperature number) for slow moving (less than 35 mph) traffic [MoDOT uses 12-45 mph]
- MoDOT bumps 2 grades for <12 mph
- Grade bumps apply to the surface mix and the top lift of the underlying mixture
- Grade bumping: no effect on low temp grade

Effect of Loading Rate on Binder Selection

under revision

90 kph

- Example
  - for toll road
    PG 64-22
  - for toll booth
    PG 70-22
  - for weigh stations
    PG 76-22

Slow

Stopping

SELECTION OF PG BINDER GRADE

- Based on:
  - Climate
  - Depth in pavement
  - Volume of traffic
  - Vehicle speed
  - ***Desired level of reliability***
  - RAS (shingle) content
  - RAP content

SELECTION OF PG BINDER GRADE

Reliability

- *Can increase reliability for a given climate & depth by increasing the high and/or low temperature values (this may lead to a modified binder)*
- PG grades chosen to match ***average*** high & low temperatures will give ~ 50% reliability
- 98% reliability is typically chosen for more critical situations
- Some DOT's choose 98% reliability for all binder grades

SELECTION OF PG BINDER GRADE

- Based on:
  - Climate
  - Depth in pavement
  - Volume of traffic
  - Vehicle speed
  - Desired level of reliability
  - ***RAS (shingle) content***
  - ***RAP content***

RAP/RAS Binders

- ***RAP*** has aged- stiffer than virgin binder
- ***RAS***- roofing binder is much stiffer
- ***Combined*** virgin & recycled binder → stiffer
- May be too hard

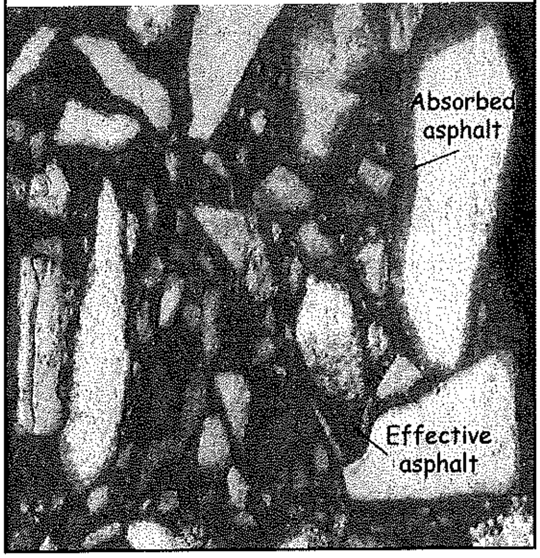
Solutions

- Limit the % of recycled effective binder ***(eg. 30% max)***
- Use a softer virgin grade binder ***(eg. PG 58-28)***
- Add a rejuvenator/viscosity modifier ***(eg. 3% Hydrogreen)***
- Combinations of the above

"Effective Binder"

- When dealing with recycled materials, interested in ***"effective binder"***, not total binder

ABSORPTIVENESS OF AGGREGATE



BINDER CONTENT

Conceptually:

- $P_b = P_{ba} + P_{be}$
  - P_b= total binder content
  - P_{ba} = absorbed binder
  - P_{be} = effective binder

RAP & SHINGLES (RAS)

- If ***effective virgin binder*** is less than 70% (more than 30% replacement by RAP+RAS), more binder testing (use of "blending charts") is required to assure that the combined binder meets the JMF specified binder grade
- So, typically contractors are limiting the effective recycle binder content of their mixes to ≤30%

SHINGLES (RAS)

- Shingles only allowed for contract specified grade of PG64-22 (if PG 70 and greater, shingles not allowed)
- If effective virgin binder is 60-70% (RAP+RAS =30 to 40%), must use PG 52-28 or 58-28 (no binder testing required)

MoDOT Binder Grade PG 64-22

- Climate= whole state
- Position in pavement=
  - surface layer and first underlying layer (lower traffic)
  - Lower lifts (~all traffic)
- Traffic speed > 45 mph
- Traffic volume < 30 million ESALS
- Reliability= ~98%
- Upper number (64) is bumped up for increased traffic and/or slower speeds in top layer/top underlying lift

M 320 PG GRADES

MoDOT typically specifies:

- *PG 64-22* in the base course and for lower traffic levels mph in the surface course
- *PG 70-22* for traffic levels >3500 AADT and/or traffic 12-45 mph in the surface course
- *PG 76-22* for some metropolitan areas (<12 mph) or steep grades with slow speeds

MoDOT Binder Selection- Depth, Traffic Volume, Vehicle Speed

Corridor	Layer	Binder Grade
Interstates	Surface= SP125 or SMA & 1st underlying lift	PG76-22
	Remaining lifts	PG64-22
Major Routes Heavy Volume	Surface= SP125 & 1st underlying lift	PG70-22
	Remaining lifts	PG64-22
Major Routes Medium or Low Volume	Surface= SP125 or BP-1	PG64-22
	Underlying lifts	PG64-22
Minor Routes	All (generally BP-1 surface)	PG64-22

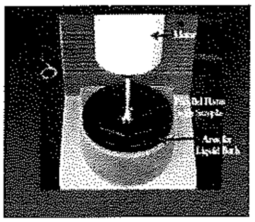
MODIFIED PG BINDERS

- How a material handles, compacts, etc., may be greatly affected if the binder is ***modified***, eg. with a polymer.
- The supplier of the binder should be contacted to determine if the binder has been modified and what effects this modification might have on the mixture (eg. special handling requirements)

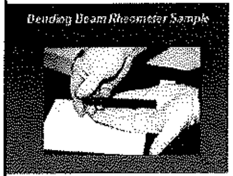
BINDER TESTING

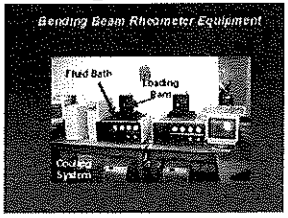
PG 64-22

- Upper PG number (eg, 64): DSR



- Lower PG number (eg, -22): BBR





OUTLINE

- ***Module 2c(1):***
  - Binder grading & selection
  - *M 332 grades*
- Module 2c(2):
  - Testing & evaluation
  - RAP & shingles
  - Mixing & compaction temperatures

ALTERNATE GRADING SYSTEMS

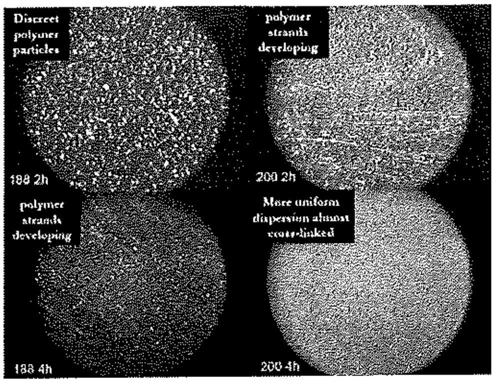
- Original: ***M 320***
- ~New (MSCR): ***M 332***

AASHTO M 320 Issues and the M 332 Solution

- **M 320 was developed based on neat asphalts and does not do PMAs justice**
  - **Therefore some Agencies have added "Plus Tests", such as % Elastic Recovery (% ER).**
  - **However empirical tests such as % ER only show the presence of, but not the effectiveness of polymer-modification.**

Polymer Modification

- Same polymer, same amount of polymer, but different behavior
- Not well characterized with M320 and PG+ tests



AASHTO M 320 Issues and the M 332 Solution

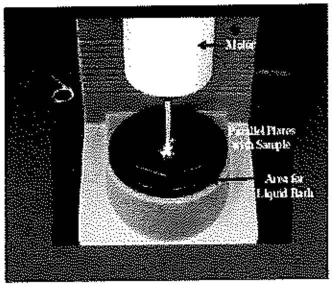
- The MSCR specification M332 corrects the M320 deficiencies by testing at the project climate temperatures and at the stress level commensurate with the expected traffic.
  - M332 uses the non-recoverable compliance % (Jnr) and % Recovery to better qualify the type of modification.

Type of Modification

- M332 (MSCR) is blind to the *type* of modifier (because the test is physical, not chemical)

M 332 (MP 19) Binder Test/Specification

- MSCR = Multiple Stress Creep Recovery test
- Extra DSR test
- Alternate AASHTO binder specification (M 332) to supplement M 320



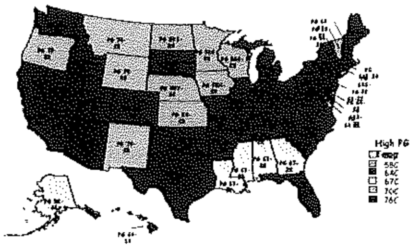
M 332 Binder Grades

Section 1015.10.3.1

- Introduces "traffic grades" increasing *S* → *H* → *V*→ *E*
- Before M332, to bump a grade for more traffic, raise upper PG number (eg, PG 64 → PG 70)
- New: Stay in climate grade (PG 64-22 for Missouri), but bump up by traffic

M 320	M 332
64-22	64-22 Grade S
70-22	64-22 Grade H
76-22	64-22 Grade V

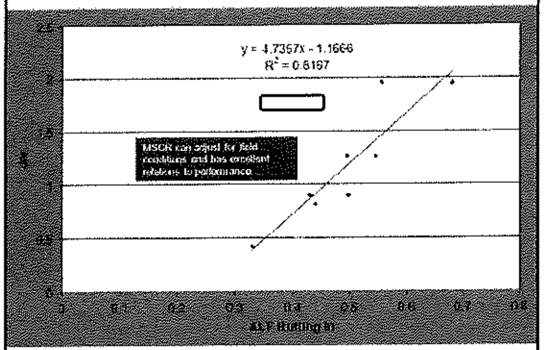
"Workhorse" Binder Grades



M 332 (MSCR) System

- Test for J_{nr} = non-recoverable creep compliance
- ***Creep*** is the plastic deformation from the wheel load (***bad*** → rutting)
- We want the asphalt to recover from creep
- Non-recoverable portion of creep is ***bad***
- So, we want a low J_{nr}
- To grade bump for higher traffic (S → H → V), lower the maximum allowable J_{nr}
- To do that, must add more modifier

Relationship Between J_{nr} and Rutting



MSCR can adjust for field conditions and has excellent relations to performance.

M 332 Grades

Grade	Traffic/ Speed	MoDOT Class
S (Standard)	<10 million ESALS *AND* > 44 mph	F, E, some C
H (Heavy)	10-30 million ESALs *OR* 12 - 44 mph	Some C
V (Very Heavy)	>30 million ESALS *OR* < 12 mph ("standing")	B
E (Extra Heavy)	>30 million ESALS *AND* "standing"	B

MoDOT SUPERPAVE QC/QA
TRAINING/CERTIFICATION
COURSE

MODULE 2C(2)

MIX DESIGN OVERVIEW:

Testing & Evaluation
RAP & Shingles
Mixing & Compaction Temperatures

11-24-06 Revision
11-9-07 Revision, 4-22-09 Revision
11-18-09 Revision, 12-29-09 Revision
11-17-10 Revision, 1-19-11 Revision
3-2-12 Revision, 2-26-13 Revision
12-18-13 Revision, 12-29-14 Revision
2-4-15 Revision, 12-28-16 Revision
2-16-18 Revision, 12-12-18 Revision
12-17-19 Revision, 1-30-20 Revision
1-20-21 Revision

OUTLINE

- Module 2c(1):
  - Binder grading & selection
  - M 332 grades
- ***Module 2c(2):***
  - ***Testing & evaluation***
  - RAP & shingles
  - Mixing & compaction temperatures

M 332 Spec
DSR Tested at 64° C

Traffic Level	Max. Allowable Jnr, kPa-1
S	4.5
H	2.0
V	1.0
E	0.5

Note: decreasing max. allowable Jnr for more severe traffic conditions

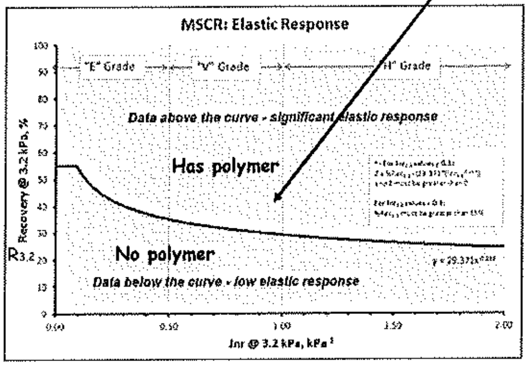
---

Binder Grade System Transition:
M 320 → M 332

- Contracts & EPG: still M 320 grades
- Many suppliers now supply M 332
- M 332 grades are cheaper than corresponding M 320 grades (less polymer), so contractors prefer
- [MoDOT did not adopt the Appendix in M 332]

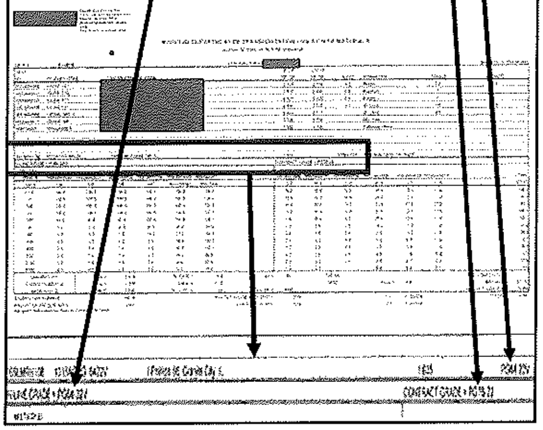
M 332 APPENDIX
MSCR % Recovery

- 2 bits of data from your MSCR test: MSCR % Recovery ($R_{3.2}$) & Jnr
- Plot: see where your point falls



Example JMF Showing Substitution of purchased grade M 332 (PG 64-22V) for contract grade M 320 (PG 76-22)

- SMA: No RAP/RAS allowed
- No additives, so in-line grade = PG 64-22V



What's My Grade?
Different Example

- ***"Contract Grade"*** = the PG grade in the contract, eg. PG 70-22
- ***"Purchased Grade"*** = what contractor buys from supplier (terminal), eg. PG 58-28 (if RAP/RAS will be used)
- ***"In-line Grade"*** = Purchased grade + ***additive*** (warm mix, anti-strip, etc.) eg. PG 58-28
- ***"In-line Grade"*** = Purchased grade + ***modifier*** (rejuvenator) eg. PG 52-28

What's My Grade, cont'd.

- ***"True Grade"*** = shows at what temperatures the binder actually met the required specs, eg., PG 59.2-29.7
- ***"Mixture Grade"*** = what the grade is after mixed with recycled binder in RAP/RAS

How Recycle Affects Binder Grade Strategy

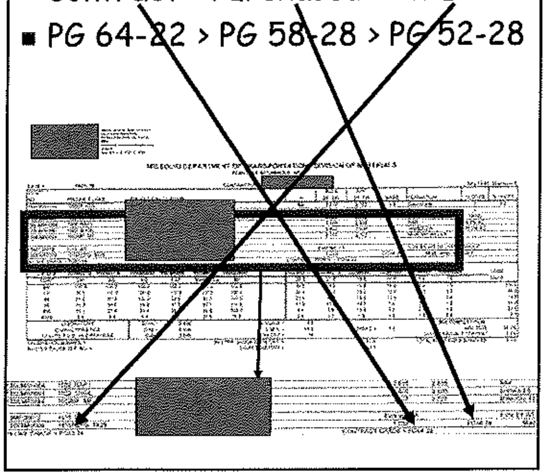
- ***Contract Grade*** is what MoDOT wants for performance (eg. PG 64-22)
- RAP/RAS binder is stiff
- To meet ***Contract Grade***, contractor may need to start with a softer ***Purchased Grade*** (eg. PG 58-28)
- RAP/RAS will provide additional stiffness
- ***Mixture grade***, hopefully, will be close to the ***Contract Grade***

ADDITIVES vs MODIFIERS

- ***Additives:***
  - Compactibility
  - Warm mix
  - Anti-strip
  - Usually a low amount (0.25-1.75% of binder)
  - Doesn't affect PG grade (Purchased grade and In-line grade ~ same)
- ***Modifiers:***
  - Rejuvenators, viscosity modifiers, etc.
  - Changes the PG base asphalt
  - Usually a greater amount: 2-5 % of binder)

Example of Contract Grade, Purchased Grade, In-Line Grade (after additives/modifiers)

- Has RAP/RAS
- Has modifier
- Contract > Purchased > In-Line
- PG 64-22 > PG 58-28 > PG 52-28



What is Sampled & Tested for Acceptance?

- ***Purchased (Terminal) Grade***

  or
- ***In-line Grade (HMA plant)***
- The results of the testing determine whether the sample passes; if rejected, penalties are assessed per Section 460.3.13 EPG:
  - If M 320 binder, the high temperature ***True Grade*** will be determined
  - If M 332 binder, penalties will be assessed ***based on the Jnr***
    (except Grade S-test as if M320)

M 320 Binder
Tested On Non-Aged ("Original") Condition
Example: PG 64

Spec	DSR Testing	Penalty
DSR ≥ 1.00 kPa	DSR > 0.90 kPa	No penalty
	If sample fails:	
Spec temp	**Hi-Temp True Grade Temp**	**Penalty**
64°	< 2° low	No penalty
64°	> 2° & < 4° low	3% of mix unit price
64°	> 4° & < 6° low	10% of mix unit price
64°	> 6° low	16% of mix unit price

M332 Binder
Tested On RTFO-Aged Condition For *Grade H*

Spec	Jnr Tested	Penalty
Jnr ≤ 2.0 kPa-1	≤ 2.2 kPa-1	No penalty
Jnr ≤ 2.0 kPa-1	> 2.1 & < 2.7	3% of mix unit price
Jnr ≤ 2.0 kPa-1	> 2.7 & < 4.0	10% of mix unit price
Jnr ≤ 2.0 kPa-1	> 4.0	16% of mix unit price

M332 Binder
Tested On RTFO-aged Condition For *Grade V*

Spec	Jnr Tested	Penalty
Jnr ≤ 1.0 kPa-1	≤ 1.1 kPa-1	No penalty
Jnr ≤ 1.0 kPa-1	> 1.1 & < 1.3	3% of mix unit price
Jnr ≤ 1.0 kPa-1	> 1.3 & < 2.0	10% of mix unit price
Jnr ≤ 1.0 kPa-1	> 2.0	16% of mix unit price

What is Sampled & Tested for Acceptance, cont'd.

- ***Mixture Grade*** - not normally tested for acceptance (technically, it has been aged in the drum, so would be difficult to compare to the specification [some criteria require that the binder not be aged at all])
- Hopefully, the ***Mixture Grade*** is close to the ***Contract Grade***
- More likely to be true if the % recycle is kept below 30%

TYPICAL TRENDS

- Most mixes are designed at less than 30% effective binder replacement
- Most products added are additives, not modifiers
- Small majority substitute M 332 for M 320
- Mixes with more than ~20% binder replacement use a softer Purchased Grade than Contract Grade; mixes with less than 20% replacement stay with Contract Grade
- Most softer Purchased Grades drop both upper & lower numbers

OUTLINE

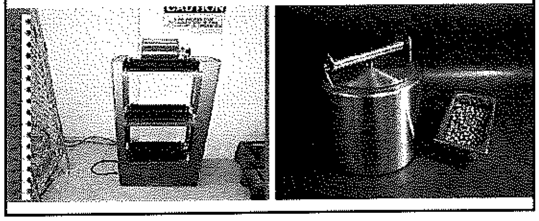
- Module 2c(1):
  - Binder grading & selection
  - M 332 grades
- ***Module 2c(2):***
  - Testing & evaluation
  - ***RAP & shingles***
  - Mixing & compaction temperatures

RECYCLED ASPHALT PAVEMENT (RAP):
Considerations

- OK in all mixes except SMA
- Can use a maximum of 30% virgin effective binder replacement without changing the binder grade
- >30% effective binder replacement can be from RAP+RAS if binder testing (use of blending charts) shows that the combined binder meets the contract specified grade
- Aggregate must meet deleterious spec 1002 (1004 if a 401 mix)
- Aggregate must pass Micro-Deval test spec (waived if RAP is from a MoDOT project)

RAP
Micro Deval
AASHTO T 327

- Remove binder coating by extraction or ignition
- Test aggregate
- % loss should be within 5% of the virgin aggregate utilized in the new mix design
- Ex.: New mix virgin MD = 21
  RAP MD should be 16-26
- 1 test per 1500 tons
- Waived if from MoDOT roadway



RECYCLED ASPHALT SHINGLES (RAS)

- May be used in any mix that has a specified contract grade of PG 64-22
- If virgin effective binder < 70% of blended total binder: drop virgin grade to PG 58-28 or PG 52-28
- Other restrictions

Re-Calculation of RAP/RAS Binder

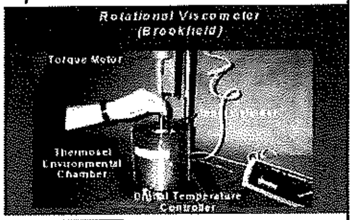
- The % effective virgin binder replacement content P_{bv} must be re-calculated when:
  - Change in % RAP or RAS from a field mix adjustment
  - Change in % binder content in the RAP (tested 1 per 4 sublots via T164 or T308)

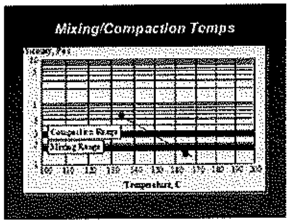
OUTLINE

- Module 2c(1):
  - Binder grading & selection
  - M 332 grades
- ***Module 2c(2):***
  - Testing & evaluation
  - RAP & shingles
  - ***Mixing & compaction temperatures***

DETERMINE MIXING & COMPACTION TEMPERATURES

- Develop the temperature-viscosity curve





TEMPERATURE - VISCOSITY

- As temperature increases, binder viscosity decreases (it gets thinner)
- This can be plotted.
- Viscosity is important to:
  - pumping
  - spraying
  - aggregate coating in mixing
  - absorption by aggregate
  - laydown and compaction
  - rutting

TEMPERATURE-VISCOSITY, cont'd.

- Establish the curve by running viscosity tests at 2 different temperatures
- Old method: capillary tubes
- New method: Brookfield rotational viscometer
- The curve is used to establish mixing and compaction temperatures necessary to achieve the required viscosity for these operations.

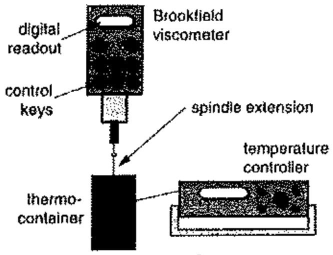


Figure 3.10 Rotational Viscometer

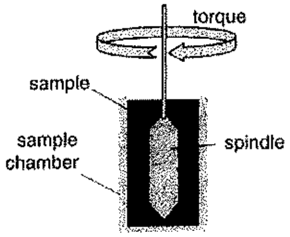


Figure 3.11 Rotational Viscometer Operation

TEMPERATURE-VISCOSITY, cont'd.

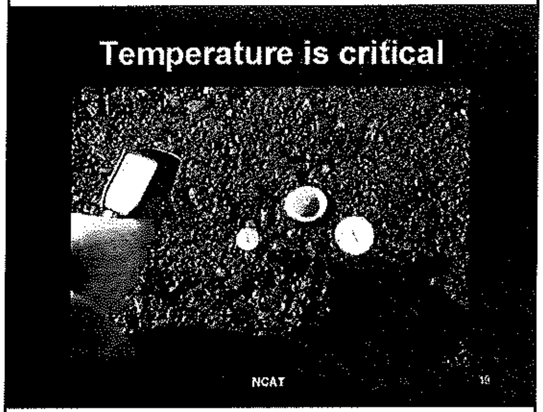
- The steepness of the curve is called "temperature sensitivity"--that is, how sensitive is a particular binder to a change in viscosity resulting from a change in temperature.
- We don't like change--so we don't like a sensitive material--we want a relatively flat curve. Modifiers help get the viscosity change under control.

LAB MIXING & COMPACTION TEMPERATURES

- For non-modified binders:
  - Mixing temperature range = what it takes to get a viscosity of 0.17 ± 0.02 Pa·s
  - Compaction temperature range= what it takes to get a viscosity of 0.28 ± 0.03 Pa·s
- For modified binders: follow manufacturer's recommendations.

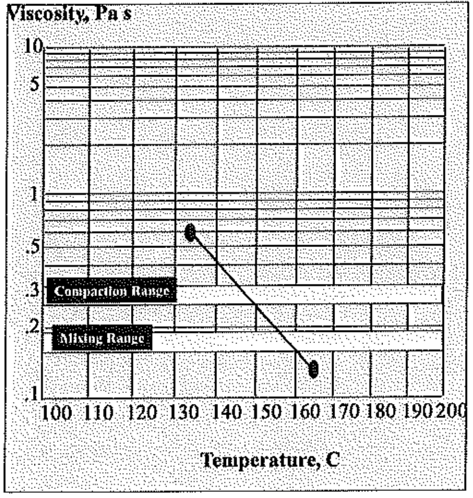
Plant Mixing & Roadway Compaction Temperatures

- May be different than lab temperatures
- Determine compaction temperature using test strips-- typically 275-310F
- Set plant mixing temperature somewhat higher, say 300-330F
- Maximum recommended temperature is 338F, should avoid exceeding 350F.



Temperature is critical

Mixing/Compaction Temps



ASPHALT CONTENT IGNITION METHOD
(AASHTO T 308-18) METHOD A
Asphalt Binder Correction Factor (C_F) Determination
(formerly "aggregate correction factor")

1. Run a butter mix through the mixing equipment.

2. For a given mix, prepare two asphalt binder correction factor (C_F) specimens at the design asphalt content using oven dry aggregate. It is recommended that the C_F and field verification specimen sizes be the same.

3. Obtain the tare weight of the baskets, pan, and lid.

4. Place the hot mix into the sample basket. If the mix has cooled, oven dry at 110 ± 5°C to constant mass prior to placing in the basket. Spread the mix in the basket, being careful to keep the mix away from the sides. Allow at least ¾" clearance.

5. Test (burn) the specimens as discussed in "Test Procedure."

6. If the difference between the measured binder contents of the two replicate specimens is more than 0.15%, test two more specimens. Discard the high and low values.

7. Calculate the C_F by determining the difference between the actual and measured asphalt binder contents [Actual %AC – Measured %AC] for each sample, and averaging the two differences. The "Actual %AC" is the amount weighed out in the batching process, expressed as a percent by weight of the mix.

8. If the C_F exceeds 1.0%, MoDOT Standard Specification Section 403.19.3.1.1 modifies AASHTO T 308-18 in the following manner:

    A. According to AASHTO T 308-18, if the C_F exceeds 1.0% at the typical chamber temperature of 538°C (1000°F), lower the chamber temperature to 482 ± 5°C (900 ± 8°F). If the C_F determined at this lower temperature is less than or equal to 1.0%, use that C_F for subsequent testing on that particular mix.

    B. However, according to MoDOT Standard Specification Section 403.19.3.1.1, if the C_F determined at 482 ± 5°C (900 ± 8°F) exceeds 1.0%, lower the chamber temperature to 427 ± 5°C (800 ± 8°F). Use the C_F obtained at 427°C even if it exceeds 1.0%.

ASPHALT CONTENT IGNITION METHOD
(AASHTO T 308-18)
METHOD A

Asphalt Binder Correction Factor (C_F) Determination

Sample____________________Lab No.________Date______Initials______

Replicate	1	2	3	4
Test Temperature				
Tare (basket, etc.) Mass (g)				
Total Dry Mass (g)				
Initial Dry Specimen Mass (g)				
Loss in Weight (g)				
%AC, measured = M				
%AC, actual = A				
%AC$_{diff}$ ($M_1 - M_2$)		> 0.15%? If so, 2 more replicates		
$C_F = M - A$				
C_F, average				

ASPHALT CONTENT IGNITION METHOD
(AASHTO T 308-18)
METHOD A

Specimen size: Use the following table. It is recommended that the field verification specimen size be the same as the correction factor specimen size.

NMS (mm)	Sieve Size	Minimum Specimen Size* (g)
4.75	#4	1200
9.5	3/8"	1200
12.5	1/2"	1500
19.0	3/4"	2000
25.0	1"	3000
37.5	1 ½"	4000

*Specimen sizes shall not be more than 500g greater than the minimum.

POSSIBLE SETTING CHANGES

1. To change the Stability Threshold:
    - A. With oven off, press the "Calibration Factor" key while simultaneously pressing the Power Switch "on."
    - B. Enter new Stability Threshold value. Observe the Percent Loss window for the new value. Maximum allowable = 0.02.
    - C. Press the Power Switch "off" then "on" to return oven to normal operation.
2. To change filter (afterburner) temperature (750°C typically):
    - A. Press #5 key while simultaneously pressing the Power Switch "on."
    - B. Enter new temperature.
    - C. Press "Enter."
    - D. New setpoint will be displayed.

MAINTENANCE

1. To check to see if the venting system is clogged, use the "Lift Test" procedure while the oven is at room temperature. With the power on, initiate a test (push "Start" button) without anything in the oven chamber. The blower fan will turn on. Watch the balance display. The display should read between -4 and -6 grams if the venting is adequate.

2. Burn accumulated soot out of the chamber by running the testing procedure at an elevated temperature without a sample.

TEST PROCEDURE

1. To change setpoint (furnace) temperature (538°C is typical):

    A. Press "Temp"

    B. Enter new setpoint

    C. Press "Enter"

    D. Press "Temp" again to verify new setpoint

2. To change the Asphalt Binder Correction Factor (C_F):

    A. Press "Calib. Factor"

    B. Enter new C_F

    C. Press "Enter"

    D. Press "Calib. Factor" again to verify

3. Preheat the oven to the setpoint, typically 538°C.

4. If the moisture content will not be determined, oven-dry the specimen at 110 ± 5°C to a constant mass.

5. Weigh the empty basket, etc. on an external scale to the nearest gram.

6. Place half the sample in the bottom basket and the other half in the top. Keep the specimen at least ¾" away from the basket sides. For larger samples, some operators make a hole in the middle of the mix.

7. Cool the loaded assembly to room temperature.

8. Weigh the loaded assembly. Calculate the mass of the specimen.

9. Press the "Weight" key and enter the specimen mass. Press "Enter."

10. Press the "Weight" key again to verify specimen mass entry.

11. Press the "0" (zero) key to tare the internal balance.

12. Don your clean gloves, safety face shield, and safety attire.

13. Carefully load the specimen into the oven by inserting the basket until the handle tines touch the back of the oven. Make sure the basket is centered and is not touching the walls. Shut the door.

14. Observe the internal scale reading. The displayed value should check with the external scale value of basket assembly + dry specimen within ± 5 grams.

15. Press the "Start/Stop" key to initiate the ignition procedure.

16. When weight loss stabilizes (the change in %AC readings will not exceed 0.01% for three consecutive minutes), the oven will automatically end the test and print out the results. Depending on the oven setup, an alarm may sound and one may have to press the "Start/Stop" key to unlock the door.

17. Remove the printed results before opening the door as the tape is heat-sensitive.

18. Again don the safety gear, open the door, and remove the basket and mount it on the cooling plate. Cover with the cooling cage and allow to cool to room temperature.

19. Determine and record the final mass of the specimen, M_f.

20. From the total % loss, the oven will automatically subtract the C_F and the Temperature Compensation to give the %AC (by weight of mix). The %AC by weight of aggregate is the "Bitumen Ratio."

21. Check for unburned asphalt (coke). If present, start with a new specimen.

    NOTE: Read the manufacturer's manual for additional information on safety and more detailed instructions on maintenance and operation.

ASPHALT CONTENT IGNITION METHOD
(AASHTO T 308-18)
METHOD A
Manual Weighing Method

Project No.	Job No.	Route	County
Technician	Date	Sublot No.	Mix No.

Empty Basket Assembly Weight (g), [T_e]	
Initial Basket Assembly + Wet (or dry) Sample Weight (g), [T_i]	
Initial Wet (or dry) Sample Weight (g), [$W_i = T_i - T_e$]	
Final Basket Assembly + Burned Sample Weight (g), [T_f]	
Loss in Weight (g), [$L = T_i - T_f$]	
% Loss, [$P_L = (L / W_i) x100$]	
Aggregate Correction (Calibration) Factor (%), [C_f]	
Calibrated %AC, [$P_{bcal} = P_L - C_f$]	
% Moisture Content, [MC]	
% AC, corrected (by weight of mix), [$P_b = P_{bcal} - MC$]	

Ignition Ovens Forms.doc (11-24-06;12-28-06;12-12-08;3-9-10;12-14-10;4-14-11; 12-18-13; 4-22-15;12-9-15; 12-28-16; 12-26-18)

Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures: AASHTO T 209-20

This test method shall be used to determine the maximum specific gravity (G_{mm}) of uncompacted asphalt mixtures. However, an option exists to obtain samples from pavement cores (AASHTO R 67) but that procedure is not presented, here.

APPARATUS

Balance
Container (pycnometer)
Thermometers
Vacuum Pump/System
Water Bath

MINIMUM SAMPLE SIZE (MoDOT)

NOM. MAX SIZE (in.)	SAMPLE (g)
1	2500
¾	2000
½	2000
3/8	2000
#4	2000

PROCEDURE

Sample Preparation and Agitation

1. Dry the paving mix to a constant weight (mass repeats within 0.1%) at a temperature of 105 ± 5°C. This drying step shall be combined with any warming of the sample necessary to prepare it for separation.

NOTE: The drying of the mix to constant weight prior to separation may be waived provided AASHTO T 329 shows the moisture content to be less than 0.1%. If the drying step is waived due to T 329 results, this fact must be documented and included in the T 209 results.

2. Separate the particles of the paving mix by hand. A small trowel can be used, but care must be taken not to fracture the mineral aggregate. Continually work the mix while, ultimately, cooling to room temperature. The particles of the fine aggregate portion should not be larger than ¼" at the completion of the separation step. Periodically, shake the pan back and forth to bring the larger clumps to the top.
3. Determine and record the weight of the empty pycnometer (without the lid).
4. When the specimen is at room temperature, place and level the sample in the pycnometer.
5. Determine and record the combined weight of the specimen and pycnometer.
6. Subtract the weight of the pycnometer from the combined weight of the specimen and pycnometer.
7. Record the net dry sample weight (A).
8. Add sufficient water at a temperature of approximately 25°C (77°F) to cover the sample completely (≈1 inch).
9. Wet O ring of vacuum lid and secure lid on pycnometer (use vacuum grease if necessary to obtain a good seal).

10. Gradually increase the vacuum and hold 27.5 ± 2.5 mm Hg (3.7 ± 0.3 kPa) absolute vacuum for 15 ± 2 minutes.
11. Agitate the pycnometer and contents using mechanical or manual agitation during the vacuum period. Mechanical agitation is accomplished using a shaker device while manual agitation entails vigorously shaking the pycnometer at intervals of about 2 minutes.

Mass Determination: Weigh in Air Method:

1. At the end of the 15 ± 2 minute vacuum period, slowly release the vacuum at a rate not to exceed 60 mm Hg (8 kPa) per second (2.36 in. Hg/sec; gage).
2. Immediately start a 10 ± 1 minute time period. The requirement is to obtain the final weight of the pycnometer, completely filled, within this second time period. It is suggested that the timer be set for 9 minutes. Since the pycnometer is to be placed back in the water bath to bring it and its contents back to 25 ± 1°C, this will allow 2 minutes after the timer goes off to obtain the final weight.
3. Slowly submerge the pycnometer in the 25 ± 1°C water bath, being careful not to expose the sample to the air.
4. Place the capillary lid on the pycnometer ensuring the removal of all air bubbles inside the pycnometer while retaining as many fines as possible.
5. When the timer goes off, carefully remove the pycnometer from the bath. Dry off the exterior of the pycnometer. Add water to the lid weephole to ensure that the pycnometer is full. Dry off the exterior of the pycnometer again.
6. Zero the balance, then obtain and record the combined weight of pycnometer and contents (E).
7. Completely empty the pycnometer and re-submerge the empty pycnometer in the 25 ± 1°C water bath.
8. Again, check for air bubbles clinging to the inside of the pycnometer and the bottom of the capillary lid prior to placement on the pycnometer.
9. Leave it in the water bath for 10 ± 1 minutes of immersion.
10. Remove the pycnometer and dry off the exterior. Add water to the weephole with an eyedropper until seepage occurs around the lid. Dry off the exterior again and obtain the total weight of the pycnometer filled with water (D).

Mass Determination: Weigh in Water Method:

A weigh-in-water station should be available that includes a water bath suitable for immersion of the suspended container with its deaerated sample, an overflow outlet for maintaining a default water level, a method for controlling or monitoring water temperature, a balance with a weigh-below capability, and some type of suspended platform on which the pycnometer/flask can be supported while submerged in the water bath. The platform and rod/wires that connect the platform to the balance should displace a minimum amount of water.

1. Prepare and vacuum sample as described earlier. After 15 ± 2 minutes of agitation and vacuum at the specified level, slowly release the vacuum at a rate not to exceed 60 mm Hg (8 kPa) per second (2.36 in. Hg/sec; gage) then disassemble apparatus.
2. The temperature of the water bath should be adjusted to and maintained at 25 ± 1°C, the water level shall be at its default level (full, but not overflowing), then the weigh-in-water system balance shall be zeroed out (tared).
3. Suspend the pycnometer (without the lid) and deaerated sample in the water bath and determine the combined weight (C) after 10 ± 1 minutes of immersion.
4. After recording the combined weight (C), immediately remove the pycnometer from the water bath, completely remove the sample from the pycnometer, and then, without delay, obtain the mass of the empty pycnometer (B) after 10 ± 1 minutes of immersion.

Note: It is important that every weight determination begins by returning the water level to its default position; i.e. the water has just stopped dripping from the overflow.

CALCULATIONS

Weigh in Air Method: Calculation of maximum specific gravity is performed in accordance with AASHTO T 209-20, Section 12.1.3.

$$G_{mm}=\frac{A}{A+D-E}$$

Where:

G_{mm} = maximum theoretical specific gravity (reported to three decimal places)
A = mass of oven-dry sample in air, (gm)
D = mass of pycnometer filled with water, (gm)
E = mass of pycnometer filled with water + sample, (gm)

Weigh in Water Method: Calculation of maximum specific gravity for this method is performed in accordance with AASHTO T 209-20, Section 12.1.2.

$$G_{mm}=\frac{A}{A+B-C}$$

Where:

G_{mm} = maximum theoretical specific gravity (reported to three decimal places)
A = mass of oven-dry sample in air, (gm)
C = mass of sample + pycnometer in water, (gm)
B = mass of pycnometer in water, (gm)

NOTE: Section 12.2 describes how to calculate a weighted average G_{mm} for large samples tested a portion at a time, if necessary.

MAXIMUM SPECIFIC GRAVITY: G_{mm}

AASHTO T 209

PROJECT________________ROUTE______________MIX NO._____________

____

LOT NO_____________SUBLOT_____________TECHNICIAN_____________

PRE-TEST REQUIREMENT: MIX MOISTURE CONTENT < 0.1%

1) Results from T 329: Moisture Content (%) = ____________________

OR

2) Mass repeats within 0.1% [percent loss < 0.1% (based on 2nd wt. per interval)]:

P_{MC} = Pan weight (g): ___________

T_0 = Initial sample + pan weight (g): ___________

$W_0 = T_0 - P_{MC}$ = Initial sample weight (g): ___________

1st Drying Interval (DI)

T_1 = 1st DI sample + pan weight (g): ___________

$W_1 = T_1 - P_{MC}$ = 1st DI sample weight (g): ___________

$L_1 = W_0 - W_1$ = 1st Loss in weight (g): ___________

$(L_1 / W_1) \times 100$ = 1st Percent loss (%): ___________

2nd Drying Interval (DI)

T_2 = 2nd DI sample + pan weight (g): ___________

$W_2 = T_2 - P_{MC}$ = 2nd DI sample weight (g): ___________

$L_2 = W_1 - W_2$ = 2nd Loss in weight (g): ___________

$(L_2 / W_2) \times 100$ = 2nd Percent loss (%): ___________

3rd Drying Interval (DI)

T_3 = 3rd DI sample + pan weight (g): ___________

$W_3 = T_3 - P_{MC}$ = 3rd DI sample weight (g): ___________

$L_3 = W_2 - W_3$ = 3rd Loss in weight (g): ___________

$(L_3 / W_3) \times 100$ = 3rd Percent loss (%): ___________

4th Drying Interval (DI)

T_4 = 4th DI sample + pan weight (g): ___________

$W_4 = T_4 - P_{MC}$ = 4th DI sample weight (g): ___________

$L_4 = W_3 - W_4$ = 4th Loss in weight (g): ___________

$(L_4 / W_4) \times 100$ = 4th Percent loss (%): ___________

"DRY-BACK" PROCEDURE: REQUIRED WHEN ANY COARSE AGGREGATE FRACTION HAS AN ABSORPTION GREATER THAN 2.0%.

Procedure complete when percent loss < 0.05% based on 2nd wt. per interval [mass repeats within 0.05%]

P_{DB} = Pan weight (g): ____________

T_0 = Initial sample + pan weight (g): ____________

$W_0 = T_0 - P_{DB}$ = Initial sample weight (g): ____________

<u>1st Drying Interval (DI)</u>

T_1 = 1st DI sample + pan weight (g): ____________

$W_1 = T_1 - P_{DB}$ = 1st DI sample weight (g): ____________

$L_1 = W_0 - W_1$ = 1st Loss in weight (g): ____________

$(L_1 / W_1) \times 100$ = 1st Percent loss (%): ____________

<u>2nd Drying Interval (DI)</u>

T_2 = 2nd DI sample + pan weight (g): ____________

$W_2 = T_2 - P_{DB}$ = 2nd DI sample weight (g): ____________

$L_2 = W_1 - W_2$ = 2nd Loss in weight (g): ____________

$(L_2 / W_2) \times 100$ = 2nd Percent loss (%): ____________

<u>3rd Drying Interval (DI)</u>

T_3 = 3rd DI sample + pan weight (g): ____________

$W_3 = T_3 - P_{DB}$ = 3rd DI sample weight (g): ____________

$L_3 = W_2 - W_3$ = 3rd Loss in weight (g): ____________

$(L_3 / W_3) \times 100$ = 3rd Percent loss (%): ____________

<u>4th Drying Interval (DI)</u>

T_4 = 4th DI sample + pan weight (g): ____________

$W_4 = T_4 - P_{DB}$ = 4th DI sample weight (g): ____________

$L_4 = W_3 - W_4$ = 4th Loss in weight (g): ____________

$(L_4 / W_4) \times 100$ = 4th Percent loss (%): ____________

<u>5th Drying Interval (DI)</u>

T_5 = 5th DI sample + pan weight (g): ____________

$W_5 = T_5 - P_{DB}$ = 5th DI sample weight (g): ____________

$L_5 = W_4 - W_5$ = 5th Loss in weight (g): ____________

$(L_5 / W_5) \times 100$ = 5th Percent loss (%): ____________

SPECIFIC GRAVITY DETERMINATION: NO "DRY-BACK" PROCEDURE

S = Weight of oven-dry sample & empty flask (g): ____________

P = Weight of empty flask (g): ____________

A = S – P = Weight of oven-dry sample (g): ____________

Weigh-in-air Method

D = Weight of flask filled with water (g): ____________

X = A + D (g): ____________

E = Weight of flask filled with water & sample (g): ____________

Y = X – E (g): ____________

Gmm = A / Y ____________

Weigh-in-water Method

C = Weight of flask & sample under water (g): ____________

B = Weight of flask under water (g): ____________

Q = C – B (g): ____________

Z = A – Q (g): ____________

Gmm = A / Z ____________

SPECIFIC GRAVITY DETERMINATION: WITH "DRY-BACK" PROCEDURE

A = Weight of oven-dry sample (g): ____________

A2 = Weight of surface-dry sample (g): ____________

Weigh-in-air Method

D = Weight of flask filled with water (g): ____________

X = A2 + D (g): ____________

E = Weight of flask filled with water & sample (g): ____________

Y = X – E (g): ____________

Gmm = A / Y ____________

Weigh-in-water Method

C = Weight of flask & sample under water (g): ____________

B = Weight of flask under water (g): ____________

Q = C – B (g): ____________

Z = A2 – Q (g): ____________

Gmm = A / Z ____________

TAB

GLOSSARY

Glossary

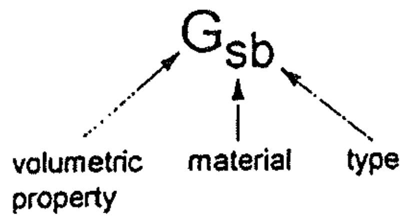
MoDOT

GLOSSARY

Maximum Size	One sieve size larger than the Nominal Maximum Size
Nominal Max Size	One sieve size larger than the first sieve retaining equal to or more than 10% of the combined gradation
G_{mm}	D, Maximum Specific Gravity of mix as determined by the Rice Method, AASHTO T 209
G_{mb}	d, Bulk Specific Gravity: specific gravity including permeable and impermeable voids of aggregates or compacted mix.
G_{mc}	Bulk Specific Gravity of core.
G_{sb}	Stone (Aggregate) Bulk Specific Gravity: weighted sum of bulk specific gravities of combined aggregates.
G_{sa}	Stone Apparent Specific Gravity: weighted sum of apparent specific gravities of combined aggregates. This excludes the water permeable voids.
G_{se}	Stone Effective Specific Gravity: specific gravity including asphalt permeable voids.
N_{des}	Gyrations simulating design life of mix to yield 4% air voids.
N_{ini}	Compaction ≥ 89% indicates a tender mix that may rut prematurely.
N_{max}	Gyrations simulating maximum life of pavement. At < 2% air voids the mix becomes plastic.
P_b	Percent binder in total mix.
P_s	Percent stone in total mix.
TSR	Tensile Strength Ratio: Result of AASHTO T 283 indicating the indirect tensile strength of wet cured specimens compared to dry cured specimens.
V_a	Percent air voids in compacted mix.
V_{ba}	Volume of absorbed binder.
V_{be}	Effective volume of binder not absorbed into the stone.
VMA	Voids in Mineral Aggregate: percent of voids in the aggregate structure.
VFA	Voids Filled with Asphalt: percent VMA filled with asphalt cement.

SUMMARY OF
DEFINITIONS AND CONVENTIONS

NAMING CONVENTION



G = specific gravity
V = volume

s = stone
b = binder
m = mix

b = bulk
e = effective
m = maximum theoretical
a = apparent (for G) *or*
a = absorbed (for V and P)

DEFINITIONS

V_a = volume of air voids
V_{ba} = volume of binder absorbed
V_{be} = volume of effective binder
G_b = specific gravity of binder
G_{sb} = bulk specific gravity of stone
G_{se} = effective specific gravity of stone
G_{sa} = apparent specific gravity of stone
G_{mb} = bulk specific gravity of mix
G_{mm} = maximum theoretical specific gravity of mix
G_{mc} = bulk specific gravity of the core
V_a = percent air
P_s = percent stone (100 - P_b)
P_b = percent binder
P_{ba} = percent binder absorbed
P_{be} = percent effective binder
W_s = weight of stone
VMA = Voids in Mineral Aggregate
VFA = Voids Filled with Asphalt