PENNDOT
ASPHALT TECHNICIAN CERTIFICATION PROGRAM

LEVEL 1 ASPHALT PLANT TECHNICIAN HANDOUT
2024

PENN STATE UNIVERSITY
NECEPT/Larson Transportation Institute
201 Transportation Research Building, University Park, PA 16802
Phone: 814-863-1293
Fax: 814-865-3039
Website: www.superpave.psu.edu

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PENNDOT ASPHALT PLANT TECHNICIAN REVIEW AND CERTIFICATION COURSE 2024

The PENNDOT Asphalt Level 1 Plant Technician Review and Certification Course includes a two-day review course for technicians directly involved with asphalt pavement mixture design, asphalt mix production, and process control and/or quality assurance testing. The course concludes with a written examination on the third day. The course was developed by NECEPT in cooperation with PENNDOT and private industry. For qualified applicants, attending this review course and passing the examination fulfills the requirements for Level 1 Plant Technician certification.

This is a review course on asphalt mixes, and not a training course on asphalt mixes. Therefore, a working knowledge of basic principles and procedures for asphalt mix design is necessary. Recommendation by signature of a Certified Asphalt Plant Technician and of a PENNDOT District Materials Engineer/District Materials Manager, and a minimum of 500 hours of work experience related to asphalt production plants are required to qualify for this course. The certification period is five years. Renewal of certification may be obtained according to procedures described in PENNDOT Pub. 351.

Course materials include a notebook compiled by NECEPT that contains numerous PENNDOT documents: specifications for materials sampling, testing and acceptance; Bulletin 27 with guidelines for designing Superpave mixtures; PENNDOT test methods (PTMs) and related AASHTO methods. The course also includes plant operations and design and construction of Stone Matrix Asphalt. Participants will only be tested on the material covered throughout the course, the AASHTO test methods incorporated by PENNDOT in Bulletin 27, and Pub. 408 Specifications. The examination will be open book, consisting of multiple-choice questions. Each participant **scoring 75 (seventy-five) percent** or better will be sent a PENNDOT Asphalt Level-1 Plant Technician certificate, wallet card, and hard had sticker within three to five weeks from the exam date.

- **Picture identification is required**. Identification will be verified upon check in and on the day of the examination. Applicants will not be allowed to take the examination without picture ID**.**

- Asphalt Plant Review and Certification Courses will be conducted through either Zoom™ platform or in-person. For the online course, instructions on how to connect to Zoom™ will be provided to the course participants through email correspondence. Refer to the training section under NECEPT website (superpave.psu.edu) to find out which courses are offered online, and which courses are offered in person.

- For virtual courses, the written exam will be conducted online. For in-person courses, the written exam will be managed in class on the last day of the course and will include paper copies. For online exams, participants should have access to a calculator and adesktop/laptop computer with webcam capability.

- For online courses, at the end of each course module, there will be a short quiz and a short break.

PLANT TECHNICIAN CERTIFICATION

Review & Certification Course

COURSE AGENDA (In-Person Classes)

Instructors: Mansour Solaimanian, PhD., P.E.
Behnam Jahangiri, PhD

DAY 1

Time*	Module	Topic
7:30 am – 8:00 am		Registration
8:00 am – 8:30 am	**0**	**Introduction & Orientation**
8:30 am – 8:50 am	**1**	**Technician's Responsibilities**
8:50 am – 9:10 am	**2**	**Safety First**
9:10 am – 10:05 am	**3**	**Introduction to Asphalt Binders**
10:05 am – 10:20 am	-	BREAK
10:20 am – 11:15 am	**4**	**Aggregate Testing, Properties, and Gradation**
11:15 am – 12:00 pm	**5**	**Aggregate Blending**
12:00 pm – 1:00 pm	**-**	LUNCH BREAK
1:00 pm – 2:00 pm	**6**	**Specific Gravity and Absorption of Aggregates and Asphalt Mixes**
2:00 pm – 3:00 pm	**7**	**Analysis of Volumetric Parameters**
3:00 pm – 3:30 pm	-	REVIEW & OPEN DISCUSSION
3:30 pm – 3:45 pm	**-**	**Dismissal**

- **Times and durations are tentative and subject to change.**

PLANT TECHNICIAN CERTIFICATION
Review & Certification Course
COURSE AGENDA (In-Person Classes)
Instructor: Mansour Solaimanian, PhD., P.E.
Behnam Jahangiri, PhD

DAY 2		
Time*	Module	Topic
8:00 am – 9:20 am	**8**	**PENNSYLVANIA ASPHALT SPECIFICATIONS**
9:20 am – 10:15 am	**9**	**PENNSYLVANIA AND AASHTO TEST METHODS**
10:30 am – 10:45 am	-	BREAK
10:45 am – 12:00 pm	**10**	**PENNDOT BULLETIN 27**
12:00 pm – 1:00 pm	-	LUNCH BREAK
1:00 pm – 1:30 pm	**11**	**PLANT QUALITY CONTROL**
1:30 pm – 2:15 pm	**12**	**ASPHALT MIX PLANT OPERATION**
2:15 pm – 2:30 pm	-	BREAK
2:30 pm – 3:15 pm	**13**	**ASPHALT MIX SEGREGATION**
3:15 pm – 4:00 pm	**14**	**STONE MASTIC ASPHALT**
4:00 pm – 4:30 pm	-	DISCUSSION & DISMISSAL

Times and durations are tentative and subject to change.

PLANT TECHNICIAN CERTIFICATION

Review & Certification Course

COURSE AGENDA (Online Classes)

Instructors: Mansour Solaimanian, PhD., P.E.
Behnam Jahangiri, PhD

DAY 1

Time*	Module	Topic
7:30 am – 8:00 am		Registrants Connect to the Webinar
8:00 am – 8:30 am	**0**	**Introduction & Orientation**
8:30 am – 8:50 am	**1**	**Technician's Responsibilities**
8:50 am – 9:20 am	**2**	**Safety First**
9:20 am – 9:30 am	1&2	POLLING QUESTIONS & BREAK
9:30 am – 10:20 am	**3**	**Introduction to Asphalt Binders**
10:20 am – 10:30 am	3	POLLING QUESTIONS & BREAK
10:30 am – 11:30 am	**4**	**Aggregate Testing, Properties, and Gradation**
11:30 am – 12:30 pm	4	POLLING QUESTIONS & LUNCH BREAK
12:30 pm – 1:15 pm	**5**	**Aggregate Blending**
1:15 pm – 1:30 pm	5	POLLING QUESTIONS & BREAK
1:30 pm – 2:30 pm	**6**	**Specific Gravity and Absorption of Aggregates and Asphalt Mixes**
2:30 pm – 2:45 pm	6	POLLING QUESTIONS & BREAK
2:45 pm – 3:45 pm	**7**	**Analysis of Volumetric Parameters**
3:45 pm – 4:30 pm	7	POLLING QUESTIONS, DISCUSSION & DISMISSAL

- **Times and durations are tentative and subject to change.**

PLANT TECHNICIAN CERTIFICATION

Review & Certification Course

COURSE AGENDA (Online Classes)

Instructor: Mansour Solaimanian, PhD., P.E.
Behnam Jahangiri, PhD

DAY 2		
Time*	Module	Topic
7:30 am – 8:00 am		Registrants Connect to the Webinar
8:00 am – 9:20 am	**8**	**8. PENNSYLVANIA ASPHALT SPECIFICATIONS**
9:20 am – 9:35 am	8	POLLING QUESTIONS & BREAK
9:35 am – 10:30 am	**9**	**9. PENNSYLVANIA AND AASHTO TEST METHODS**
10:30 am – 10:45 am	9	POLLING QUESTIONS & BREAK
10:45 am – 12:00 pm	**10**	**10. PENNDOT BULLETIN 27**
12:00 pm – 1:05 pm	10	POLLING QUESTIONS & LUNCH BREAK
1:05 pm – 1:35 pm	**11**	**11. PLANT QUALITY CONTROL**
1:35 pm – 1:50 pm	11	POLLING QUESTIONS & BREAK
1:50 pm – 2:00 pm	**12**	**12. ASPHALT MIX PLANT OPERATION**
2:00 pm – 2:15 pm	12	POLLING QUESTIONS
2:15 pm – 3:00 pm	**13**	**13. ASPHALT MIX SEGREGATION**
3:00 pm – 3:15 pm	13	POLLING QUESTIONS & BREAK
3:15 pm – 4:00 pm	**14**	**14. STONE MASTIC ASPHALT**
4:00 pm – 4:30 pm	14	POLLING QUESTIONS, DISCUSSION & DISMISSAL

Times and durations are tentative and subject to change.

N E C E P T

Asphalt Pavement Construction Program

Bituminous Plant Technician Certification

Presented By

Northeast Center of Excellence for Pavement Technology

2024

Northeast Center of Excellence for Pavement Technology

NECEPT

Asphalt Construction Program

Asphalt Plant Technician Certification
(Level I Certification)

Presented by

Northeast Center of Excellence for Pavement Technology

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Introductory Topics

- Certification Categories
- Certification Requirements
- On-Line Registration
- Course Objective
- Course Agenda
- Acronyms
- Housekeeping Items

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Certification Categories

- Asphalt Field Technician
- Asphalt Plant Technician Level I
- Asphalt Plant Technician Level II
- Concrete Field Testing Technician
- Aggregate Technician
- PG Asphalt Binder Technician
  - (Binder Course is through NETTCP)

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NECEPT

Website: www.superpave.psu.edu

Email: superpave@psu.edu

Covers PENNDOT Certification Program

Click on Training to Access Course Information:

Courses, Registration, Schedule & Agenda, Pub 351, FAQ

PennState College of Engineering | NORTHEAST CENTER OF EXCELLENCE FOR PAVEMENT TECHNOLOGY

Program Assistant

(814-863-1293)

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On-Line Registration

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Certification Publications

- Asphalt: PennDOT Pub 351
- Concrete: PennDOT Pub 536
- Aggregate: PennDOT Pub 725

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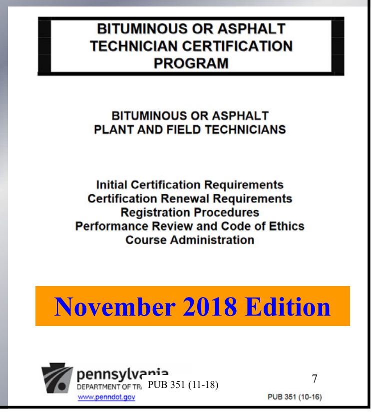
Certification Requirements

Covered in Publication 351


BITUMINOUS OR ASPHALT TECHNICIAN CERTIFICATION PROGRAM

BITUMINOUS OR ASPHALT PLANT AND FIELD TECHNICIANS

Initial Certification Requirements
Certification Renewal Requirements
Registration Procedures
Performance Review and Code of Ethics
Course Administration

November 2018 Edition

pennsylvania DEPARTMENT OF TR... PUB 351 (11-18) 7
www.penndot.gov PUB 351 (10-16)

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PennDOT Publication 351

- Publication 351 Covers
  - Requirements for Initial Certification
  - Requirements for Recertification
  - Application Procedure
  - Exam Review & Retests
  - Code of Ethics
  - Covers both plant and field tech certification
- Certification Program developed to satisfy requirements of Code of Federal Regulations, 23 CFR, Part 637, QA Procedures for Construction

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PennDOT Publication 351
Code of Ethics

- **1. Beneficence/Autonomy: demonstrate concern for the welfare and dignity of the recipients of the services, including Department personnel.**
- **2. Competence: maintain high standards of professional competence**
- **3. Public Information: provide accurate information about Asphalt technician services**
- **4. Professional Relationships: function with discretion and integrity in relation with colleagues and other professionals.**

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Certification Requirements
Asphalt Level I Plant Technician

Pub 351: Section VII

- **500 hours of documented** experience in asphalt laboratory or plant since date of last certification.
- **sign-off from supervisor** or from a Level II Tech in company.
- **sign-off from PennDOT** DME/DMM.
- Must attend and pass NECEPT Level I Plant Tech Course

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Renewal/Recertification
Asphalt Level I Plant Technician

Pub 351: Section XII (Option A)

- Must have been Level I certified for previous 5 years
- Must have **500 hours of documented** experience in asphalt lab or plant performing QC/QA testing or inspection since date of last certification
- Must have **sign-off from supervisor** or from a Level II Tech in company.
- Must have **sign-off from PennDOT** DME/DMM Within the previous 5 years, must have attended :
  - Two NECEPT Plant Technician Update/Refresher Courses, or….
  - One NECEPT Update/Refresher Course and one or more acceptable asphalt-related conferences, seminars, or workshops

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Examples of Accepted Asphalt-Related Annual Conferences, Seminars, and Workshops

- Annual APC Conferences
- Annual PAPA Conference
- Annual PAPA Regional Technical Meetings
- Annual Asphalt Pavement Conference from any MARTCP states
- Mid-Atlantic States QAW
- Nationally Recognized Conferences or Courses (NAPA, NCAT, NEAUPG, …)
- PennDOT pre-approved Department or Industry sponsored training

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Accepted Asphalt-Related Annual Conferences, Seminars, and Workshops

Abbreviations for Terms

- APC: Associated Pennsylvania Contractors
- PAPA: Pennsylvania Asphalt Pavement Association
- MARTCP: Mid-Atlantic Reciprocity Certification Program states
- QAW: Quality Assurance Workshop
- NAPA: National Pavement Association
- NCAT: National Center for Asphalt Technology

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Requirements for the Learning Activity to be Acceptable for NECEPT Asphalt Certification

- Total asphalt related course material must add up to **SIX hours**.
- **Example 1**. A technician attends three winter schools within the five years during their current certification. Each of these three courses has two hours of asphalt related topics. Total adds up to six hours of asphalt relevant training and that is acceptable as a learning activity.
- **Example 2**. A technician takes a one-day national workshop or webinar fully allocated to asphalt related topics. Such workshop or webinar satisfies the requirements and is acceptable as a learning activity.

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Course Objectives

This is a course for certification as an Asphalt Plant Level I Technician.

- The course objectives are
  - To learn about the primary materials used in asphalt concrete mix
  - To understand basic concepts of asphalt mix design
  - To understand relevant PennDOT/AASHTO specifications and tests
  - To conduct basic calculations for asphalt mix design

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Plant Technician Certification – Level I Course Agenda

- **1. Technician's Responsibilities**
- **2. Safety First**
- **3. Introduction to Asphalt Binders: Properties, Grading, and Tests**
- **4. Introduction to Aggregates: Properties, Gradation, and Tests**
- **5. Aggregate: Blending Different Stockpiles**
- **6. Aggregate and Asphalt: Specific Gravity and Absorption**
- **7. Asphalt Concrete: Analysis of Volumetric Parameters**
- **8. PennDOT Asphalt Specifications**
- **9. PennDOT/AASHTO Test Methods**
- **10. PennDOT Bulletin 27**
- **11. Plant Quality Control**
- **12. Asphalt Plant Operation**
- **13. Material Segregation in the Plant**
- **14. Stone Mastic Asphalt**

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ACRONYMS

01. AASHTO: American Association of State Transportation Officials (www.transportation.org)
02. AET: Asphalt Emulsion Tack
03. AI: Asphalt Institute (www.asphaltinstitute.org)
04. ATPBC: Asphalt Treated Permeable Base Course
05. DME/DMM: District Materials Engineer/District Materials Manager
06. ESAL: Equivalent Single Axle Load
07. FHWA: Federal Highway Administration (www.fhwa.dot.gov)
08. HMA: Hot Mix Asphalt
09. JMF: Job Mix Formula
10. LTS: (PennDOT) Laboratory Testing Section

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ACRONYMS

11. MTV: Materials Transfer Vehicle
12. NAPA: National Asphalt Paving Association (www.asphaltpavement.org)
13. NECEPT: Northeast Center of Excellence for Paving Technology (www.superpave.psu.edu)
14. NMAS: Nominal Maximum Aggregate Size
15. OSHA: Occupational Safety and Health Administration (www.osha.gov)
16. PAPA: Pennsylvania Asphalt Pavement Association (www.pahotmix.org)
17. PG: Performance Grade
18. PTM: Pennsylvania Test Method (ftp://ftp.dot.state.pa.us/public/pdf/BOCM_MTD_LAB/PUBLICATIONS/PUB_19/PTM_TOC.pdf)
19. QC/QA: Quality Control / Quality Assurance
20. RPS: Restricted Performance Specifications

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N E C E P T

ACRONYMS

21. PWL: Percent Within Limits
22. RAM: Reclaimed Aggregate Material
23. RAP: Reclaimed Asphalt Pavement
24. RAS: Recycled Asphalt Shingle
25. SGC: Superpave Gyratory Compactor
26. SRL: Skid Resistance Level
27. SMA: Stone Matrix Asphalt (Stone Mastic Asphalt)
28. TSR: Tensile Strength Ratio
29. VFA: Voids Field with Asphalt
30. VMA: Voids in the Mineral Aggregate
31. WMA: Warm Mix Asphalt

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Housekeeping

1. Attendance and Participation
2. Course Schedule and Breaks
3. Quiz at the end of each Module
4. Access to Course Material
5. Videos
6. Written Exam

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1. Attendance and Participation (only for online courses)

- Attendance in the course through Zoom is required.
- Zoom record must show at least 90% attendance.
- Participants' webcams will be off.
- Participants' microphones will be off.
- Have your speakers ON.
- Questions can be asked through Zoom.
- Attendance monitored through Zoom.

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1. Attendance and Participation only for online courses

How to use Q/A and Chat Buttons on Zoom Webinar:

Remember these two rules:

1. **Do you want to ask questions?**
   Then USE Q/A

2. **Do you want to answer the instructor's questions?**
   Then USE CHAT

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2. Course Schedule and Breaks (only for online courses)

- Part 1: Today, finish at 4:30 P.M.?
- Part 2: Wednesday– one day. Will start at 8 A.M.
- Breaks: Short Breaks (5 to 10 minutes) at the End of each Module (after quiz)

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3. Quiz at the end of each module (only for online courses)

- Short Quiz – Self Graded
- 5 to 10 Questions
- 5 to 8 minutes
- REQUIRED:
  - Must answer **85 percent** of questions
  - Not graded for correct or wrong answers

NOTE: At the end of the module, take the quiz first before taking a break. The quiz time is limited and will not be reopened.

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4. Access to Course Material (only for online course)

Course Material:

is available online at the link provided to registrants (through Penn State Canvas).

Optional:

Have a printed copy of the course material available for review during the course and the exam. You could also review the course material online.

Mandatory:

Print the Hands-out Portion of Course Material. Will work with this material through the course

NOTE: For in-person classes, the course material is available at superpave.psu.edu

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5. Videos

There are three videos to be watched for this course:

- **Mixing and Compaction in the Lab (2.5 min., Module 7)**
- **Sampling and Truck Loading (4.2 min, Modules 11 and 13)**
- **How An Asphalt Plan Works (51 min, Module 12)**

You must have watched the videos before start of the course. If you have not, please allocate time to watch them before the second day of the course. The link to the videos is available through the Course Material Link in Canvas for online courses as well as at the Superpave.psu.edu.

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6. Written Exam

- Written Test will be online if the course is held online and will be in-person if the course is held in person.
- For online courses, the exam will be accessible on the exam date/time in Penn State Canvas.
- Exam has 60 multiple choice questions.
- Passing grade is 75% correct answers.
- One retest is allowed after 30 days from the date of the first test but completed within 120 days from the date of the first test.

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6. Written Exam (Continued)

For online exam, on the Exam Date, follow these three steps:

1. Log into Canvas
2. Log into Zoom and have your webcam on. Maintain Zoom connection and your webcam on during the exam.
3. Start taking the exam on Canvas.

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Plant Technician Certification Program

Module 1

Asphalt Plant Technician's Responsibilities

Northeast Center of Excellence for Pavement Technology

NECEPT

Plant Technician Certification Program

Module 1

Asphalt Plant Technician's Responsibilities

1

Module 1 – Objectives

- **To understand:**
  - **What is a Certified Bituminous Plant Technician?**
  - **and**
  - **What are responsibilities of a Certified Bituminous Plant Technician?**

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What is a Certified Bituminous Plant Technician?

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Certified Bituminous Technician

- A technician who has satisfied a set of minimum requirements to become a certified bituminous technician.
- The requirements were established in response to the Code of Federal Regulations, 23 CFR, Part 637, Quality Assurance (QA) Procedures for Construction, issued June 29, 1995.
- These Federal Regulations required that all sampling and testing data to be used in the acceptance decision or the independent assurance program will be executed by qualified sampling and testing personnel

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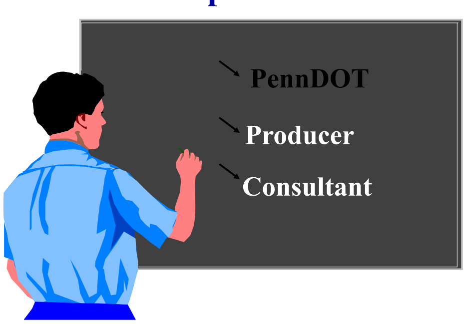
Whom does the Technician Represent?



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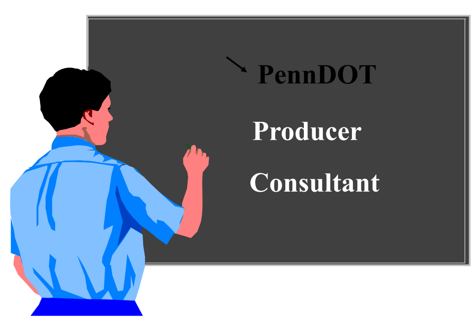
What are my duties? If I work for…….



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What are my duties?
If I work for the…….

PennDOT

Producer

Consultant

7

7

What are my duties?
If I work for the…….

PennDOT

Producer

Consultant

8

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What Are Your Responsibilities ?

1. Know the specifications
2. Know the PTMs & AASHTO tests needed to ensure a quality mixture
3. Be familiar with plant operation
4. Recognize mixture deficiencies
5. Be able to recommend corrective action
6. Adhere to the four principals of the code of ethics

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What are the four principles of the code of ethics ?

1. Beneficence/Autonomy: demonstrate concern for the welfare and dignity of the recipients of the services, including Department personnel.

2. Competence: maintain high standards of professional competence.

3. Public Information: provide accurate information about bituminous technician services.

4. Professional Relationships: function with discretion and integrity in relation with colleagues and other professionals.

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Example of Responsibilities

- Conduct relevant asphalt tests
- Sample stockpiles for testing
- Conduct mix design
- Communicate with the plant operator
- Communicate with field technicians & field operators
- Be familiar with various forms, for example:
  - Sample Identification Form: TR-447
  - Job Mix Formula Report Form: TR-448A

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TR-448A (6-15) JOB MIX FORMULA REPORT

Supplier Code: pave 123 | Material Class: SR25BC

pennsylvania DEPARTMENT OF TRANSPORTATION

PennDOT Mix Design Designation — Year: 2015 | Number: 5220R

Supplier JMF/Design Number (Optional)

Design ESAL Range: 0.3 to < 3 Million
Aggregate Skid Resistance Level: Non-Applicable
Mixure Final Asphalt Binder Grade: PG6422
Asphalt Mix Type: HMA
Gradation Classification: Coarse-Graded
Original Approval Date
JMF Status: Approved

Supplier: Pave , Inc | Location: anywhere
ECMS Number | PO No.-Line Item No. | 408 Spec
SR & Contractor | Plant Type: AB | Plant: 10 | Location
Mix Time: Dry(s) 5 | Wet(s) 35

Material Supplier	Material Code - Class	Product Name	%	Spec.	%
HAP41A14	207 (Aggregate Fine) - A	Sand A1	4.100	2.568	1.72
HAP41B14	207 (Aggregate Fine) - B3	B3 (W)	16.400	2.663	1.37
HAP41B14	203 (Aggregate) - A467	A467	17.400	2.724	0.89
HAP41B14	203 (Aggregate) - A57	A57	36.100	2.710	1.33
HAP41B14	203 (Aggregate) - A8	A8	7.300	2.698	1.27
NOBLT 14	17 (Hot Rap Design) - RAP	RAP	15.000	2.740	0.00
UNRC0 15	1 (Asphalt Cement) - PG6422	AC	3.700	1.031	

JOB MIX FORMULA AND DESIGN

A.C. / Sieve Size	A.C%	#200	#100	#50	#30	#16	#8	#4	3/8"	1/2"	3/4"	1"	1 1/2"
Design Target	4.4	4.0	5	7	12	17	25	37	53	66	86	96	100

% Virgin A.C.	3.7	% Reclaimed A.C. from RAP	0.70	Total % Asphalt (Pb)	4.4
Virgin A.C. PG Binder Grade	PG6422	% Reclaimed A.C. from RAS		% Eff. Asphalt Binder	4.1
Calc. Asp. Film Thickness	11.20	Total Reclaimed Binder Ratio	0.16	Fines / Asphalt (F/A) Ratio	1.0

MIX CHARACTERISTICS (GYRATORY)

Design ESAL Range	Mold Diameter (mm)	# Gyrations at Ninitial	# Gyrations at NDesign	# Gyrations at NMaximum	Voids in Mineral Aggregate (VMA) %	Theoretical Max. Sp. Grav. (Gmm)	Bulk Sp. Grav. of Mixture (Gmb)
0.3 to < 3 Million	150	7	75	115	13.8	2.537	2.436
Bulk Sp. Grav. of Combined Aggr.(Gsb)	**Mixture Mass to Compact (g)**	**% Air Voids at Ninitial**	**% Aid Voids at NDesign**	**% Air Voids at NMaximum**	**Voids filled with Asphalt (VFA) %**	**Theoretical Max. Density (lbs/ft3)**	**Bulk Density of Mixture (lbs/ft3)**
2.701	4,740.0	14.5	4.0	2.6	71.0	157.9	151.6

ASPHALT CONTENT TEST METHOD

A.C. Test Method	External Party Oven Make/Model	Furnace Temp (°C)	Sample Size for C.F.	Asphalt	200 C.F.
PTM No. 757	Thermolyne/NCAT AP-20x	538.0	2,000.0	0.47	0.00

MOISTURE SUSCEPTIBILITY DATA

A.C. Supplier	Name	Dry PSI Strength	Wet PSI Strength	TSR Value	Date of TSR	Date of Boil Test
UNRC0 15	AC	105.7	100.4	0.95	11/9/09	11/9/09

COMBINED AGGREGATE CONSENSUS PROPERTIES

AASHTO T 176 Sand Equivalency (%)	AASHTO T 304 Fine Aggr. Angularity Uncompacted Voids (%)	ASTM D5821 - Coarse Aggregate Angularity % 1 Face Crush	ASTM D5821 - Coarse Aggregate Angularity % 2 Face Crush	ASTM D4791 Flat / Elongated Particles 5:1	ASTM D4791 Flat / Elongated Particles 3 SMA	Total % Reclaimed Agg. From RAP and / or RAS
89.6	45.9	100.0	100.0	1.6		14.3

Designed By : designer | Designed By Certification ID : ROBIN | Designed 4/1/11
Submitted By : submitter | Submitted By Certification ID : BATMAN | Submitted 7/21/15
Approved By : approver | Approved By Certification ID : Materials Engineer | Approved 7/21/15

Print ####### 7:47:45 AM | Page 1 of 1

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Be Familiar with PennDOT Publication 351

BITUMINOUS OR ASPHALT
TECHNICIAN CERTIFICATION
PROGRAM

BITUMINOUS OR ASPHALT
PLANT AND FIELD TECHNICIANS

Initial Certification Requirements
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DEPARTMENT OF TRANSPORTATION
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PUB 351 (11-18)

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Your Effort Towards Achieving A Quality Product Makes The Difference Between A Great Job And A Mediocre One.

- **MAKE THE EFFORT**

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Plant Technician Certification Program

Module 2

Safety First

Northeast Center of Excellence for Pavement Technology

NECEPT

Plant Technician Certification Program

Module 2
SAFETY FIRST!

1

Safety First!

- Two Major Priorities
  - Your Safety
  - Lab Safety

2

Safety

"If for no other reason,
You
Owe it to Yourself
to be
Safe!"

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Safety Concerns
in
Handling Asphalt

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Safety Concerns in Handling Asphalt

- Asphalt Fumes (Need fume hood in the lab)
- Hot Asphalt Liquid or Mix (Burns!)
- Fire & Explosion Hazard from Heated Asphalt
  - Flammable Vapors
  - Water splashing into asphalt

Keep working temperature well below Flash Point of material.

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Safety Concerns in Handling Asphalt

- Get Training and Use Safe Practice at Work
- Know Available Resources
- Read and Follow SDS (previously known as MSDS)

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Safety
Hot Liquid Asphalt Handling

- Safe Heating Temperature
  - – Function well below <u>Flash Point</u> of material
- Application temperature
  - SDS (MSDS) – law since 1984
  - PennDOT Bulletin #25 (Pub 37: Specs for Bituminous Materials) – Nov. 2018
  - Shipping Bill of Lading

(M)SDS: (Material) Safety Data Sheet

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FIRST AID for Hot Asphalt Burns

- DO NOT attempt to remove asphalt from the skin.
- Submerge affected area in ice water.
- Seek medical attention.

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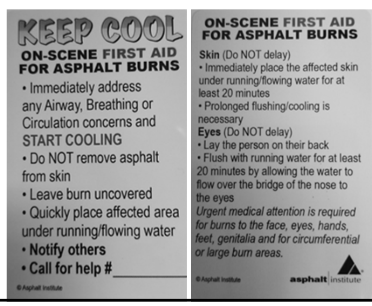
FIRST AID for Hot Asphalt Burns

Source:
Asphalt Institute



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If overcome by Asphalt Fumes

- Move person to fresh air.
- Administer oxygen if breathing is difficult.
- Seek medical attention.

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Safety Data Sheet (SDS)
(formerly known as MSDS)

- Required for any Hazardous Material
- No Standard Form but Standard Content
- SDS: a Very Useful Guide
- Match with the Label on the Product
- SDS more detailed and technical than Label
- Must have easy access to SDS

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Contents of SDS

- 16 Major Sections, appear in order
  1. Product Identification (Name, Contact)
  2. Hazard Identification (e.g., flammable liquid, …)
  3. Composition/Information on Ingredients
  4. First Aid Measures (inhalation, skid/eye contact, …)
  5. Fire Fighting Measures (fire extinguisher, protection)
  6. Accidental Release Measures
  7. Handling and Storage (e.g., ventilation requirements)
  8. Exposure Control, Personal Protection

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Contents of SDS

- 16 Major Sections, appear in order
  9. Physical and Chemical Properties (density, flash point, …)
  10. Stability and Reactivity
  11. Toxicological Information
  12. Ecological Information (envir. impact, non-mandatory)
  13. Disposal Considerations (methods, non-mandatory)
  14. Transport Information
  15. Regulatory Information (health, safety, and envir. regulations)
  16. Other Information

13

Product Identification

- Standard Information
  – Name of the Substance
  – Name, Address, and Phone Number of the Manufacturer or Distributor

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Hazardous Ingredients

- Chemical Identity and Concentrations of Ingredients

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Physical/Chemical Characterization

– Boiling Point
– Vapor Pressure and Density
– Rate of Evaporation
– Specific Gravity
– Percent Volatiles
– Odor and Appearance

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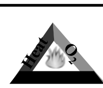
Fire/Explosion Hazards



- Flash Point
  – Lowest temperature for vapor to ignite
    - Gasoline: -45°F (-43°C)
    - Diesel Fuel: 100-130°F (38-55°C)
- Flammable versus Combustible Liquids
  – Flash point < 100°F : **Flammable**
    (can easily catch fire, can be ignited at room temperature) – Gasoline, Toluene
  – Flash point > 100°F : **Combustible**
    (needs higher temperatures to generate vapor to ignite) – Kerosene, Diesel Fuel

Question:
Is asphalt binder flammable or combustible? **It is Combustible (Flash Point ≈ 500°F)**

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Fire/Explosion Hazards

Explosion at Asphalt Plant (OK, July 2021)
SOURCE: https://www.kxii.com/2021/07/16/explosion-ardmore-asphalt-plant/

Top of asphalt tank ripped off (NJ, June 2020)
SOURCE: https://www.youtube.com/watch?v=ckFJoS5j63A 18

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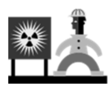
Health Hazard Information

- Permissible Exposure Limit (PEL)
  - Chemical concentration most often reported in ppm (parts per million):
    - Mass of the component divided by total mass of solution, multiplied by million.
  - Or reported in mg/M^3



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Reactivity Data

- Keep Chemicals Separate from
  - Other chemicals
  - High Temperature
  - Moisture
  - Air
  - Rough Handling

FIRE TRIANGLE: Heat, Oxygen, Fuel

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Safe Handling

- In Case of Spill or Leak

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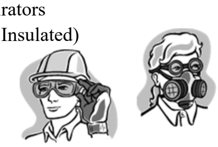
Protective Equipment

- Exposure Control (Engineering Control)
  - Ventilation (Fume Hoods, Local Exhaust Ventilation)
  - Sound Dampening
  - Radiation Shielding
- Personal Protective Equipment (PPE)
  - Respiratory Protection - Respirators
  - Protective Gloves (Thermally Insulated)
  - Eye Protection – Goggles
  - Hearing Protection
  - Hard Hats
  - Safety Vest



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Protective Equipment

- 29 CFR 1926.95(a) requires protective equipment to be worn "whenever it is necessary by reason of hazards...."

CFR: Code of Federal Regulations

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Sources for Safety Information

- Occupational Safety & Health Administration (OSHA) - U.S. Department of Labor
- Preventing Fires & Explosions in Hot Mix Asphalt Plants (NAPA)
- Employee Hazard Communication Guidebook (NAPA)
- Material Safety Data Sheets (NAPA)
- Best Management Practices to Minimize Emissions During HMA Construction (NAPA, AI, SAPA)

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N E C E P T

Plant Technician Certification Program

Module 3
Introduction to Asphalt Binders

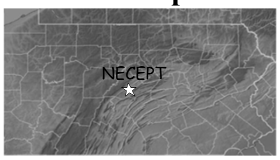
Northeast Center of Excellence for Pavement Technology

NECEPT

PENNSTATE

Plant Technician
Certification Program

Module 3
Introduction to Asphalt Binders



NECEPT

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Topics related to Asphalt Binder

- Terms
- Production
- Properties
- Grading
- Tests
- Specification

NECEPT

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UNDERSTANDING TERMINOLOGY

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There are Many Terms:

- Tar (is not asphalt)
- Terms for Binder:
  - Neat Binder (Unmodified)
    - Asphalt, Asphalt Cement, Asphalt Binder
    - Bitumen, Virgin Binder
  - Modified Binder
    - Polymer Modified Binder (PMB)
    - Crumb Rubber Modified Binder (CRM Binder)
    - Fiber re-enforced Binder
- Emulsions
- Cutbacks
- Asphalt Concrete (Bituminous Concrete)

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Coal Tar

- Viscous black liquid from <u>destructive distillation</u> of coal
- Contains numerous organic compounds
- Applications
  - roofing, waterproofing, and insulating compound
  - raw material for many dyes, drugs, and paints.

Destructive Distillation: <u>heating solid material (Coal) at high temperature without contact with air</u>. Produces by-products: Coke, Coal Tar, Amino Acid Liquor, and Coal Gas

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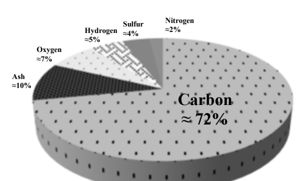
PENNSTATE

Coal Tar

An Example of Coal Composition



Tar comes from Viscous black liquid from <u>destructive distillation</u> of coal

NECEPT

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Asphalt

- Viscous black liquid, fractional distillation of oil (a by-product of oil refining process)
- Contains numerous organic compounds
- Applications
  - road construction, roofing shingles, waterproofing

fractional distillation: Separating volatile components of a mixture (oil) from one another by heating the mixture in a column and collecting and condensing the vapors drawn from different levels of the column.

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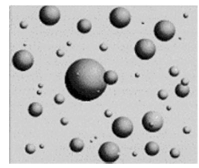
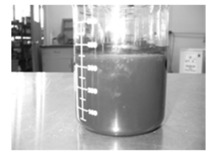
Asphalt Emulsions

- Finely divided asphalt droplets, dispersed in a water phase using an emulsifier (chemical stabilizer)





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Asphalt Cutbacks

- Blend of Asphalt Cement and a Petroleum Solvent

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ASPHALT PRODUCTION

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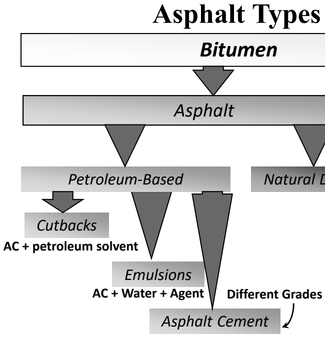
Asphalt Types



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Asphalt Types

Naturally Occurring Asphalt

Pitch Lake, Trinidad

Roughly 500 barrels a day
Roughly 75 m (246 ft) deep

Largest Asphalt Lake in the World

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Asphalt Types

Naturally Occurring Asphalt

Rock Asphalt

- Porous rock such as sandstone or limestone impregnated with natural asphalt through a geological process
- Mostly in Texas, California, Oklahoma, Kentucky, and Alabama
- Mostly applied in construction of rural roads

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Petroleum-Based Asphalts

- Asphalt is by-product from refining process of crude oil
  - Sometimes called the ***"bottom of the barrel"***
- Properties depend on:
  - Refinery operations
  - Crude source

Barrel of Crude Oil

Gasoline (19.5 gal.)
Liquid Petroleum Gas (LPG)
Kerosene

Diesel
Motor Oils
Gas Oil

Asphalt (≈ 1.3 gal.)

Question: How many gallons are in one barrel of crude oil?

Answer: 42 gallons
(established based on water-tight wooden barrels made in mic-1800s).

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PROPERTIES OF ASPHALT BINDER

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Asphalt Properties

- Cold: Elastic Response to Load
- Hot: Viscous Response to Load
- High Rate of Loading: Elastic Response
- Low Rate of Loading: Viscous Response

Asphalt Behavior?:

Viscoelastic Response

or

Viscoelastoplastic Response

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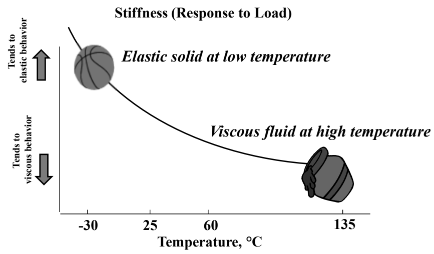
Asphalt Properties
(highly depends on Temperature)



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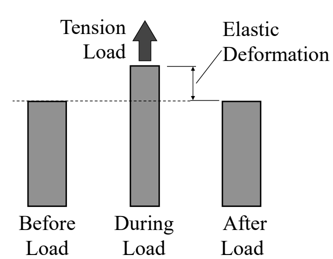
Asphalt Properties
(understanding elastic behavior)



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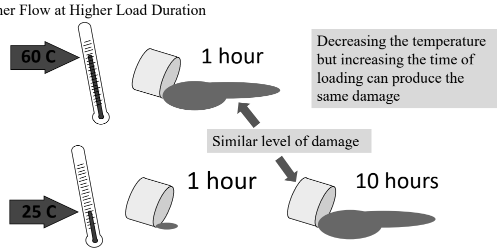
Asphalt Properties

Highly Dependent on Time and Temperature

- Higher Flow at Higher Temperature (Less Viscosity)
- Higher Flow at Higher Load Duration



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Asphalt Aging (Age Hardening of Asphalt)

- **Asphalt hardens with time due to loss of volatile components and oxidation.**
- **With aging, asphalt becomes**
  - Hard
  - Highly viscous
  - Brittle

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Asphalt Aging

- **Volatilization**
  - Mostly a short-term phenomenon (happens at early age)
  - Volatile components (lighter petroleum products) evaporate
  - Occurs during mixing, hauling, and placement
  - An irreversible process
- **Hardening due to Oxidation**
  - Mostly a long-term phenomenon (happens through years)
  - Changes in properties (chemical and physical) over time
  - Increase of viscosity
  - Increase of stiffness
  - Increase of Brittleness
  - Decrease in molecular weight
  - Decrease in quantity of oil component
  - Irreversible

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Aging, cont'd

- **Oxidation (leading to hardening of asphalt)**
  - A Long-term process
  - Organic molecules react with oxygen
  - Occurs faster in warmer climates
  - Irreversible

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Aging

- **Three Stages for Aging:**
  - During mixing and construction (Considered **short-term** aging)
  - Early years in the pavement's life (Considered **short-term** aging)
    - Post construction to roughly a year or two
  - Late in the pavement's life (Considered **long term** aging)
    - During long-term pavement service life

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Binder Properties Affecting Performance

- Constructability: ***Viscosity***
  - Pumping
  - Mixing
  - Compaction

  Construct Viscosity-Temperature Relationship Curve
- Distresses: ***Stiffness and Strength***
  - Rutting — *High Temperature*
  - Fatigue Cracking — *Moderate Temperatures*
  - Thermal Cracking — *Low Temperature*

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Asphalt Binders: Testing

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Review

- Reason for Testing!
- Pavement Distresses?
- Asphalt Binder Tests
- Summary

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WHY DO WE NEED TO TEST ASPHALT BINDERS?

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Testing Asphalt Binders

We Test An Asphalt Binder To Ensure that

– the binder satisfies specifications

– the binder is of the quality to resist development of distresses

– proper capturing of asphalt behavior at different stages during pavement service life

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Binder Tests

- **Take into Account Three Factors**
  - Temperature
  - Time
  - Aging Effect

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Asphalt Binder Tests

Temperature is IMPORTANT.

- High Temperature: typically over 90°F (32°C)
- Intermediate Temperature: typically in the range of 50°F(10°C) to 85°F (30°C).
- Low Temperature: typically below 40°F (5°C), sometimes as low as -40°F (-40°C)

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ASPHALT BINDER TESTS

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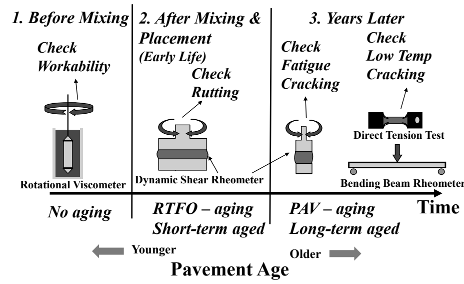
Asphalt Binder Tests

Are Performed at Different Aging Levels:



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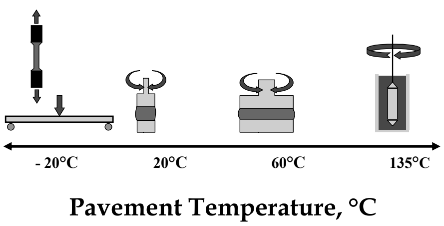
Asphalt Binder Tests

Are Performed at Different Temperatures:



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Asphalt Binders: Grading & Specifications

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Review

- Old Binder Grading Systems
- Significant of Temperature and Aging in Grading
- New Grading System (Superpave^{TM})
- Binder Specifications
- Summary

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OLD BINDER GRADING SYSTEMS

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Previous Ways to Characterize and Specify Asphalt Binders

- Penetration Grading
- Viscosity Grading

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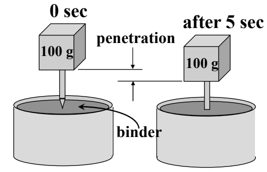
Penetration Grading

Penetration Test (25ºC, 77ºF)



Measuring penetration of a 100-gram needle after 5 seconds

One Penetration Unit = 0.1 mm

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Penetration Grades

Penetration Grade	Remarks
40-50	Hardest
60-70	Typical Grade
85-100	Typical Soft Grade
120-150	Softer
200-300	Softest

NOTE: **Pen 40-50 implies that needle penetration is 4 to 5 millimeters based on standard test procedure.**

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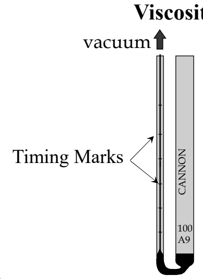
Viscosity Grading

Viscosity Test (60ºC, 140ºF)



<u>Measuring Absolute Viscosity:</u>

Measure the time it takes for a fixed volume of asphalt binder to be drawn up through a capillary tube by means of vacuum, under closely controlled conditions of vacuum and temperature

Viscosity = K.t

K = selected calibration factor

t = flow time, seconds

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Viscosity Grades

Viscosity Grade	Remarks
AC-2.5 → (250 ± 50 poise)	Softest
AC-5 → (500 ± 100 poise)	
AC-10 → (1000 ± 200 poise)	Typical Grade
AC-20 → (2000 ± 400 poise)	Typical Grade
AC-30 → (3000 ± 600 poise)	
AC-40 → (4000± 800 poise)	Hardest

NOTE: **AC-2.5 implies that the absolute viscosity of the asphalt is 250±50 poise based on standard test procedure.**

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SIGNIFICANCE OF TEMPERATURE & AGING IN ASPHALT BINDER GRADING

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Temperature Effect

- 1. Rutting occurs at high pavement temperatures, $T_{(high)}$
- 2. Fatigue Cracking occurs at intermediate pavement temperatures, $T_{(inter)}$, and
- 3. Low Temperature Cracking occurs at low pavement temperatures, $T_{(low)}$.

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Pavement Behavior at High Temperature

- Permanent Deformation
- Mixture is Plastic
  - ✓wheel path rutting
  - ✓shoving at intersections
- Depends on
  - ✓asphalt binder properties
  - ✓mineral aggregate properties and gradation

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Pavement Behavior at Low Temperature

- Thermal Cracks
  - ✓internal stresses induced by temperature change
  - ✓stresses exceed strength
- Mixture is Brittle
  - ✓transverse cracks
- Depends on
  - ✓asphalt binder properties to a large extent
  - ✓mineral aggregate properties and gradation to a little extent

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Pavement Behavior Aging Effect

- Asphalt Reacts with Oxygen
  - ✓"oxidative" or "age" hardening
- During Construction - Short Term
  - ✓hot mixing
  - ✓placing/compaction
- In Service - Long Term
  - ✓hot climate worse than cool climate
  - ✓summer worse than winter
- Volatilization - Short Term
  - ✓volatile components evaporate during construction

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Pavement Behavior Aging Effect

- Durability Cracks
- Mixture is Brittle
  - ✓random, wandering cracks
- Depends on
  - ✓asphalt cement (lots)
  - ✓mineral aggregate (little)

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Superpave Asphalt Binder Specification (Performance Grading)

The binder designation is based on expected extremes of hot and cold pavement temperatures.

PG 64 - 22

- Performance Grade (PG)
- Average 7-day maximum **pavement** temperature (64)
- Minimum **pavement** temperature (22)

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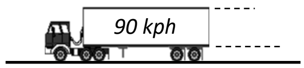
Effect of Loading Rate on Binder Selection



- **Dilemma**
  - specified DSR loading rate is 10 rad/sec
  - what about longer loading times ?
- **Use binder with more stiffness at higher temps**
  - slow - - increase one high temp grade
  - stationary - - increase two high temp grades
  - *no effect on low temp grade*

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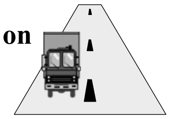
Effect of Loading Rate on Binder Selection



- **Example**
  - **for toll road PG 64-22** ← *90 kph*
  - **for toll booth PG 70-22** ← **Slow**
  - **for weigh stations PG 76-22** ← **Stopping**

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PG "Grade Bumping"

- **Effect of Traffic level and speed**
- **AASHTO M 323, Table 1:**
  - ✓ to provide guidance on grade selection.

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Grade Bumping (AASHTO M 323-17)

Traffic ESALs (Million)	Adjustment to the High-Temperature Grade of the Binder		
	Traffic Load Rate		
	Standing	Slow	Standard
< 0.3	------		------
0.3 to <3	2	1	------
3 to <10	2	1	------
10 to <30	2	1	------
≥ 30	2	1	1

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Binder Selection for Mixtures with RAP (AASHTO M 323-17)

RAP Percentage	Adjustment to Binder PG
< 15	No change in binder selection
15 to 25	Select virgin binder one grade softer than normal
> 25	Follow blending charts

NOTE: M 323-17 also covers Mixtures with RAP using RAPBR (RAP Binder Ratio)

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Binder Selection for Mixtures with RAP (AASHTO M 323-17)

RAPBR	Recommended Virgin Asphalt Grade
< 0.25	No change in binder selection
> 0.25	Follow blending charts

RAPBR: Reclaimed Asphalt Pavement Binder Ratio

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SUPERPVAE BINDER SPECIFICATION

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Binder Specification

- Performance Based
  - ✓rutting
  - ✓fatigue cracking
  - ✓low temp cracking
- Physical Properties
  - ✓criteria remain the same
  - ✓temperature changes
  - ✓measured on aged binders

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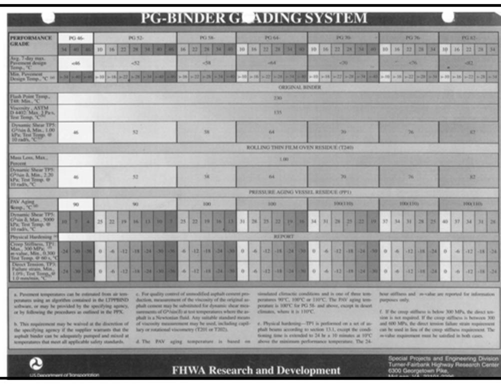
Based on AASHTO M 320



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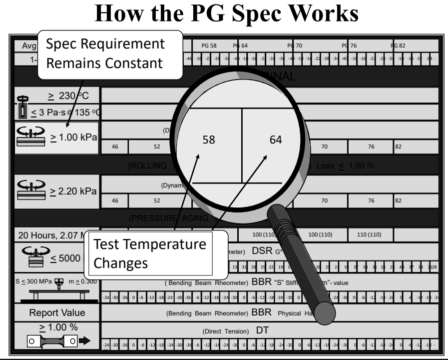
How the PG Spec Works



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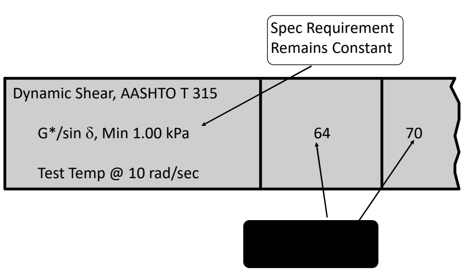
How the Spec Works



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Multiple Stress Creep Recovery (MSCR)

- **Test Method AASHTO T 350**
  Standard Method of Test for Multiple Stress Creep Recovery (MSCR)
- **AASHTO Spec M 332**
  Standard Specification for Performance-Graded Asphalt Binder Using Multiple Stress Creep Recovery (MSCR) Test

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Multi-Stress Creep and Recovery (MSCR) – AASHTO M 332

Traffic Level (million ESALs)	Binder Grade
< 3	Standard (S)
>3 and < 10	Heavy (H)
>10 and < 30	Very Heavy (V)
> 30	Extreme (E)

PennDOT now uses PG binders based on AASHTO M 332

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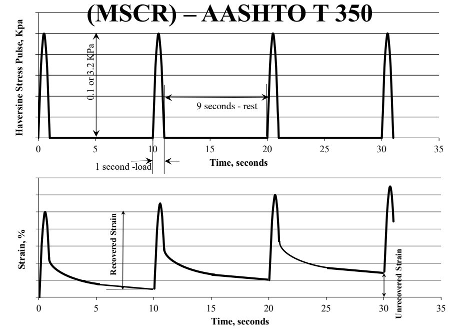
Multi-Stress Creep and Recovery (MSCR) – AASHTO T 350



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MSCR – Creep Compliance

τ = Peak Shear Stress

γ_{nr} = Non-recoverable Shear Strain

$$J_{nr} = \frac{\gamma_{nr}}{\tau}$$

J_{nr} = **Nonrecoverable Creep Compliance**

Creep Compliance defined as time dependent strain per unit of stress

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MSCR Specification

Jnr @ 3.2 KPa Stress Test Temp. = 64°C	Binder Grade
< 4.5	Standard (S)
< 2.0	Heavy (H)
< 1.0	Very Heavy (V)
< 0.5	Extreme (E)

Determine J_{nr} Stress Dependency:

$$\frac{(J_{nr@3.2KPa} - J_{nr@0.1KPa}) \times 100}{J_{nr@0.1KPa}} < 75$$

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PennDOT MSCR Specification (AASHTO M 332)

PennDOT has now moved to AASHTO M 332 Specification

AASHTO M 320 Grading	AASHTO M 332 Grading
PG 58-28	PG 58S-28
PG 64-22	PG 64S-22
PG 76-22	PG 64E-22

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Summary

- Introduction to Asphalt Binder
- Asphalt Behavior
- Tests to Characterize Binder
- Old Binder Grading Systems
- Asphalt Binder Grading System
- Asphalt Binder Specifications

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N E C E P T

Plant Technician Certification Program

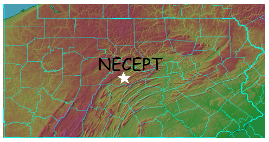
Module 4
Aggregates
Properties, Tests, and Gradation

Northeast Center of Excellence for Pavement Technology

NECEPT

Plant Technician Certification Program

Module 4
Aggregates: Properties, Tests, and Gradation



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Overview of Topics

- Size Classification
- Aggregate characteristics/properties
- Aggregate tests
- Gradation & sieve analysis / workshop
- Aggregate blending

2

2

Aggregate Classification
(**based on size in asphalt paving mixtures**)

- Coarse Aggregate **(retained on #4 Sieve)**
- Fine Aggregate **(passing #4 Sieve)**
- Mineral Filler
  - **At least 70% Passing #200 (0.075 mm) sieve**

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Aggregate Characteristics

- **Shape**
  – rounded, sub-rounded, sub-angular, angular
  – flat, elongated, fracture level
- **Surface Texture**
  – very rough, rough, smooth, polished
- **Porosity**
  – highly porous, porous, non-porous
- **Toughness**
  – resistance to wearing and abrasion under load
- **Soundness**
  – resistance to disintegration by weathering and freeze-thaw cycles

4

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Aggregate Characteristics

- **Particle Size Distribution (Gradation)**
  – Dense, Open, Gap, Uniform
- **Cleanness**
  – Free of detrimental fines
- **Specific Gravity**
  – Is a function of density, porosity and composition
- **Fracture Level**
  – Crushed aggregate versus uncrushed

5

5

Publication 408, Section 703
Table A: Fine Aggregate Grading and Quality Requirements

	Cement Concrete Sand	Bituminous Concrete Sand Type B			Mortar Sand
Sieve Size	Type A	#1	#3	Filler	Type C
9.5 mm (3/8-inch)	100	100	100	—	—
4.75 mm (No. 4)	95-100	95-100	80-100	—	100
2.36 mm (No. 8)	70-100	70-100	65-100	—	95-100
1.18 mm (No. 16)	45-85	40-80	40-80	—	—
600 µm (No. 30)	25-65	20-65	20-65	100	—
300 µm (No. 50)	10-30	7-40	7-40	95-100	—
150 µm (No. 100)	0-10	2-20	2-20	90-100	0-25
75 µm (No. 200)	—	0-10	0-10	70-100	0-10
Material Finer Than 75 µm (No. 200) Sieve (Max. Percent Passing)	3	—	—	—	—
Min. Strength Ratio, %	95	—	—	—	95
Max. Soundness Loss, %	10	15	15	—	10
Fineness Modulus	2.30-3.15	—	—	—	1.6-2.5

6

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Publication 408, Section 703
Table B: Coarse Aggregate Quality Requirements

	Type A	Type B	Type C
Soundness, Max. %	10	12	20
Abrasion, Max. %	45******	45******	55******
Thin and Elongated Pieces, Max. %	15	20	—
Material Finer than 75 mm (No. 200) Sieve, Max, %	*	*	10
Crushed Fragments, Min. %	55**	55**	50
Compact Bulk Unit Weight, lbs./cu.ft.	70	70	70
Deleterious Shale, Max. %	2	2	10
Clay Lumps, Max. %	0.25	0.25	3
Friable Particles, Max. % (excluding shale)	1.0	1.0	—
Coal or Coke, Max. (%)	1	1	5
Glassy Particles, Max (%)	4 to 10***	4 to 10***	—
Iron, Max. (%)	3*****	3*****	3*****
Absorption, Max. %	3.0****	3.5****	—
Total of Deleterious Shale, Clay Lumps, Friable Particles, Coal, or Coke Allowed, Max. %	2	2	15

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Footnote to Table B: Coarse Aggregate Quality Requirements Publication 408, Section 703:

- * See Section 703.2(c)4.
- ** See Section 703.2(c)5.
- *** See Section 703.2(c)9.
- **** Gavel only. See Section 703.2(a)2.
- ***** See Section 703.2(c)10.
- ****** Blast Furnace Slag excluded. See Section 703.2(a)3.

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Aggregate Tests follow

PTM, AASHTO, or ASTM

- **PTM:** Pennsylvania Test Methods
- **AASHTO:** American Association of State Highway Transportation Officials
- **ASTM:** American Society for Testing and Materials

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Aggregate Tests

- **T 11 -** Amount of Material Finer the No. 200 Sieve in Aggregate
- **T 27 -** Sieve Analysis
- **T 84 -** Specific Gravity and Absorption of Fine Aggregate
- **T 85 -** Specific Gravity and Absorption of Coarse Aggregate
- **T 304 -** Uncompacted Void Content of Fine Aggregate
- **T 176 -** Sand Equivalent
- **T 96 -** Toughness (LA Abrasion)
- **T 104 -** Soundness (Sodium or Magnesium Sulfate)
- **T 112-** Clay Lumps & Friable Particles in Aggregate
- **D 5821** - Percentage of Crushed Fragments
- **D 4791** - Flat & Elongated Particles

T : AASHTO D: ASTM

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Aggregate Tests - PTM's

NOTE: PennDOT has replaced several PTMs with equivalent AASHTO Test Standards

- **PTM 505 –** Specific Gravity and Absorption of Fine Aggregate. **Has been Removed. Use AASHTO T 84.**
- **PTM 506 -** Specific Gravity and Absorption of Coarse Aggregate. **Has been removed. Use AASHTO T 85.**
- **PTM 510 (AASHTO T 104) -** Soundness using Sodium Sulfate
- **PTM 616 (AASHTO T 27) -** Sieve Analysis
- **PTM 620 (AASHTO T 112)** - Friable Particles in Coarse Aggregate
- **PTM 622** -Toughness (LA Abrasion). **Has been removed. Use AASHTO T 96**

→ **PTM 510: Immerse in solution for 16 to 18 hrs. Dry at 110C until mass loss < 0.1% within 4 hrs. of drying.**

Question: How Many Immersion/Dry Cycles in PTM 510? **Answer: Five**

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AGGREGATE GRADATION (Particle Size Distribution)

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Aggregate Gradation

- **Definition**
  - The distribution of particle sizes expressed as a percent of total weight.
  - Determined by sieve analysis
    - Dry
    - Wet
- **Significance**
  - Influences aggregate structure/skeleton of a PCC, AC, or Unbound Base
  - Application-based gradations; e.g.: SMA vs. Open Graded

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Sieve Analysis/Gradation AASHTO & PTM's

- **AASHTO T 27:** Sieve Analysis of Coarse and Fine Aggregate
- **PTM 739:** Sieve Analysis of Extracted Aggregate
- **PTM 743:** Determination of Combined Gradation of Aggregate

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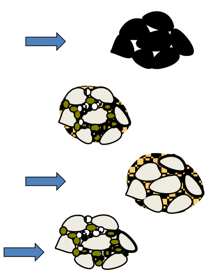
Some Common Types of Gradation

- **Uniformly graded**
  - Particles of almost the same size
  - Few points of contact
  - Poor interlock (shape dependent)
  - High permeability
- **Well graded (Dense Graded)**
  - Particles of all sizes
  - Good interlock
  - Low permeability
- **Gap graded**
  - Gap in mid range sizes
  - Good interlock
  - High or Low permeability
- **Open graded**
  - Extremely low content of very fine size
  - High permeability



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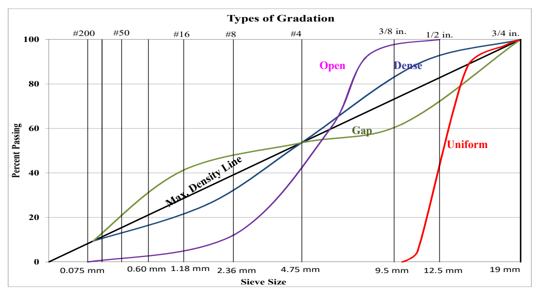
Common Types of Gradation



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Definition of Nominal Maximum Aggregate Size (NMAS)

We distinguish between **nominal maximum size** and **absolute maximum size** to ensure.

- Nominal Maximum Aggregate Size:
  - In a standard set of sieves, the **Nominal Maximum Sieve Size (Aggregate Size)** is one sieve larger than the first sieve to retain more than 10% of the aggregate.
- Maximum Aggregate Size:
  - In a standard set of sieves, the **Maximum Sieve Size** (Aggregate Size) is one sieve larger than the Nominal Maximum Sieve.

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Definition of NMAS (continued)

Example:

Aggregate 1	% Passing	Aggregate 2	% Passing
25 mm	100%	25 mm	100%
19 mm	100%	19 mm	98%
12.5 mm	92%	12.5 mm	87%
9.5 mm	72%	9.5 mm	72%

Max Sieve

Nom. Max. Sieve

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Gradation Classification

- Below PCS = Coarse Gradation
- Above PCS= Fine Gradation

NMAS, mm	PCS	% Pass - PCS
37.5	9.5	47
25.0	4.75	40
19.0	4.75	47
12.5	2.36	39
9.5	2.36	47

NMAS = Nominal Maximum Aggregate Size

PCS = Primary Control Sieve

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Starting Point for a Design Gradation
0.45 Power Gradation

$$P = 100\left(\frac{d}{D}\right)^{0.45}$$

P: % Passing
d: size of aggregate
D: Max. aggregate size

→ *Provides Maximum Density* ***(Dense Gradation)***

Pros	*Cons*
High Strength	**Frost Damage**
Low Permeability	**Minimal space for Cement**

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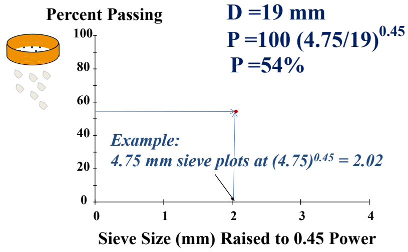
0.45 Power Grading Chart

D =19 mm
P =100 (4.75/19)$^{0.45}$
P =54%



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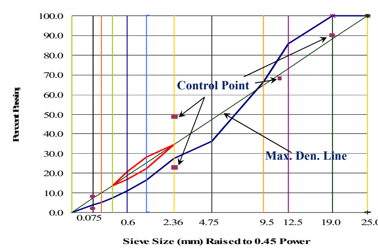
0.45 Power Gradation Chart



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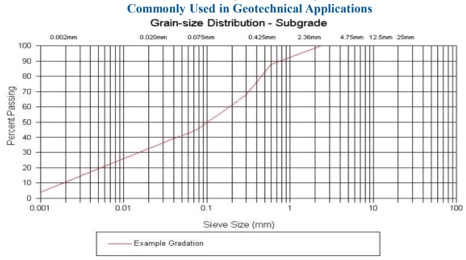
Logarithmic Grading Chart
Not Used for Asphalt Mix Design, but
Commonly Used in Geotechnical Applications



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SIEVE ANALYSIS

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What is a sieve analysis?

- Sieve analysis is performed to determine the distribution of particle sizes
- An aggregate sample is shaken through a stack of sieves of decreasing size, and the percent passing through each mesh is calculated and plotted
- The results of a sieve analysis are often called a gradation or gradation curve

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Why perform sieve analysis?

- To ensure aggregates meet specification
- To determine aggregate gradation for blending to JMF
- To ensure mix design meets specification and JMF
- Aggregate gradation one of most important factors affecting performance of asphalt mixes

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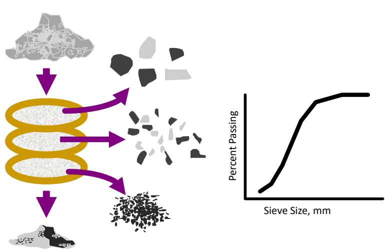
Sieve Analysis and Gradation



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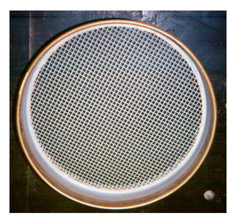
Mechanical Sieving

Individual Sieve



Stack in Mechanical Shaker

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Common Sieves

Sieves, mm	
50.0	2.36
37.5	1.18
25.0	0.60
19.0	0.30
12.5	0.15
9.5	0.075
4.75	

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Sieve Analysis/Gradation AASHTO & PTM's

- **AASHTO T 27**: Sieve Analysis of Coarse and Fine Aggregate
- **PTM 739 (AASHTO T 30):** Sieve Analysis of Extracted Aggregate
- **PTM 743**: Determination of Combined Gradation of Aggregate (sampling from the hot bins in an asphalt plant for QC)

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AASHTO T 27: Sieve Analysis of Fine and Coarse Aggregate

- Dry aggregate
- Select sample size according to maximum aggregate size
- Select sieves according to specification for selected aggregate
- Shake aggregate through sieves
- Weight fraction retained on each sieve
- Calculate percent passing

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PTM 739: Sieve Analysis of Extracted Aggregate

- Similar to sieve analysis as described in AASHTO T 27
- Sample size is entire aggregate sample from extraction
- Sample may be split and sieved in parts
- Sieve stack selected according to the given bituminous concrete specification
- Shake for eight minutes
- Calculate percent passing

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PTM 743: Combined Gradation of Aggregates from Hot Bins

- Similar to AASHTO T 27 and PTM 739
- Special care is needed in obtaining sample; refer to PTM 743
- Select sample size according to aggregate size
- Select sieve stack according to given bituminous concrete specification
- Calculate percent passing

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Notes on Procedure

- Coarse aggregate--air or oven dried
- Fine aggregate--oven dried
- Sample size increases with maximum aggregate size
- Avoid overloading sieves (**200 grams** maximum on 8-inch diameter sieve)
- Check thoroughness of sieving

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Comments on Sieve Analysis

- Make certain a representative sample is obtained!
- Reduce sample to proper testing size by quartering or using a sample splitter!
- Check sieves regularly and discard damaged sieves
- Don't overload sieves
- Check sieving efficiency for AASHTO T 27 and PTM 743

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AASHTO T 27 Example Sieve Analysis

$= \frac{4550}{5000}$ X100

Sieve	Cum. Wts (g)	Passing (g)	Passing (Wt. %)
1/2"	5000	5000	100
3/8"	5000	4550	91
No. 4	4550	1450	29
No. 8	1450	50	1
Pan	50	---	---

original sample weight = 5002 grams
error = (5002-5000)/5002 x 100 % = 0.04 %

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Question: What is percent passing #8 Sieve?

$$= \frac{547.5}{1998} \times 100 = 27.4$$

Sieve Size		A	B	C	D
US Units	SI,mm Units	Retained Ind. Sieves grams	Cumulative Retained grams	Cumulative Passing grams	Percent Passing
1	25	0.0	1998.0	1998.0	100.0
3/4	19	0.0	1998.0	1998.0	100.0
1/2	12.5	287.7	1998.0	1710.3	85.6
3/8	9.5	383.6	1710.3	1326.7	66.4
#4	4.75	601.4	1326.7	725.3	36.3
#8	2.36	177.8	725.3	547.5	27.4
#16	1.18	217.8	547.5	329.7	16.5
#30	0.6	111.9	329.7	217.8	10.9
#50	0.3	69.9	217.8	147.9	7.4
#100	0.15	42.0	147.9	105.9	5.3
#200	0.075	28.0	105.9	77.9	3.9
pan	0	77.9	77.9	0.0	0.0

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AASHTO T 27 - Sieve Analysis, Class Activity

See also PTM 616, which is the modified version of AASHTO T 27.

WORKSHOP
AGGEGATE GRADATION ANALYSIS

A sample of No. 8 aggregate is taken from the plant stockpile. It is quartered to a sample size of 5013.2 grams. The sample is then sieved to give the following weight passing each sieve:

Sieve Size (mm)	Sieve Size English	Cumulative Mass Retained (g)	Mass Passing (g)	Percent Passing Each Sieve
12.5	½"	5001.7		
9.5	3/8"	5001.7		
4.75	No. 4	4351.5		
2.36	No. 8	700.3	250.1	
1.18	No. 16	250.1	2.0	
Pan	Pan	2.0	----	

1. Determine the mass passing for the 12.5, 9.5, and 4.74 mm sieves. Determine the percent passing for all sieves.
2. Plot the gradation curve on 0.45 power chart.
3. Does this aggregate meet PennDOT Spec 703 or AASHTO Spec M43, for a No. 8 aggregate?
4. What is the loss or error for this analysis? Is this acceptable according to PTM 616?

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AASHTO T 27 - Sieve Analysis
Class Activity

$\frac{4351.5}{5001.7}$ X100 = 87

Sieve	Cum. Wts (g)	Passing (g)	Passing (Wt. %)
1/2"	5001.7	5001.7	100
3/8"	5001.7	4351.5	87
No. 4	4351.5	700.3	14
No. 8	700.3	250.1	5
No. 16	250.1	2.0	
Pan	2.0	---	---

3. Yes Spec 408 – Section 703, Table C
4. original sample weight = 5013.2 grams
   error = (5013.2-5001.7)/5013.2 x 100 % = 0.23 % < 0.8%
   So, the error is acceptable.

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PENNSTATE

Summary

- Aggregate Properties important to asphalt mix
- Aggregate Tests to capture properties
- Gradation of aggregate structure
- Various types of gradation (dense, uniform, gap, open)
- Nominal Max. Aggregate Size vs Max. Aggregate Size
- Sieve analysis and size distribution
- How to determine %passing each sieve size

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N E C E P T

Plant Technician Certification Program

Module 5
Aggregate Blending

Northeast Center of Excellence for Pavement Technology

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Plant Technician Certification Program

Module 5

Aggregate Blending

1

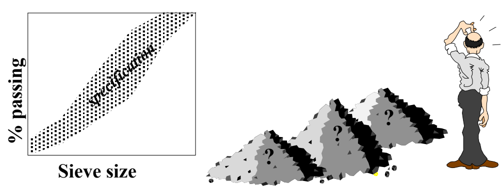
Aggregate Blending: Introduction

- Background: what is aggregate blending?
  - Why?
  - When?
  - How?
- Example problems
- Workshop

2

What is Aggregate Blending?

- Finding out what proportions, or "recipe" of different aggregates we need to mix together to meet a selected specification or target gradation



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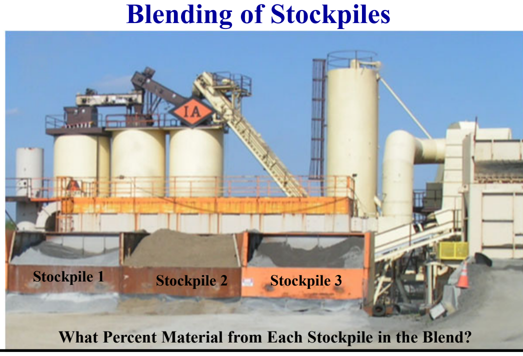
When Do We Need to Determine Aggregate Blends?

- For new mix designs
- For adjusting existing mix designs
- For verifying existing mix designs
- Other cases?

4

Blending of Stockpiles



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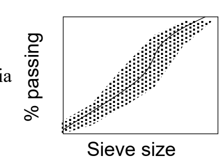
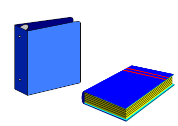
Determine Target Gradation

Based on

- Contract documents
- Superpave gradations criteria
- AASHTO specifications
- PennDOT specifications
- Experience & judgment





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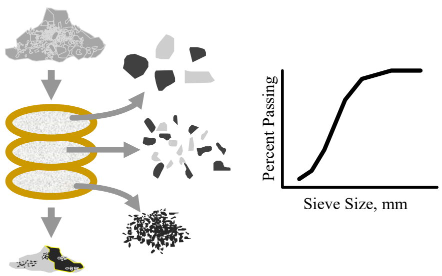
Perform Sieve Analyses on Each Aggregate, or Use Avg. Gradations



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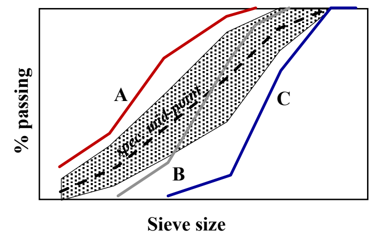
Determine Percentage of Each Aggregate Needed



A.....20%
B.....45%
C.....35%

8

8

To Complete a Mix Design

- Break down aggregates on each coarse sieve
- Separate fine fraction out of each aggregate
- Get additional mineral filler if needed
- Combine aggregate fractions to meet blend gradation
- Mix & compact specimens
- Determine bulk & maximum specific gravities; other tests as specified.

9

9

During Production...

- Adjust blend if aggregates are significantly different for production
- Set cold bin feeds according to aggregate blend in JMF
- Verify gradation by extracting small sample from trial production
- For batch plants
  - determine hot-bin proportions
  - similar to aggregate blending
  - fine adjustments made using hot-bins

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Methods for Determining Aggregate Blend Proportions

- Trial and error
  - hand calculations
  - computer spreadsheet (Example: Excel™ Solver)
- Graphical methods
- Simultaneous equations
  - computer programs
  - Kramer's rule
  - "criss-cross" forms

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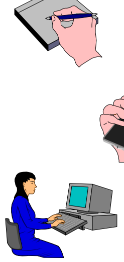
Trial and Error Steps

- Select critical sieves in blend.
  - Look at mid-size sieves (No. 4, No. 8, No. 16)
- Determine initial proportions which will meet critical sieves.
  - Estimate proportions of blend needed to meet target.
- Check calculated blend against specification.
- Adjust if necessary and repeat above steps.

12

12

Proportioning Aggregates Can Be Difficult...



- Two-aggregate blends: *hand calculations*
- Three and four aggregate blends: *simultaneous equations*
- Many real mix designs with complex aggregate blends: *computer programs or spreadsheets*

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13

Software for Proportioning Aggregates

- Computer programs
- Custom spreadsheets
- Pinepave and other gyratory software
- Various versions of Superpave Program

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Blending Stockpiles (Graphics)

- Use for initial assessment.
  - Identify critical sieves.
  - Determine if blend can be made from available materials.
  - Estimate trial proportions.
- Plot individual gradations.
- Plot specification limits.

15

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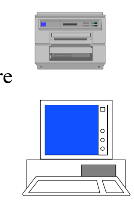
Demonstration of Blending Spreadsheet

- Pinepave software, included with gyratory
- Excel template (blank spreadsheet)
- Other gyratories usually have similar software
- Can construct your own template if desired



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Some Comments on Aggregate Blending Methods

- Hand calculation with simultaneous equations difficult for more than two aggregate stockpiles.
- Spreadsheet templates and graphical methods can be used for trial-and-error blending of more than two aggregate stockpiles.

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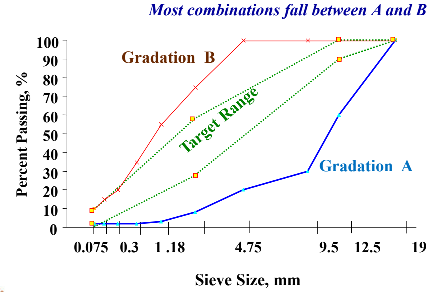
Blending of Stockpiles

Most combinations fall between A and B



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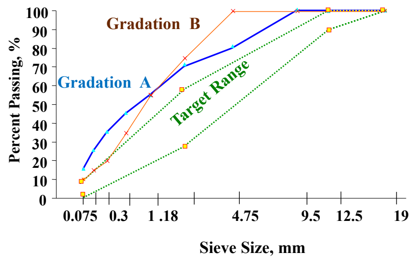
Blending of Stockpiles

All possible combinations <u>do not</u> fall between A and B.



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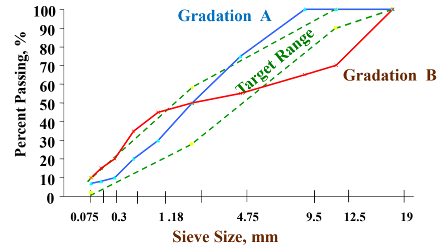
Blending of Stockpiles

All possible combinations pass through cross-over point.
Blends containing more A than B will be closer to A.



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Let's Look at Some Examples for Blending Stockpiles in the Next Few Slides

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Example Problem 1:

Blend must meet Superpave 9.5 mm (3/8") Specification

US Sieve Size (metric)	Control Points	Target Gradation
1/2" (12.5 mm)	100	100
3/8" (9.5 mm)	90 - 100	95
# 4 (4.75 mm)	---	70
# 8 (2.36 mm)	32 - 67	40
#16 (1.18 mm)	---	28
#30 (0.600 mm)	---	20
#50 (0.300 mm)	---	15
#200 (0.075 mm)	2.0-10.0	6

Notice that here we have selected the target gradation almost as an average of speciation limits (average of Control Points)

Practically, we have a limited number of stockpiles and it will be impossible to hit the target gradation on every single sieve for any selected percentages of stockpiles.

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Example Problem 1 (Cont'd)

Let's Assume we have Two Stockpiles:
Fine Aggregate (FA) and Coarse Aggregate (No. 8)

Sieve Size	FA	No. 8	Target
1/2" (12.5 mm)	100	100	100
3/8" (9.5 mm)	100	98	95
# 4 (4.75 mm)	100	22	70
#8 (2.36 mm)	75	1	40
#16 (1.18 mm)	45	---	28
#30 (0.600 mm)	27	---	20
#50 (0.300 mm)	17	---	15
#200 (0.075 mm)	6.7	---	6

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Example Problem 1 (Cont'd)

Trial and Error Method

- Look at mid-size sieves (No. 4, No. 8, No. 16)
- Estimate proportions of blend needed to meet target
- For this example, a 50/50 blend would give about 38 percent passing the No. 8 sieve
- Target is 40 percent--looks OK as it is within the control points (32 percent and 67 percent)

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Example Problem 1 (Cont'd)
50/50 Blend of Fine and Coarse Aggregate

- Blend on paper using the decimal equivalent of the percentage of each aggregate in blend: use 0.5 for 50/50
- %FA x % passing + %CA x % passing = % of Blend passing the subject sieve
- **Example**: Use % passing #4 (4.75 mm):

(0.5 x 100%) + (0.5 x 22%) = 61%
This means 61% of the 50/50 blend passes the #4 (4.75 mm) sieve

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Example Problem 1 (Cont'd)
50/50 Blend of Fine and Coarse Aggregate

Sieve Size US (metric)	Fine Aggregate	Coarse No. 8	50/50 Blend
1/2" (12.5 mm)	100	100	100
3/8" (9.5 mm)	100	98	99
# 4 (4.75 mm)	100	22	61
# 8 (2.36 mm)	75	1	38
# 16 (1.18 mm)	45	---	23
# 30 (0.600 mm)	27	---	14
# 50 (0.300 mm)	17	---	9
#200 (0.075 mm)	6.7	---	3.4

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Example Problem 1 (Cont'd)
50/50 Blend of Fine and Coarse Aggregate Meets Specifications.

Sieve Size US (metric)	Control Points	50/50 FA/No.8
1/2" (12.5 mm)	100	100
3/8" (9.5 mm)	90 - 100	99
# 4 (4.75 mm)	---	61
# 8 (2.36 mm)	32 - 67	38
#16 (1.18 mm)	---	23
#30 (0.600 mm)	---	14
#50 (0.300 mm)	---	9
#200 (0.075 mm)	2.0 - 10.0	3.4

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Example Problem 1 (Cont'd)
Simultaneous Equations to hit exact target gradation

- Use No. 8 as ***control sieve***
  - $P_{FA}\ x75 + P_{CA}x1 = 40$ *(Eq.1)*
  - $P_{FA} + P_{CA} = 1.0$
  - $P_{CA} = 1.0 - P_{FA}$ *(Eq. 2)*
- Put Eq. 2 into Eq. 1:
  - $P_{FA}\ x\ 75 + (1.0 - P_{FA})\ x\ 1 = 40$
  - $P_{FA}\ x\ 74 = 40 - 1$ *(Eq. 3)*
- P_{FA} = 39/74 = <u>0.527</u> or <u>53%</u>
- P_{CA} = 100 - 53 = <u>47%</u>

With two stockpiles, it is possible to hit the target gradation on one sieve. We typically choose a control sieve such as #8 or #4 for computation of percent of blends.

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A Simple Form for Blending Two Aggregates

- % passing control sieve, target 40.0
- \- % passing control sieve, CA .... - 1.0
  - *= X =* 39.0
- % passing control sieve, FA 75.0
- \- % passing control sieve, CA .... - 1.0
  - *= Y =* 74.0
- P_{FA} = (X / Y) x 100 % 52.7
- P_{CA} = 100 - PFA 47.3

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Example Problem 1 (Cont'd)
53/47 Blend of Fine and Coarse Aggregate

Sieve Size US (metric)	Fine Aggregate	Coarse No. 8	53/47 Blend
1/2" (12.5 mm)	100	100	100
3/8" (9.5 mm)	100	98	99
# 4 (4.75 mm)	100	22	63
# 8 (2.36 mm)	75	1	40
# 16 (1.18 mm)	45	---	24
# 30 (0.600 mm)	27	---	14
# 50 (0.300 mm)	17	---	9
#200 (0.075 mm)	6.7	---	3.6

Notice that the 53/47 blend is close to 50/50 blend. In any case, when we have only two stockpiles, we only have one degree of freedom and can only hit the target gradation only on one sieve (here for example, we hit #8 sieve). Other percents passing land wherever the 53/47 blend leads them.

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Example Problem 2:
Determine Blend using Two Stockpiles

Sieve Size	FA	No. 8	Target
1/2" (12.5 mm)	100	100	100
3/8" (9.5 mm)	100	92	95
#4 (4.75 mm)	99	13	70
#8 (2.36 mm)	85	5	40
#16 (1.18 mm)	57	4	28
#30 (0.600 mm)	42	2	20
#50 (0.300 mm)	28	1	15
#200 (0.075 mm)	12	0	6

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Blank Form
for Comparing Blend to Specification

Sieve Size (std) (metric)	Control Points	Restricted Zone	Blend
1/2" (12.5 mm)	100		
3/8" (9.5 mm)	90 - 100		
# 4 (4.75 mm)	---		
# 8 (2.36 mm)	32 - 67	47.2	
#16 (1.18 mm)	---	31.6 - 37.6	
#30 (0.600 mm)	---	23.5 - 27.5	
#50 (0.300 mm)	---	18.7	
#200 (0.075 mm)	2.0-10.0		

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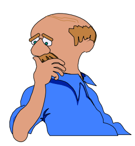
Example Problem 2:
1. Trial and Error Method

- Look at mid-size sieves (No. 4, No. 8, No. 16)
- Estimate proportions of blend needed to meet target
- For this example, a 45/55 blend would give about 40 percent passing the No. 8 sieve



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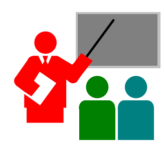
Example Problem 2:
2. Simultaneous Equations

- **Use No. 8 as *control sieve***
  - $P_{FA} x85 + P_{CA} x5 = 40$ (Eq.1)
  - $P_{FA} + P_{CA} = 1.0$
  - $P_{CA} = 1.0 - P_{FA}$ (Eq. 2)



- Put Eq. 2 into Eq. 1:
  - $P_{FA} x\ 85 + (1.0 - P_{FA}) x\ 5 = 40$
  - $P_{FA} x\ 80 = 40 - 5$ (Eq. 3)
- P_{FA} = 35/80 = 0.438 or 44%
- P_{CA} = 100 - 44 = 56%

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Example Problem 2:
3. Form for Blending Two Aggregates

- % passing control sieve, target 40.0
- - % passing control sieve, CA .... - 5.0

  = *X* = 35.0
- % passing control sieve, FA 85.0
- - % passing control sieve, CA .... - 5.0

  = *Y* = 80.0
- P_{FA} = (X / Y) x 100 % 43.8
- P_{CA} = 100 - PFA 56.2

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Example Problem 2 Solution:
44/56 Blend of Fine and Coarse Aggregates

Sieve Size US (metric)	Control Points % Passing	Blend % Passing
1/2" (12.5 mm)	100	100
3/8" (9.5 mm)	90 - 100	96
# 4 (4.75 mm)	--	51
# 8 (2.36 mm)	32 - 67	40
#16 (1.18 mm)	---	27
# 30 (0.600 mm)	---	20
# 50 (0.300 mm)	---	13
#200 (0.075 mm)	2.0-10.0	5.3

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Example Problem 2 Solution: Comparison of 44/56 Blend with Target Gradation

Sieve Size	44/56 Blend % Passing	Target % Passing
1/2" (12.5 mm)	100	100
3/8" (9.5 mm)	96	95
# 4 (4.75 mm)	51	70
# 8 (2.36 mm)	40	40
#16 (1.18 mm)	27	28
#30 (0.600 mm)	20	20
#50 (0.300 mm)	13	15
#200 (0.075 mm)	5.3	6.0

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Workshop Problem:
Blending Two Aggregates

Sieve Size	F.A. % Pass	C.A. % Pass
75 µm	2.2	0.2
150 µm	3.0	0.3
300 µm	14.2	0.5
600 µm	47.7	0.9
1.18 mm	66.0	2.2
2.36 mm	85.0	2.9
4.75 mm	97.2	14.0
9.5 mm	100.0	91.0
12.5 mm	100.0	100.0

See your book:

Find Proportions of these two aggregates needed to give a final blend with 45 percent passing the 2.36-mm sieve.

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Workshop Solution:
Form for Blending Two Aggregates

- % passing control sieve, target 45.0
- \- % passing control sieve, CA .... - 2.9

= *X* = 42.1

- % passing control sieve, FA 85.0
- \- % passing control sieve, CA .... - 2.9

= *Y* = 82.1

- P_{FA} = (X / Y) x 100 % 51.3
- P_{CA} = 100 - PFA 48.7

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Specific Gravity of Blended Aggregate

*** Important Note:**

- Once the percentages of the stockpiles have been established, the specific gravity of combined aggregate must be calculated using specific gravity values of individual stockpiles and their percentages in the blend.
- See Example on the next slide.

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Combined Specific Gravity

An Example for 3 Stockpiles:
Agg. #1, Agg. #2, Agg.#3

$$G_s = \frac{100}{\frac{P_1}{G_1}+\frac{P_2}{G_2}+\frac{P_3}{G_3}}$$

G_1=2.825 P_1=31%
G_2=2.546 P_2=47%
G_3=2.715 P_3=22%

Combined Sp. Gr. G_s=2.664

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Summary

We Discussed:

- Concept of Aggregate Blending
- Why We Blend Stockpiles
- Methods of Determining Percent of Different Stockpiles to Achieve a Target Gradation
- How to Calculate Combined Specific Gravity of Blended Aggregates

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Module 6
Specific Gravity and Absorption

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Module 6

Specific Gravity and Absorption

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1

Outline

- Review concepts and calculations related to specific gravity of aggregates (calculation of specific gravity essential to the mix design process).
- Review AASHTO T 84 & T 85 for determination of Sp. Gr.
- Cover definition of specific gravity, types of specific gravity, computation, and a short workshop.

2

2

Why Do We Measure Specific Gravity and Absorption?

- Design of asphalt mixes is largely based upon the weights and volumes of the aggregates and asphalt.
- Specific gravity of these materials is needed to establish these weight-volume relationships.

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What is Specific Gravity?

- Use "*G*" to present **Specific Gravity**
- Use "*D*" to present **Density**

$$D = \frac{\textit{Mass} \text{ of Material}}{\textit{Volume} \text{ of Material}}$$

$$G = \frac{D \text{ of Material}}{D \text{ of Water}}$$

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What is Specific Gravity?

- The ratio of the density of an object to the density of water
- Specific gravity is proportional to the density
- The higher an object's specific gravity, the heavier a given amount of that material

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Example for Specific Gravity?

$$G = \frac{D \text{ of Asphalt Concrete}}{D \text{ of Water}} = \frac{145.7 \text{ lbs/ft}^3}{62.245 \text{ lbs/ft}^3} = 2.341$$

Density in English Units (at 77°F)

$$G = \frac{D \text{ of Material}}{D \text{ of Water}} = \frac{2.334 \text{ grams/cm}^3}{0.997 \text{ grams/cm}^3} = 2.341$$

Density in cgs Units (at 77°F)

77°F (Fahrenheit) = 25°C (Celsius)

NOTE: Always report the value of Sp. Gr. to three decimal places.

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Density of Water

As can be seen, density of water decreases as temperature increases. Why?

Temperature (°C), (°F)	Density of Water	
	grams/cm³	lb./ft³ *
0.1 (32.2)	0.9998495	62.4186
4.0 (39.2)	0.9999749	62.4264
10.0 (50.0)	0.9997000	62.4094
20.0 (68.0)	0.9982067	62.3160
25.0 (77.0)	0.9970470	62.2436
50.0 (122.0)	0.9880400	61.6813

* lb. is used to indicate pound mass, sometimes written as lb_m
1 lb. = 0.45359 kg = 453.59 grams = 16 avoirdupois ounces

Almost always, our density measurements for asphalt and aggregate are conducted around 25°C (77°F)

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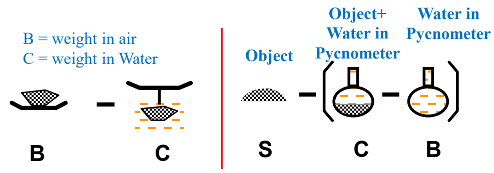
Determining the Volume of an Object

- Weight in water method
- $W_W = B - C$

- Pycnometer (Volumeter) method
- $W_W = S - (C - B)$

W_W in grams is equivalent to Volume in cm³.



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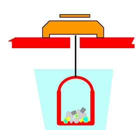
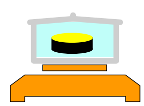
Methods for Determining Specific Gravity

- **Weight-in-water methods:**
  - PTM 715, 716 (for compacted mix)
  - AASHTO T 209 (for loose mix)
  - AASHTO T 85 (for coarse aggregate)



- **Pyncnometer/volumeter methods:**
  - PTM 715, 716 (for compacted mix)
  - AASHTO T 209 (for loose mix)
  - AASHTO T 84 (for fine aggregate)



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Comparing PTMs to AASHTO Tests related to Sp. Gr.

PTM
- 715 Mix Bulk Sp. Gr. ↔ T 166 Mix Bulk Sp. Gr.
- 716 Mix Bulk Sp. Gr. ↔ T 166 Mix Bulk Sp. Gr.

AASHTO
- T 84 Fine Agg. Sp. Gr.
- T 85 Course Agg. Sp. Gr.
- T 166 Mix Bulk Sp. Gr.
- T 166 Mix Bulk Sp. Gr.
- T 209 Mix Max. Sp. Gr.
- T 304 Uncompacted Voids of Fine Agg.

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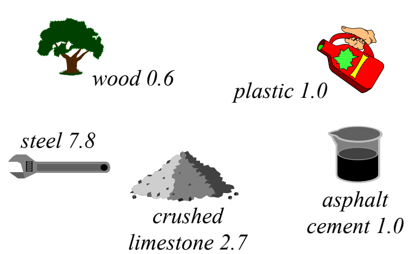
Specific Gravities of some common materials...



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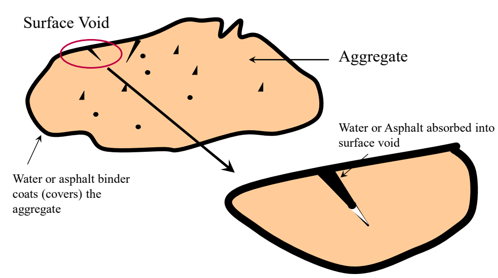
Specific Gravity of Aggregate (Absorption Effect)



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Specific Gravity of Aggregate (Absorption Effect)

As shown in the previous slide, aggregates are porous and have surface voids. Water (or asphalt) is absorbed into these surface voids.

Specific gravity of an aggregate is inversely proportional to its volume. So, the question is what is the volume of the aggregate? Does it include or does it exclude the surface voids filled with water (or asphalt)?

One can see that including or excluding the surface voids affects the specific gravity. We will see later that depending on whether we include or exclude the voids filled with water (or asphalt), the specific gravity is defined as bulk, effective, or apparent. The values will be different depending on the volume of aggregate considered in calculation of the specific gravity.

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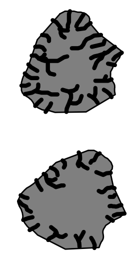
Absorption of Aggregate

- **Absorption**: amount of water an aggregate will take up into microscopic voids on its surface
- Asphalt absorption is less than Water absorption
- Amount of absorption must be known to perform the density and voids analysis and calculate VMA, VFA, and so forth



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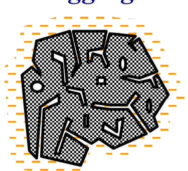
Permeable & Impermeable Voids of Aggregate



- Permeable voids: continuous with the air or water surrounding the aggregate particle
- Impermeable: surrounded by solid aggregate

Saturated, surface-dry (SSD): condition in which permeable voids in aggregate particles are just filled with water**.**

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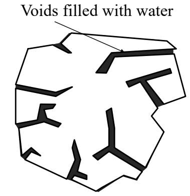
Water Absorption of Aggregate



- **Absorption** is the moisture content in the SSD state.
- Or, moisture content when permeable voids just filled with water.

Percent Absorption = $(W_{SSD} - W_{OD}) / W_{OD} \times 100$

W_{SSD} = Saturated Surface Dry Weight
W_{OD} = Oven Dry Weight

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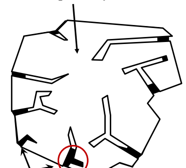
Effective Volume of Aggregate

- Used to find aggregate effective specific gravity, G_{se}
- Effective volume is the volume of aggregate, not including voids filled with asphalt



Effective volume of aggregate excludes the part of void space which is filled with asphalt.

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Types of Aggregate Specific Gravity

- Bulk specific gravity (G_{sb})
- Apparent specific gravity (G_{sa})
- Effective specific gravity (G_{se})
- **Remember: $G_{sb} < G_{se} < G_{sa}$**
- Bulk specific gravity, SSD basis (G_{sbs}), used in portland cement concrete work

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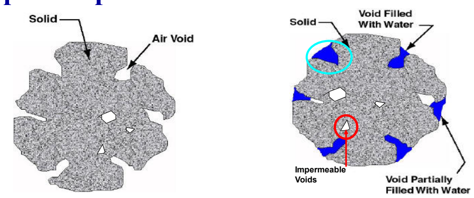
Types of Specific Gravities



Apparent

$$G_{sa} = \frac{W_s}{(V_s)\gamma_w}$$

$\rangle$

Bulk

$$G_{sb} = \frac{W_s}{(V_s + V_{pw})\gamma_w}$$

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AASHTO T 84: Test for Specific Gravity and Absorption of Fine Aggregate

- Oven dry aggregate is soaked in water
- Dried to saturated, surface-dry condition
- Sample is placed in flask and weighed
- Flask is filled with water and weighed again
- Contents are poured into a pan, oven-dried, and weighed again
- Specific gravity and absorption are calculated

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Comments on AASHTO T 84

- Sand cone slump test devised for natural sand--doesn't work well for some manufactured sand
- Don't over dry sand
- Use clean water at 23±1.7 °C (73.4±3.1°F)
- Watch out for air bubbles in pycnometer

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Computation of Specific Gravity: Fine Aggregate (AASHTO T 84)

- G_{sb} = A / (B + S - C)
- G_{sa} = A / (A + B - C)
- Abs. = (S - A) / A x 100%
- G_{se}: determined from G_{mm}
- A = oven dry Wt.; S = SSD Wt.; C = Wt. of flask with sample & water; B = Wt. of flask with water only.

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AASHTO T 85: Test for Specific Gravity and Absorption of Coarse Aggregate

- Oven-dry sample is soaked in water
- Sample is dried to saturated, surface-dry condition and weighed
- Sample is weighed again in water
- Sample is dried in oven and weighed again
- Specific gravity and absorption are then calculated

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Comments on AASHTO T 85

- Make certain sample is washed and that all material finer than 4.75 mm (No. 4 sieve) is discarded.
- Drying to SSD takes some practice.
- Must work quickly once aggregate is dried to SSD condition.
- Weigh basket should be of 3.4 mm (No. 6) mesh or finer

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Computation of Specific Gravity: Coarse Aggregate (AASHTO T 85)

- $G_{sb} = A / (B - C)$
- $G_{sa} = A / (A - C)$
- Abs. = (B - A) / A x 100 %
- G_{se}: determined from G_{mm}
- A = oven dry Wt.; B = SSD Wt.; C = Wt. in water

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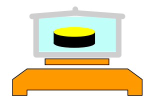
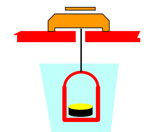
PTM 715/716: Specific Gravity of Compacted Asphalt Mixture

- Can be determined using either volumeter (pycnometer) method or weight in water



Using volumeter (Method A)



Using submergence in water and measuring reduced weight (Method B)

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PTM 715/716: Specific Gravity of Compacted Mixture

- Dry specimen weighed in air
- Specimen soaked in water for at least 10 minutes
- Specimen blotted dry, and weighed again ("saturated, surface-dry weight")
- Absorption is calculated

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PTM 715 (continued)

- For absorption of 3.0 percent or less, use PTM 715
- Place specimen in volumeter, fill with water, and weigh (Method A)
- Or Find dry weight, SSD weight, and weight in water (Method B).
- Calculate specific gravity

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PTM 716 (continued)

- For absorption over 3.0 percent, use PTM 716
- Specimen oven-dried to constant weight
- Coat specimen with paraffin and weight again
- Place specimen in volumeter, fill with water, and weigh
- Calculate specific gravity

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Comments on PTM 715/716

- Make certain loose particles are removed from sample before testing.
- Make certain pycnometer is level, and that there are no bubbles when full (Method A).
- Can also use weight-in-water method (Method B).

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AASHTO T 209: Theoretical Maximum Specific Gravity of Paving Mixtures

- Heat the specimen if necessary, separate into small particles, and cool.
- Place sample into a pycnometer and weigh
- Cover with water, apply vacuum and agitate for 15 minutes.
- Fill pycnometer with water and weigh.
- Calculate maximum specific gravity.

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AASHTO T 209: Theoretical Maximum Specific Gravity of Paving Mixtures

Nominal Max. Aggregate Size, mm (in.)	Minimum Sample Size, grams
37.5 (1.5) or larger	4,000
25.0 (1.0) or 19.0 (0.75)	2,500
12.5 (0.5) or smaller	1,500

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Types of Mixture Specific Gravity, AASHTO T 209

- **G_{mm}** - theoretical maximum specific gravity or "Rice's;" specific gravity of asphalt-coated aggregated, or *specific gravity of mix at zero air voids*.
- **G_{mb}** - specific gravity of compacted specimen or pavement core, including air voids.

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Notes on Procedures: AASHTO T 209

- Balance accurate to 0.5 g for glass or metal pycn., 1 g for large plastic pycn.
- Use clean water at 25±1.0°C (77±1.8°F).
- Use good aspirators or maintenance-free vacuum pump.
- Use good residual pressure gauges, or calibrate gages against a standard.
- Use mechanical shaker.

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Computation of Asphalt Mixture Specific Gravities

- PTM 715/716 (bulk), AASHTO T 209 (maximum)
- $G_{mb} = A / [B - (C-D)]$ (Method A)
- A = dry Wt.of sample; B = Wt. of water in volumeter; C = Weight of sample and water in volumeter; D = SSD Weight of sample
- $G_{mm} = A / (A + D - E)$
- A = dry Weight; D = Weight of Pync. with water; E = Weight of Pycnometer with water & sample

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Percent Compaction and Air Void Content

- % Compaction = $(G_{mb} / G_{mm}) \times 100$ %
  NOTE: % Compaction also referred to as % G_{mm} or % Density
- $P_a = (1-G_{mb}/G_{mm}) \times 100$ %
- G_{mb} = bulk specific gravity
- G_{mm} = max. specific gravity
- P_a = air void content, percent by volume.
  NOTE: P_a is sometimes shown as V_a

36

36

Workshop, Part One: Aggregate Specific Gravity

- **Fine aggregate:**
  - Oven-Dry Wt.: 1,122.0 g
  - SSD Wt.: 1,140.3 g
  - Weight of Pycn. + Water: 751.3 g
  - Weight of Pycn. + Water + Sample: 1,467.8 g
- **Coarse aggregate:**
  - Oven-Dry Weight: 2,007.2 g
  - SSD Weight: 2,014.2 g
  - Weight in water: 1,197.6 g

37

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Workshop, Part One: Aggregate Specific Gravity [Cont'd]

- **Determine**
  - Percent Water Absorption for fine aggregate
  - Bulk Sp. Gr. for fine aggregate
  - Apparent Sp. Gr. for coarse aggregate.

38

38

Absorption of Fine Aggregate

$$\% \text{ Absorption} = \frac{S - A}{A} \times 100$$

A = oven dry Weight
S = SSD Weight
C = Wt. of flask with sample & water
B = Wt. of flask with water only

39

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Part One Solution

$$\text{Abs.} = \frac{(1140.3 - 1122.0)}{1122.0} \times 100\%$$

- **Abs. = 1.6 % by weight of aggregate**

40

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Bulk Sp. Gr. of Fine Aggregate

$$G_{sb} = \frac{A}{B + S - C}$$

A = Oven Dry Wt.;
S = SSD Wt.;
C = Wt. of Flask with Sample & Water;
B = Wt. of Flask with Water Only.

41

41

Part One Solution

- Fine Aggregate Bulk Sp. Gr., G_{sb}

$$\frac{1122.0}{751.3+1140.3-1467.8} = \underline{2.647}$$

42

42

Apparent Sp. Gr. of Coarse Aggregate

$$G_{sa} = \frac{A}{A - C}$$

A =Oven Dry Weight
C = Weight of Specimen in Water

43

43

Part One Solution

Coarse Aggregate Apparent Sp. Gr. , G_{sa}

$$\frac{2007.2}{2007.2 - 1197.6} = \underline{2.479}$$

44

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Workshop, Part Two: Specific Gravity of Asphalt Mixture

- HMAC (Hot Mix Asphalt Concrete) Sample: Loose Mix
- Loose Mix (Not Compacted) for G_{mm}:
  - Wt. in Air = 2000.0 g;
  - Wt. of Pycnometer + Water = 7347.5 g;
  - Wt. of Pycnometer + Water + Sample = 8571.5 g.

Compute G_{mm}

45

45

Workshop, Part Two: Mixture Specific Gravity

- HMAC Sample: Compacted Sample
- Compacted Sample for G_{mb} (PTM 715, Method A)
  - Dry Weight: 1,300.4 g;
  - SSD Weight: 1,303.0 g;
  - Weight of Sample + Water: 1,881.0 g;
  - Weight of Water in Volumeter: 1,118.2 g.

Compute G_{mb} and % Air Voids

46

46

Theoretical Maximum Sp. Gr. of Loose Asphalt Mixture

$$G_{mm} = \frac{A}{A + D - E}$$

A = Dry Weight
D = Weight of Pycnometer with Water
E = Weight of Pycnometer with Water & Specimen

47

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Part Two Solution

- Theoretical Maximum Sp. Gr., G_{mm}

$$\frac{2000.0}{2000.0 + 7347.5 - 8571.5} = \underline{2.577}$$

48

48

Bulk Sp. Gr. of Compacted Mix (PTM 715, Method A)

$$G_{mb} = \frac{A}{B-(C-D)}$$

A = Dry Weight of Sample
B = Weight of Water in Volumeter
C = Weight of Sample and Water in Volumeter
D = SSD Weight of Sample

49

49

Part Two Solution

- Bulk Sp. Gr. of the Mix, G_{mb}

$$\frac{1300.4}{1118.2-(1881-1303.0)} = \underline{2.407}$$

50

50

Air Void of Compacted Mix

$$\%\ Voids,\ P_a = \left(1 - \frac{G_{mb}}{G_{mm}}\right) \text{X } 100$$

51

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Part Two Solution

- Air void content, P_a =

[1-(2.407/2.577)] x 100 % = 6.6 %

52

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Summary

- Density vs Specific Gravity (Sp. Gr.)
- Aggregate Specific Gravity
- Effect of Porosity on Sp. Gr.
- Different Types of Aggregate Sp. Gr.
- Mixture Specific Gravity (bulk vs max.)
- How to Calculate Sp. Gr.

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Thank You!

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Plant Technician Certification Program

Module 7

Analysis of Volumetric Parameters

Northeast Center of Excellence for Pavement Technology

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Module 7

Analysis of Volumetric Parameters

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NECEPT

1

Asphalt Mixture Volumetrics

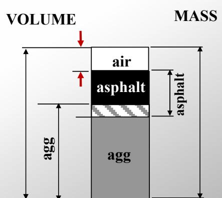
Objectives of This Module

- Define and Calculate Volumetric Parameters
- Understand and Use Phase diagram
- Conduct Examples

2

2

Air Voids



- **Definition**
  - volume concentration of air voids
- **Reported as percent of the mix volume**
- **Represented as V_a or P_a**

3

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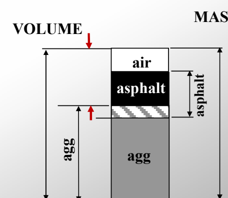
Voids in the Mineral Aggregate (VMA)



- **Definition**
  - volume concentration of *intergranular* void space in a compacted mix. VMA is the sum of air voids and volume of effective asphalt as percent of total volume
- **Reported as percent of the mix volume**

4

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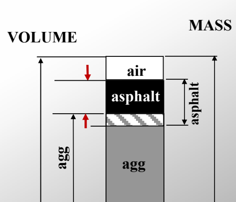
Voids Filled with Asphalt (VFA)



- **Definition**
  - Volume concentration of asphalt in the *intergranular* void space of a compacted mix
  - **Reported as % of VMA**

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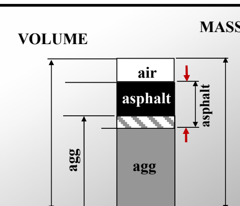
Asphalt Content



- **Asphalt Content (i.e., Total Asphalt Content)**
  - mass concentration of total asphalt binder
- **Reported as percent of the mix mass**
- **Represented as P_b**

6

6

Asphalt Content (Example Calculation 1)

- We add 241 grams of asphalt binder to 4,500 grams of aggregate batch. What is the asphalt content?
- SOLUTION:

Total Mass = 241 + 4,500 = 4,741 grams

Now, we find the Asphalt Content (AC):

$P_b = (241/4{,}741) \times 100 = 5.08\% \approx 5.1\%$

7

7

Asphalt Content (Example Calculation 2)

- Aggregate batch is 3,700 grams, and we need an asphalt mixture at 6.2% binder content (AC). How many grams AC to add?
- SOLUTION

% aggregate in mix is = 100 – 6.2 = 93.8

So, total mix in grams is = 3,700/0.938 = 3,944.6

So, binder in grams is = 6.2/100 × 3,944.6 = 244.6

Or, binder in grams is = 3,944.6 – 3,700 = 244.6

8

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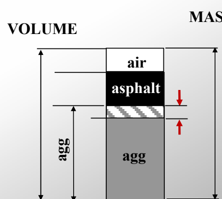
Absorbed Asphalt Content



- **Definition**
  - mass concentration of asphalt absorbed by aggregate
- **Reported as percent of the aggregate mass**
- **Represented as P_{ba}**

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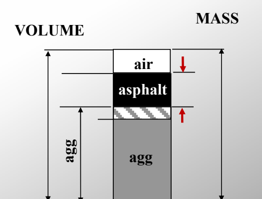
Effective Asphalt Content



- **Definition**
  - Total asphalt content minus absorbed asphalt
  - Asphalt coating the aggregates in the mix
- **Reported as percent of the mix mass**
- **Represented as P_{be}**

10

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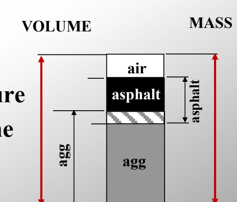
Specific Gravity

- **Applies to agg, binder, and mixture**
- **Bridge Between Mass and Volume**



Using grams and centimeters:

$$G = \frac{M_o / V_o}{M_w / V_w}, \quad \frac{M_w}{V_w} = 1.000 \text{ g/cm}^3$$

← approximate density of water at 77°F (25°C)

11

11

Specific Gravity (G)

- **Relates Density of An Object to Density of Water**

Using grams and centimeters:

$$D = G \times 1.000$$

Density in g/cm³ — specific gravity of object — approximate density of water (g/cm³) at 77°F (25°C)

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Specific Gravity

- **Relates Volume to Mass of an Object**

Using grams and centimeters:

$$V = \frac{M}{G \times 1.000}$$

- volume of object → V
- mass of object → M
- specific gravity of object → G
- approximate density of water at 77°F (25°C) → 1.000

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Specific Gravity

- **Relates Mass to Volume of an Object**

Using grams and centimeters:

$$M = V \times G \times 1.000$$

- mass of object → M
- volume of object → V
- specific gravity of object → G
- approximate density of water at 77°F (25°C) → 1.000

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Aggregate Specific Gravity (There are 3 Types)

- **1.** Bulk (G_{sb}) Volume (i.e., total volume of agg.)
- 2. Effective (G_{se}) Volume (excludes absorbed asphalt volume)
- 3. Apparent (G_{sa}) Volume (excludes absorbed water volume)

All determined from the Same Mass but Different Volumes

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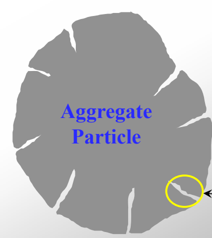
Aggregate Bulk Specific Gravity

"Saturated Surface Dry"

$$G_{sb} = \frac{\frac{\text{Dry Mass}}{\text{Bulk Vol.}}}{1.000\ g/cm^3}$$



Bulk Volume = solid volume + water permeable pore volume

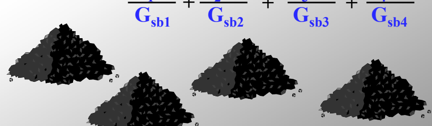
water permeable pore volume

16

Combined Aggregate Bulk Specific Gravity

Determine Weighted Average

$$G_{sb}\text{ (combined)} = \frac{100}{\frac{P_1\%}{G_{sb1}} + \frac{P_2\%}{G_{sb2}} + \frac{P_3\%}{G_{sb3}} + \frac{P_4\%}{G_{sb4}}}$$



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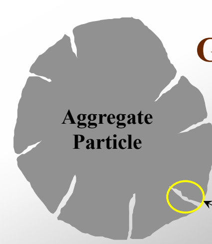
Aggregate Apparent Specific Gravity

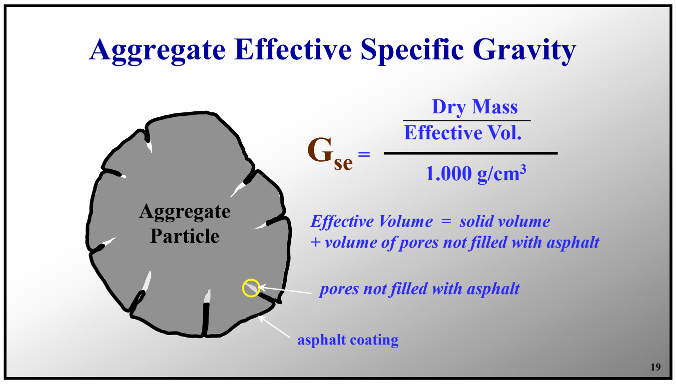
$$G_{sa} = \frac{\frac{\text{Dry Mass}}{\text{Apparent Vol.}}}{1.000\ g/cm^3}$$



Apparent Volume = volume of solid aggregate particle <u>only</u>

DO Not Include

18



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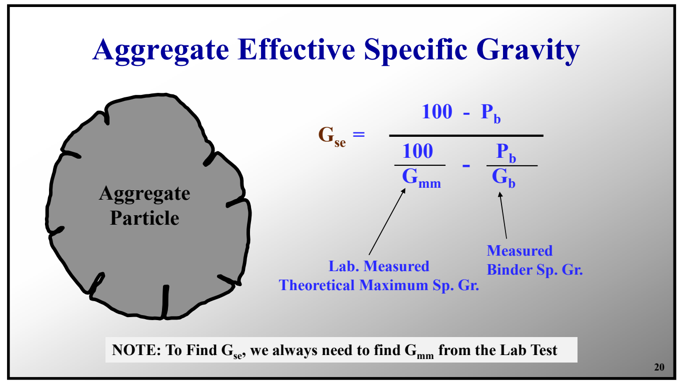

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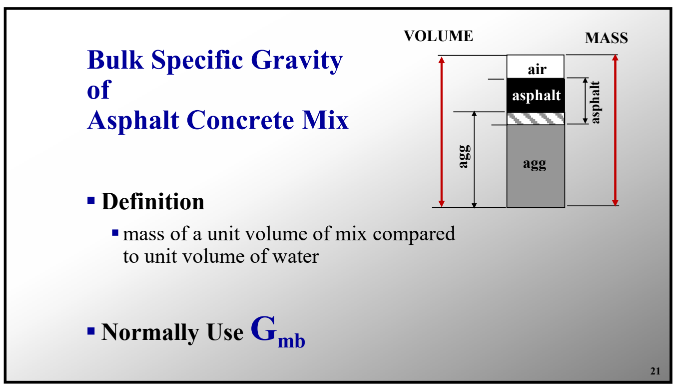
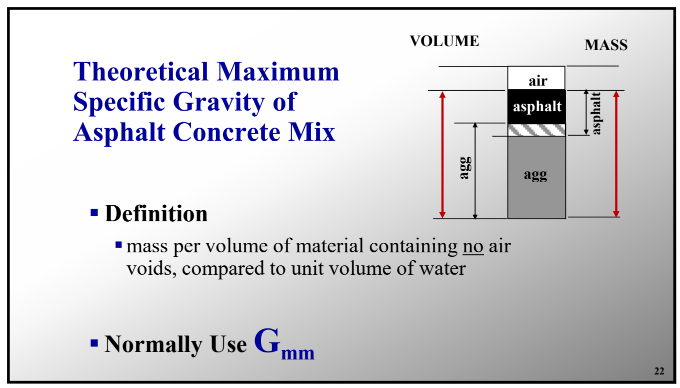


21



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Density & Voids Analysis of HMAC Using Phase Diagram

- **Graphical Presentation of Weight-Volume Relationship for HMAC**
  - Need G_{mb} , G_{sb} ,, and G_b
  - Also Need G_{mm} or G_{se} (One gives the other)
  - $G_{mb} = G_{mm}$ at zero air voids.

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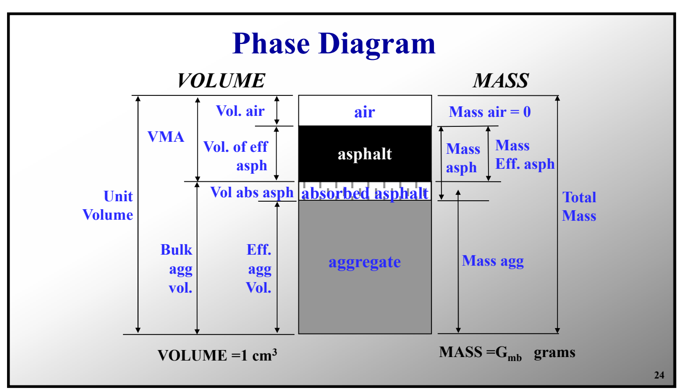

24

Equations

$$G_{mm} = \frac{100}{\frac{P_s}{G_{se}} + \frac{P_b}{G_b}}$$

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

$$VMA = 100 - \frac{G_{mb}\ x\ P_s}{G_{sb}}$$

$$VFA = \left(\frac{VMA - V_a}{VMA}\right) x\ 100$$

$$P_{ba} = 100\ x \left(\frac{G_{se} - G_{sb}}{G_{se}\ x\ G_{sb}}\right) x\ G_b$$

$$P_{be} = P_b - \frac{P_{ba}\ x\ P_s}{100}$$

NOTE: G_{mm} is always found from the Lab Test.
This Eq. is only used for an estimate of G_{mm} when G_{se} is known.

25

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Example Problems for Calculating Volumetrics

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Workshop Assignment

- **Lab Measurements For Aggregates:**
  - Aggregate 1 (56.4 % of total aggregate in the mix),
  - bulk Sp. Gr. = 2.683, and absorption = 0.5 %.
  - Aggregate 2 (43.6 % of total aggregate in the mix),
  - bulk Sp. Gr. = 2.701, and absorption = 0.4%
  - Asphalt Binder = 5.9 % by Wt. of Mix,
  - Binder Sp. Gr. = 1.023

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Workshop Assignment (continued)

- **Lab Measurements for G_{mb}, at 77°F:**
  - Weight of sample in air: 1,235.3 g
  - SSD Weight of sample: 1,239.9 g
  - Weight of sample + water in volumeter: 1,836.2 g
  - Weight of Water in volumeter (calibration): 1,114.8 g
  - Volume of volumeter: 1118.2 cm^3
    - **(NOTE: this volume is calculated from weight of water. Remember that at 77°F, density of water is 0.997 g/mL. See below)**

$$Volume_{of\ volumeter} = \frac{1114.8\ g}{0.997\ g/mL} = 1118.2\ mL$$

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Workshop Assignment (continued)

- **Lab Measurements for G_{mm}, at 77°F:**
  - Wt. of mix in air: 2010.7 g
  - Wt. of Pyc. + water: 7385.2 g
  - Wt. of Pyc. + sample + water: 8582.2 g
- **Find effective asphalt content, air voids, VMA, VFA**

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Follow these steps for calculations

- **1.** Determine G_{sb}, G_{mb}, and G_{mm}
- **2.** Determine G_{se} and Air Voids (P_a or V_a)
- **3.** Determine P_{ba}, P_{be}, VMA, and VFA

NECEPT

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30

Combined Bulk Sp. Gr. of Agg.

$$G_{sb}\text{ (combined)} = \frac{100}{\frac{P_1\%}{G_{sb1}} + \frac{P_2\%}{G_{sb2}} + \frac{P_3\%}{G_{sb3}} + \frac{P_4\%}{G_{sb4}}}$$

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31

Combined Bulk Sp. Gr. of Agg.

$$G_{sb}\text{ (combined)} = \frac{100}{\frac{56.4}{2.683} + \frac{43.6}{2.701}}$$

$$G_{sb}\text{ (combined)} = 2.691$$

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Bulk Sp. Gr. of Compacted Mix (G_{mb})

Calculations below are based on the equation given in section 5 of PTM 715

$$\textit{Density (g/mL)} = \frac{A}{B - \{1.003(C - D)\}}$$

1.003 is the volume of one gram of water in mL (cm^3) at 77°F.

$$G_{mb} = \frac{\text{Density of Asphalt Specimen}}{0.997\ \text{(Density of Water in g/mL)}}$$

A = Dry Weight of sample
B = **Volume** of volumeter
C = Weight of sample and water in volumeter
D = SSD Weight of sample

All in grams and mL (cm^3)

All testing at 77±1.8°F (25±1.0°C)

33

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Bulk Sp. Gr. of Compacted Mix (G_{mb})

(Option 1)

$$\textit{Density} = \frac{1235.3}{1118.2 - \{1.003(1836.2 - 1239.9)\}}$$

$$\textit{Density} = 2.375\ \text{g/mL}$$

This is using equations as given in PTM 715, using volume of the water in the volumeter

$$G_{mb} = \frac{2.375\ g/mL}{0.997\ g/mL}$$

$$G_{mb} = 2.382$$

(compare this with option 2 on next slide)

34

34

Bulk Sp. Gr. of Compacted Mix (G_{mb})

(Option 2)

NOTE: If we use weight of water in volumeter rather than volume of volumeter, then we could directly use G_{mb} equation.

$$G_{mb} = \frac{A}{B - (C - D)}$$

$$G_{mb} = \frac{1235.3}{1114.9 - (1836.2 - 1239.9)}$$

$$G_{mb} = 2.382$$

A = Dry Weight of sample
B = **Weight** of water in volumeter
C = Weight of sample and water in volumeter
D = SSD Weight of sample

ALL IN GRAMS, except G_{mb} which does not have units.

35

35

Theoretical Maximum Sp. Gr. of Loose Mix

$$G_{mm} = \frac{A}{A + D - E}$$

All in grams and mL (cm^3)

A = Dry Weight
D = Weight of Pycnometer with water
E = Weight of Pycnometer with water & specimen

All testing at 77±1.8°F (25±1.0°C)

36

36

Theoretical Maximum Sp. Gr. of Loose Mix

$$G_{mm} = \frac{2010.7}{2010.7 + 7385.2 - 8582.2}$$

$$G_{mm} = 2.471$$

37

Air Void of Compacted Mix

$$\%\ Voids,\ P_a = \left(1 - \frac{G_{mb}}{G_{mm}}\right) \times 100$$

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Air Void of Compacted Mix

$$\%\ Voids,\ P_a = \left(1 - \frac{2.382}{2.471}\right) \times 100$$

$$\%\ Voids,\ P_a\ (\text{or } V_a) = 3.6$$

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Air Void of Compacted Mix

Or we could find % compaction first and then find air void

$$\%\ Compaction\ (\%Gmm) = \frac{2.382}{2.471} \times 100 = 96.4$$

$$\%\ Voids,\ P_a = 100 - 96.4$$

$$\%\ Voids,\ P_a\ (\text{or } V_a) = 3.6$$

40

Effective Specific Gravity of Aggregate

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

P_b = Percent Binder
G_b = Sp. Gr. of Binder

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Effective Specific Gravity

$$G_{se} = \frac{100 - 5.9}{\frac{100}{2.471} - \frac{5.9}{1.023}}$$

$$G_{se} = 2.712$$

42

G_{se} Smaller than G_{sb}?

Something Wrong!

43

Absorbed Asphalt Binder

$$P_{ba} = 100 \text{ x } \left(\frac{G_{se} - G_{sb}}{G_{se} \times G_{sb}}\right) \times G_b$$

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Absorbed Asphalt Binder

$$P_{ba} = 100 \text{ x } \left(\frac{2.712 - 2.691}{2.712 \times 2.691}\right) \times 1.023$$

$$P_{ba} = 0.29\%$$

45

Effective Asphalt Binder

$$P_{be} = P_b - \left(\frac{P_{ba} \text{ x } P_s}{100}\right)$$

P_{be} = Effective Asphalt Binder

46

Effective Asphalt Binder

$$P_{be} = 5.9 - \left(\frac{0.29 \text{ x } 94.1}{100}\right)$$

$$P_{be} = 5.6\ \%$$

47

Voids in the Mineral Aggregate

$$VMA = 100 - \left(\frac{G_{mb} \text{ x } P_s}{G_{sb}}\right)$$

48

Voids in the Mineral Aggregate

$$VMA = 100 - \left(\frac{2.382 \times 94.1}{2.691}\right)$$

VMA = 16.7

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Voids Filled with Asphalt

$$VFA = \left(\frac{VMA - P_a}{VMA}\right) \times 100$$

50

50

Voids Filled with Asphalt

$$VFA = \left(\frac{16.7 - 3.6}{16.7}\right) \times 100$$

VFA = 78.4 %

51

51

Summary of Solution

- G_{sb}: 2.692
- G_{mm}: 2.471
- G_{se}: 2.712

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Summary of Solution

- Air voids: 3.6 %
- Absorbed Asphalt: 0.29% (of agg. weight)
- Effective asphalt: 5.6 % (of mix weight)
- VMA: 16.7 %
- VFA: 78.4 %

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Thank You!

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1

Your Role with PennDOT Specifications

- You must be
  - familiar with specifications that cover your project.
  - be aware of the effective change dates and your project let date.

NECEPT

2

Your Role with PennDOT Specifications

- You must be
  - familiar with specifications that cover your project.
  - be aware of the effective change dates and your project let date.

NECEPT

3

Powers of Observation

- Do you think this is important for you as a certified plant technician?
- How would you rate yourself on a scale of 1 to 10, with 10 being the best!

4

FINISHED FILES ARE THE RESULT OF
YEARS OF SCIENTIFIC STUDY
COMBINED WITH THE EXPERIENCE OF
MANY YEARS.

5

Can you read this?

I cdnuolt blveiee that I cluod aulaclty uesdnatnrd what I was rdanieg. The phaonmneal pweor of the hmuan mnid, aoccdrnig to a rscheearch at Cmabrigde Uinervtisy, it dseno't mtaetr in what oerdr the ltteres in a word are, the olny iproamtnt tihng is that the frsit and last ltteer be in the rghit pclae. The rset can be a taotl mses and you can still raed it whotuit a pboerlm. This is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the word as a wlohe. Azanmig huh? Yaeh and I awlyas tghuhot slpeling was ipmorantt! If you can raed this forwrad it

6

R34D 7H15

7

7H15 M3554G3 53RV35 70 PROV3 7H47 OUR M1ND5 C4N DO 1MPR3551V3 TH1NG5!
1N 7H3 B3G1NN1NG 17 WA5 H4RD. BU7 NOW, ON 7H15 LIN3 YOUR M1ND 15 R34D1NG 4UTOM471C4LLY W17HOU7 3V3N 7H1NK1NG 4BOU7 17. ONLY C3R741N P3OPL3 C4N R34D 7H15!

8

So, Are you using your Powers of Observation?

Be observant to all aspects of the products you are working with.

Learn from you mistakes and mistakes of others.

Be knowledgeable of specifications and JMF.

9

9

Publication 408/ Pub 408

Year (Version)	Effective Dates
2000	April 3, 2000 to September 30, 2003
2003	October 1, 2003 to April 1, 2007
2007	April 2, 2007 to March 31, 2011
2011	April 1, 2011 to March 31, 2016
2016	April 1, 2016 to April 2, 2020
2020	April 10, 2020 to October 6, 2023

10

10

What you need to know...

- **PennDOT Specifications Publication 408**
- **Sections covering Asphalt & the important aspects of these specifications**
- **PennDOT website: www.penndot.gov/**

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PennDOT Specifications (Publication 408)

Pub 408/2020:
Initial Edition (IE)

(Effective April 10, 2020)

12

12

PennDOT Specifications (Publication 408)

Pub 408/2020:
Change No. 7

(Effective October 6, 2023)

Go to: https://www.dot.state.pa.us/public/PubsForms/Publications/Pub_408/PUB%20408.pdf

Then, click on 2020 Version
Then, click on Change No. 7

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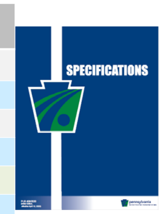
PennDOT Specifications (Publication 408)

Version	Effective Date
Initial Edition	April 10, 2020
Change No. 1	October 2, 2020
Change No. 2	April 9, 2021
Change No. 3	October 8, 2021
Change No. 4	April 1, 2022
Change No. 5	October 7, 2022
Change No. 6	April 14, 2023
Change No. 7	**October 6, 2023**



2020

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Sections of Publication 408

Question:
How Many Sections Are There in Spec 408?
Answer:
Twelve

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Contents of Publication 408

- Sections 1 through 12
- Appendix A - Metric (SI) Information
- Appendix B – Standard Special Provisions
  - as set forth in the Bid Proposals
  - need further tailoring for use on specific projects
  - Includes seven indices
- Appendix C – Designated Special Provisions
  - Standard documents previously included in PennDOT Bid Proposals.
- General Index (indexing the Publication)
- Change Letters and Indices

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Sections Publication 408

- 100 - General Provisions ⬅
- 200 - Earthwork
- 300 - Base Courses ⬅
- 400 - Flexible Pavements ⬅
- 500 – Rigid Pavements
- 600 – Incidental Construction

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Sections Publication 408

- 700 - Materials ⬅
- 800 – Roadside Development
- 900 – Traffic Accommodation & Control
- 1000 - Structures
- 1100 – Manufactured Materials
- 1200 – Intelligent Transportation System Devices

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Sections of Publication 408

- 100 - General Provisions
  - Abbreviations and definitions
  - Bidding requirements and conditions
  - Award and contract execution
  - Scope and control of work
  - **Control of materials (Section 106)**
  - Measurement of quantities
  - Payment
  - Several others

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Sections of Publication 408

- 300 – Base Courses
  - SP Asphalt Mix Design & Construction, Base Course (Section 313)
  - Cold Mixes (Sections 341 and 342)
  - Asphalt Treated Permeable Base (Section 360)

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Sections of Publication 408

- 400 – Flexible Pavements
  - SP Asphalt Mix Design & Construction, Plant Mixed Courses with PWL and LTS Testing (Section 413)
  - SP Asphalt Mix Design & Construction, 6.3 mm NMAS Mixes (Section 412)
  - SMA (Section 419)

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Sections of Publication 408/2016

- 700 – Materials
  - Asphalt materials (Section 702)
  - Aggregates (Section 703)

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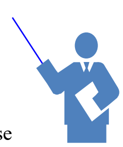
What You Need to Know about Specifications

- Sections in **Publication 408** covering specifications on ASPHALT
- Important aspects of these specifications
- Understand these specifications
- How to perform calculations related to these specifications



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See
Publication 408
to find details of specifications

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Pub 408 Table of Contents

Section	Title	
100	General Provisions	←
200	Earthwork	
300	Base Courses	←
400	Flexible Pavements	←
500	Rigid Pavements	
600	Incidental Construction	
700	Material	←
800	Roadside Development	
900	Traffic Accommodation & Control	
1000	Structures	
1100	Manufactured Material	
1200	Intelligent Transportation System (ITS) Devices	

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Pub 408 Asphalt Specifications

106	Control of Material
313	Superpave Asphalt Mixture Design, Standard Construction, Base Course
314	Asphalt Rich Base Course (ARBC)
316	Flexible Base Replacement
344	Full Depth Reclamation
360	Asphalt Treated Permeable Base Course
404	Evaluation of Asphalt Pavement Ride Quality and Payment of Incentive
405	Evaluation of Asphalt Pavement Longitudinal Joint Density And Payment of Incentive/Disincentive

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Pub 408 Asphalt Specifications

410	Superpave Mixture Design, Standard & RPS Construction of Plant-Mixed Fine-Graded Courses
412	Superpave Mixture Design, Construction of Plant-Mixed 6.3 mm Thin Asphalt Overlay Courses
413	Superpave Mixture Design, Standard & RPS Construction of Plant-Mixed Courses with PWL and LTS Testing
419	Stone Matrix Asphalt Mixture Design, RPS Construction of Plant-Mixed Wearing Courses
420	Pervious Asphalt Pavement System
460	Asphalt Tack Coat
483	Polymer-Modified Emulsified Asphalt Paving System (Microsurfacing)
489	Ultra-Thin Bonded Wearing Course
491	Milling of Asphalt Pavement Surface
496	Asphalt Concrete Pavement, 60-Month Warranty

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Other Related Pub 408 Specifications

210	Subgrade
350	Subbase
450	Manual Asphalt Patching
461	Asphalt Prime Coat
469	Asphalt Joint & Crack Sealing
491	Milling of Asphalt Paving Surface
492	Profile Milling of Asphalt Paving Surfaces

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Section 106:
Control of Materials

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Section 106:
Control of Material

- Material
- Tests and Acceptance of Material
  - Form CS-4171 Certificate of Compliance
- Storage of Material
- Handling and Transportation of Material
- Unacceptable Material
- Several other subsections...

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Several Important Bulletins
covering materials, applications, and sources

- Bulletin 14 (Approved Aggregates)
- Bulletin 15 (List of Prequalified Materials and Products)
- Bulletin 41 (Approved Asphalt Materials)
- Bulletin 42 (Approved Concrete Materials)

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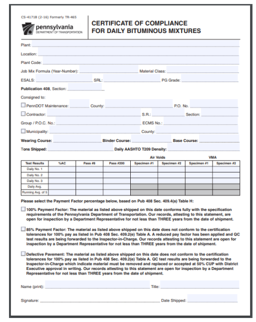
Form CS-4171B Certificate of Compliance



CS-4171B (2-16) Formerly TR-465

pennsylvania DEPARTMENT OF TRANSPORTATION

CERTIFICATE OF COMPLIANCE FOR DAILY BITUMINOUS MIXTURES

Plant:
Location:
Plant Code:
Job Mix Formula (Year-Number): Material Class:
ESALS: SRL: PG Grade:
Publication 408, Section:
Consigned to:
☐ PennDOT Maintenance: County: P.O. No.
☐ Contractor: S.R.: Section:
Group / P.O.C. No.: ECMS No.:
☐ Municipality: County:
Wearing Course: **Binder Course:** **Base Course:**
Tons Shipped: **Daily AASHTO T209 Density:**

				Air Voids		VMA	
Test Results	%AC	Pass #8	Pass #200	Specimen #1	Specimen #2	Specimen #1	Specimen #2
Daily No. 1							
Daily No. 2							
Daily No. 3							
Daily Avg.							
Running Avg. of 5							

Please select the Payment Factor percentage below, based on Pub 408 Sec. 409.4(a) Table H:

☐ **100% Payment Factor: The material as listed above shipped on this date conforms fully with the specification requirements of the Pennsylvania Department of Transportation. Our records, attesting to this statement, are open for inspection by a Department Representative for not less than THREE years from the date of shipment.**

☐ **85% Payment Factor: The material as listed above shipped on this date does not conform to the certification tolerances for 100% pay as listed in Pub 408 Sec. 409.2(e) Table A. A reduced pay factor has been applied and QC test results are being forwarded to the Inspector-in-Charge. Our records attesting to this statement are open for inspection by a Department Representative for not less than THREE years from the date of shipment.**

☐ **Defective Pavement: The material as listed above shipped on this date does not conform to the certification tolerances for 100% pay as listed in Pub 408 Sec. 409.2(e) Table A. QC test results are being forwarded to the Inspector-in-Charge which indicate material must be removed and replaced or accepted at 50% CUP with District Executive approval in writing. Our records attesting to this statement are open for inspection by a Department Representative for not less than THREE years from the date of shipment.**

Name (print): Title:
Signature: Date Shipped:

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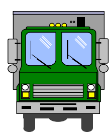
Section 106.02: Control of Material



- Have the source of material supply accepted before delivery is started…
  - Preapproved sources
  - Other sources (requires approval before use)

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Section 106.02: Control of Material

- Inspect material & store only the material meeting specification requirements.
- Allow designated Department representatives to inspect material being used.
- Department reserves the right to obtain samples for testing to verify compliance with specifications

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Section 106.03: Tests and Acceptance of Material

- Department responsible for determining acceptability of material & construction (**QA: Quality Acceptance**)
- Contractor responsible for control of the material quality (**QC: Quality Control**)
- Sample and test according to PTM's or other PennDOT approved test protocols (AASHTO, ASTM, …)

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Section 106.03 (a)2:

- Quality Control Plan should cover
  - Raw materials (list source of materials, documentation, testing)
  - Production control (lot size, sampling, testing, …)
  - Product testing (type and frequency of tests, methods of documentation and reporting, equipment, calibration, …)
  - Personnel (list and areas of responsibility)
  - Packaging and shipping (methods, of identifying, storing, loading, transporting, and unloading)
  - Documentation (procedures for documentation and certification)
- Quality Acceptance Plans (percent within tolerance)

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Calculating Percent Within Tolerance Limits

- Calculate lot mean
- Calculate lot standard deviation
- Calculate upper and lower quality index
- Find percent within upper and/or lower tolerance limit
- Calculate total percent within limits, when necessary

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Calculate Average of Measurements

- The average, or $\overline{X}$ ("x-bar"), for a lot is calculated by summing all values and dividing by the number of measurements (# of sublots)

4.2
4.9
5.1
6.3
7.1
27.6

$\overline{X}$ = 27.6 / 5 = 5.5

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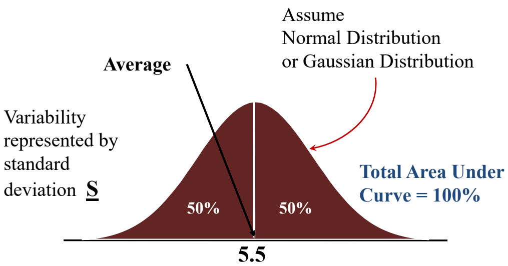
Production Variability



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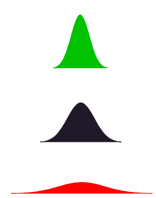
Normal Distribution Curve



#	$\overline{x}$	s
5	5.5	1.25 (lowest variability)
5	5.5	2.50
5	5.5	4.50 (highest variability)

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Standard Deviation

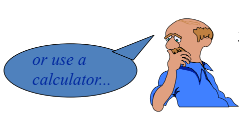
- The standard deviation ("s") is calculated by summing the square of the deviations, dividing by one less than the number of measurements, and then taking the square-root of this number

$(4.2-5.5)^2 = 1.69$
$(4.9-5.5)^2 = 0.36$
$(5.1-5.5)^2 = 0.16$
$(6.3-5.5)^2 = 0.64$
$(7.1-5.5)^2 = 2.56$

5.41

5.41/(5-1) = 1.35

$\sqrt{1.35} = 1.1630$



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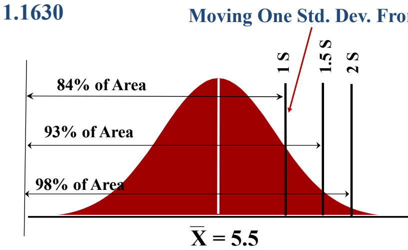
Building Confidence Intervals

S = 1.1630



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Specification Limits

- A specification may have an upper limit, U, and lower limit, L, or both an upper and lower limit, U and L
- Calculation of percent within tolerance depends on whether the spec has an upper or lower limit, or both
- For example, consider a JMF with a target asphalt content of 5.7%, then

U=6.1%, and L=5.3%

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Calculation of Quality Index

Upper quality index:

$$Q_U = (U - \bar{X}) / s = (6.1-5.5)/1.1630 = 0.5159$$

Lower quality index:

$$Q_L = (\bar{X} - L) / s = (5.5-5.3)/1.1630 = 0.1720$$

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Percent Within Limits

- Use Table B in 106.03 to find upper limit of tolerance
- In this case, n=5, so for Q_U=0.5159,

  P_U = 68%
- For the lower tolerance limit, n=5 and Q_L=0.1720, so

  P_L= 56%
- The total percent within limits is

  $P_U+P_L-100 = 68 + 56 - 100 = 24\%$

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Caution!!!

- There are two different tables for calculating percent within limits--one for positive values of the quality index, and one for negative values
- Make sure you are in the right table!

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Section 106.03 (b): Specifications, Other Than Restricted Performance

106.03 (b) 1: Responsibility

- Department responsible for determining acceptability of material & construction
- Contractor responsible for quality control
- Sample and test according to PTM's, AASHTO, ASTM, …

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Section 106.03 (b): Specifications, Other Than Restricted Performance

106.03 (b) 2: Quality Control

- Raw materials
- Production control
- Product testing
- Personnel
- Packaging and shipping
- Documentation

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Section 106.03 (b): Specifications, Other Than Restricted Performance

106.03 (b) 3: Certification

- Certificate of Compliance - Form CS-4171(formerly known as TR-465) to certify material is in compliance with the Bulletin materials)
- Certification file (retain CS-4171 forms for not less than 3 years)
- Certification Documents
  - CS-4171 – Daily Asphalt Certification (Supplied the next day)
  - Bill of Lading
  - Approved Job Mix Formula

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Section 106.03 (b): Specifications, Other Than Restricted Performance

106.03 (b) 3.e: Levels of Certification

Determined by Bureau of Operations and Project Delivery (BOPD) for Each Producer based on Producer's ability to comply with the materials specifications

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106.03 (b) 3.e: Levels of Certification

Level of Certification for Bulletin 15 Producers		Producer Material Shipment Procedure	Producer Additional Requirements
Level 1	Standard Certification	Ship on Certification with Form CS-4171*	None
Level 2	Standard Certification - Reduced	Ship on Certification with Form CS-4171*	See Section 106.03(b)3.e.2
Level 3	Lot Approval Certification	Ship only after Material Lot Approval using Modified Certification, with Form CS-4171*	See Section 106.03(b)3.e.3
Suspension or Removal	In accordance with the State's Contractor Responsibility Program: Producer may be suspended on removed from Bulletin 15 for any of the reasons stated in the Bulletin 15 Preface, regardless of producer Certification level. Failure of Producer to advance above Certification level 3 will result in PennDOT's initiating action for suspension or removal from Bulletin 15.		

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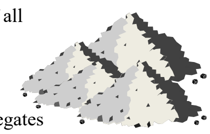
Section 106.05/106.06: Storage & Handling of Material

- Store and handle material to ensure quality of all work
- Store aggregates in separate stockpiles
- Avoid segregation and contamination of aggregates
- Schedule deliveries so there is sufficient time to inspect and test aggregates



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Section 313: Superpave Asphalt Mixture Design & Construction Base Course

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Section 313.1 Description

- This work is the standard construction of plant mixed asphalt base course on a prepared surface using a volumetric mixture design developed with the Superpave Gyratory Compactor.

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Section 313.3(a)7.a General Requirements

- If **25.0-mm** asphalt base is specified at **> 6"** compacted, place in two or more ≈ equal lifts, **none less than 3 inches or more than 6"** compacted.
- If **37.5-mm** asphalt base is specified at **> 8"** compacted, place in two or more ≈ equal lifts, **none less than 4 inches or more than 8"** compacted.

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Section 360: Asphalt Treated Permeable Base Course

56

Section 360.1 Description

- This work is the standard construction of an asphalt treated permeable based course (ATPBC) on a prepared surface.

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Section 360.2 Materials

a) Asphalt Material. Asphalt Cement, Class **PG 64S-22**.

b) Coarse Aggregate. **Type A or B**. When Crushed Gravel is used a **min. of 75% two faced crushed**.

c) Fine Aggregate. **Type A or B.**

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Section 360.2 Materials (continued)

d) Additives

1. Hydrated Lime. Added prior to mixing with asphalt to eliminate stripping.
2. Heat stable anti-stripping additive.

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Section 360.2 Materials (continued)

e) Composition of Mixtures

TABLE A

Passing Sieve	Percent Passing
37.5 mm (1 ½")	100
25.0 mm (1")	95 – 100
19.0 mm (3/4")	75 – 100
12.5 mm (1/2")	35 – 65
4.75 mm (#4)	12 – 24
1.18 mm (#16)	6 – 16
75 µm (#200)	0 – 5
Bitumen Content	2.0 – 3.0*

*** For approved gravel and slag mixtures, the Representative may allow the contractor to exceed the upper limit.**

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Section 360.3 Construction

a) Weather Limitations. Do not place if unstable, frozen or temperature of surface or air is < **35°F**.

b) Asphalt Mixing plant.
- **Do not exceed 320°F** to produce ATPBC
- Do not stockpile ATPBC for more than 8 hours
- ATPBC must be placed within 8 hours from the time made

c) Density Acceptance. Delete this section.

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Section 412
Superpave Mixture Design, Construction of Plant Mixed 6.3-mm Thin Asphalt Overlay Courses

- Used in Thin Lifts (3/4" min, 1 ¼" max.)
- Useful Tool for Pavement Preservation
- An alternative to microsurfacing and seal coats.
- **Mixture Details**
  - PG 64E-22 binder required
  - Coarse aggregate: Type A
  - Sand fine aggregate must be from the same source as coarse aggregate with SRL rating in Bulletin 14
  - No RAP or RAS in mix (virgin)

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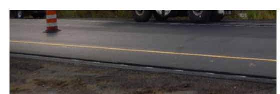
Section 412
6.3 mm Thin Overlay Courses

Construction details:
- >50°F air and surface temperature
- MTV required, unless waived by Rep.
- Box samples from roadway, hopper, or screed
- Density acceptance by optimum rolling pattern or non-movement


One-inch thick placed 6.3 mm, SR 220

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Section 412
6.3 mm Thin Overlay Courses

Critical points for success:
- Clean existing surface.
- Proper, uniform tack application
- Selection of compaction rollers
- Begin Rolling immediately.
- Time available for compaction is limited.
- Do not use pneumatic-tire rollers.

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413–Superpave Asphalt Mixture Design and Construction of Plant Mixed Courses with PWL and LTS Testing

- 413.1 Description
- 413.2 Materials
- 413.3 Construction
- 413.4 Measurement & Payment

Where most changes have occurred in Specs.

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Section 413.2: MATERIALS

TABLE A

JMF – Composition Tolerance Requirements

Gradation	Single Sample (n=1)	Multiple Sample (n≥3)
Passing 12.5 mm (1/2 inch) and Larger	± 8.0 %	± 6.0 %
Passing 9.5 mm (3/8 inch) to 150 µm (No 100) Sieves (Inclusive	± 6.0%	± 4.0 %
Passing 75 µm (No. 200) Sieve	± 3.0%	± 2.0%
Asphalt Content		
19.0 mm asphalt mixtures and smaller	± 0.7%	± 0.4%
25.0 mm asphalt mixtures and larger	± 0.8%	± 0.5%

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Section 413.2: MATERIALS, Table A

Temperature of Mixture (°F)				
Class of Material	Type of Material	Chemical, Organic, Foaming Additives, Minimum	Mechanical Foaming Equip/Process Minimum*	Maximum*
PG 58S-28	Asphalt Binder	215	230	310
PG 64S-22	Asphalt Binder	220	240	320
PG 64E-22	Asphalt Binder	240	260	330
All other binders	Asphalt Binder	The higher of 215 or the minimum temp. specified in Bulletin 25 minus 45F	The higher of 230 or the minimum temp. specified in Bulletin 25 minus 30F	As specified in Bulletin 25

* Outline in the Producer QC Plan and follow more restrictive temperature requirements provided by the WMA technology manufacturer or Technical Representative(s) for production and placement of the mixture. Determine the SGC compaction temperature for the production QC which yields the same target air voids as the designed JMF . Include the SGC compaction temperature in the Producer QC Plan. Compact the completed mixture in the SGC for QC volumetric analysis at the SGC compaction temperature according to the guidelines provided by the Technical Representative.

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Section 413.2:Materials

TABLE B

JMF – Volumetric Tolerance Requirements

Nominal Max Agg. Size (mm)	Each Specimen	Multiple Specimens
Air Voids at N_{des} (V_a)	±2%	±1.5%
Min. VMA% for 4.75 mm mixes	16.0	-
Min. VMA% for 9.5 mm mixes	15.0	-
Min. VMA% for 12.5 mm mixes	14.0	-
Min. VMA% for 19.0 mm mixes	13.0	-
Min. VMA% for 25.0 mm mixes	12.0	-
Min. VMA% for 37.0 mm mixes	11.0	-

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Section 413.2: MATERIALS

TABLE C

Mixture Acceptance

Acceptance Level	Acceptance Method
Certification Acceptance	Producer Certification of Mixture Section 413.2 (i) 2
Lot Acceptance	Mixture Acceptance Sample Testing Section 413.3(h) 2

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Section 413.3(h) 2: Mixture Lot Acceptance

- Normal Lot Size: **2,500 tons**, **5** equal sublots
- Each sublot: 500 tons
- Special circumstances may change the lot size
  - Minimum possible number of sublots: 3
  - Maximum possible number of sublots: 7

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Section 413.3: Construction

- **TABLE D.** - Re-adjustment of Lot Size and Associated Number of Sublots
- **TABLE E.** - Density Limits for Partially Completed Lots
- **TABLE F.** - Density Acceptable Levels & Criteria
- **TABLE G.** - Minimum Mixture Compacted Depths

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Section 413.2(h): Density Acceptance

TABLE E

Density Limits for Partially Completed Lots

Mixture NMAS	Density Limits
All RPS 9.5 mm, 12.5 mm, 19 mm, and 25 mm Wearing or Binder Course	≥ 92.0% and ≤ 98.0%
All Standard 9.5 mm, 12.5 mm, 19 mm, and 25 mm Wearing or Binder Course	≥ 91.0% and ≤ 98.0%
All 25 mm and 37.5 mm Base Course	≥ 90.0% and ≤ 100.0%

- **PAYMENT:**
- If density meets Table E Criteria: 100% Pay
- If density no more than 2% below min. or no more than 2% above max: 90% Pay
- Other cases: Defective work. Remove & Replace unless directed otherwise by the District

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Section 413.2(j): Density Acceptance

TABLE F

Density Acceptance

Density Acceptance Level	Acceptance Criteria
Non-movement	Table H
Optimum Rolling Pattern	Table H
Pavement Cores*	Table I
* Only when mixture is accepted by lots	

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Section 413.2(j): Density Acceptance

TABLE G

Mixture Minimum Compacted Depths

Mixture	Minimum Depth
9.5-mm Wearing Course	1 ½" (≈ 40 mm)
12.5-mm Wearing Course	2" (≈ 50 mm)
19-mm Wearing and Binder Course	2 ½" (≈ 60 mm)
25-mm Binder Course	3" (≈ 80 mm)

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Section 413.4: Measurement & Payment

TABLE H

Contract Unit Price Adjustments - Mixture Acceptance by Certification

- **Asphalt Content**

NMAS	Criteria	Value		PF, %
All sizes	Printed Tickets	At least 90% is ± 0.2 of JMF		100
		Less than 90% is ± 0.2 of JMF		85
19 mm and smaller	QC Sample Testing	Single, n=1	n≥ 2	-------------
		±0.7%	±0.5%	100
		±0.8% to 1.0%	±0.6%	85
		> ±1.0%	≥ ±0.7%	RR or 50%
25 mm and larger	QC Sample Testing	±0.8%	±0.6%	100
		±0.9% to 1.2%	±0.7%	85
		> ±1.2%	≥ ±0.8%	RR or 50%

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Section 413.4: Measurement & Payment

TABLE H

Contract Unit Price Adjustments - Mixture Acceptance by Certification

- **Gradation**

NMAS	Criteria	Value		PF, %
		n=1	n≥ 2	
All sizes	QC Sample Testing for % Passing #200 Sieve	±3.0%	±2.1%	100
		±3.1% to ±4.0%	±2.2% to ±2.7%	85
		> ±4.0%	≥ ±2.8%	RR or 50%
All sizes	QC Sample Testing for % Passing #8 Sieve	±6%	±4%	100
		±7% to ±8%	±5%	85
		> ±8%	≥ ±6%	RR or 50%

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Section 413.4: Measurement & Payment

- **Mixture Acceptance by Lots**

TABLE I

Upper & Lower Spec Limits for Calculating Percent Within Tolerance

TABLE J

Dispute Resolution Retest Cost Table

78

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Section 413.4: Measurement & Payment Mixture Acceptance by Lot

1. Lot results on asphalt content, gradation, and density are used with lower and upper spec limits to determine Percent Within Limits (PWL).

2. PWL for each parameter is used to determine a single Pay Factor (PF) for that parameter.

3. An overall pay factor (OLPF) is determined from combination of individual pay factors. See next slide.

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Section 413.4: Measurement & Payment Mixture Acceptance by Lot

$$OLPF = (0.50 \times PF_D) + (0.30 \times PF_{AC}) + (0.10 \times PF_{200}) + (0.10 \times PF_{PCS})$$

Where

OLPF = Overall Lot Pay Factor

PF_D = Pay Factor for In-Place Density

PF_{AC} = Pay Factor for Asphalt Content

PF_{200} = Pay Factor for Percent Passing the 75 mm (No. 200) Sieve

PF_{PCS} = Pay Factor for Percent Passing the Primary Control Sieve (PCS)

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Section 413.4: Measurement & Payment Mixture Acceptance by Lot

LOT PAYMENT = C_p (OLPF)/100

Where

Cp = Contract unit price per lot (unit price times lot quantity)

and

OLPF = Overall Lot Pay Factor

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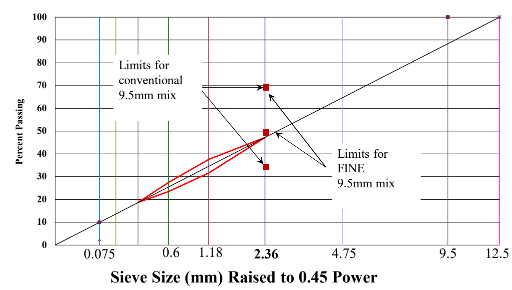
Section 410: 9.5 mm Fine Graded Mixes



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Section 410: 9.5 mm Fine Graded Mixes

Mixture	Minimum Depth
9.5 mm Fine Grade Wearing Course	1 in. (≈ 25 mm)

Compare with typical 9.5 mm mix at 1.5 inches of depth (See Table G in Section 413)

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Thank You!

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Plant Technician Certification Program

Module 9
Pennsylvania/AASHTO Test Methods

Northeast Center of Excellence for Pavement Technology

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Plant Technician Certification Program

Module 9

Pennsylvania/AASHTO Test Methods

1

Why Conduct Laboratory Tests?

- We use lab. tests to design asphalt mixes.
- We used lab. tests to determine the quality of the asphalt being produced.
- Standard testing is essential to both contractor quality control and material acceptance.
- If tests are not carefully and uniformly performed, QC/QA decisions will often be wrong, hurting both the contractor and State Highway Agency.

2

What you need to know...

- The most important PTM's for asphalt design and plant production quality
- The purpose of each of these important test methods
- Major steps and problem areas for each of these selected PTM's

3

What we will cover in this unit...

- Overview of several PTM's
- NOTE:
  - Mixture designers and lead technicians should also take a hands-on laboratory course

4

PTM's for Plant Technicians

- PTM 001: Probability Sampling
- PTM 005: Evaluation of Testing Repeatability
- PTM 006: Percent Within Limits (PWL)
- PTM 639: Sampling Aggregates from Roadway
- PTM 746: Sampling Bituminous Paving Mixtures

5

PTM's for Plant Technicians

- PTM 702: Quantitative Extraction of Asphalt
- PTM 715: Bulk Sp. Gr. Of Compacted Mixture
- PTM 716: Bulk Sp. Gr. Of Compacted Mixture (water absorption > 3 percent)
- PTM 739: Sieve Analysis of Extracted Agg.
- PTM 742: Binder Content by Pycnometer Method
- PTM 757: Determination of Asphalt Content and Gradation of Hot Mixed Asphalt (HMA) by the Ignition Method

6

Some PTM's have been replaced by AASHTO Test Methods and Practices

- T-40: Sampling Bituminous Materials
- T-209: Theoretical Maximum Sp. Gr.

7

7

AASHTO Practices, Specs, and Test Methods

- **AASHTO R 30-02 (2019)**
  - **Standard Practice for Mixture conditioning of HMA**
- **AASHTO R 35-17**
  - **Standard Practice for Superpave Volumetric Design for HMA**
- **AASHTO M 323-17**
  - **Standard Specification for Superpave Volumetric Design for HMA**
- **AASHTO T 312-19**
  - **Standard Method of Test for Preparing and Determining the Density of HMA Specimens by Means of the SGC**
- **AASHTO T 283-14 (2018)**
  - **Standard Method of Test for Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage**

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PA Test Method No. 1:

Method of Test for PROBABILITY SAMPLING

9

Summary

- Selecting sampling sites using probability methods
- Proper sampling is essential to good QC/QA
- Sample divided into lots and sublots
- Sample location determined by values in random number table

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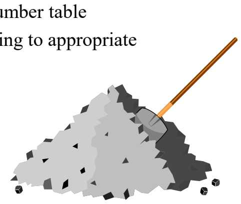
Taking Samples

- PennDOT sampling as directed by the engineer
- Location chosen in an unbiased manner, using lots, sublots, and random number table
- Sampling procedure according to appropriate PTM



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Lots and Sublots

- *Lot*--a quantity of specified material from a single source or produced by the same process
- *Sublot*--a portion of a lot; location from which sample is taken
- Lot size, sublot size, and number of sublots per lot specified by *PTM*

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Random Number Table

	X	Y
1	0.29	R0.66
2	0.74	R0.49
3	0.89	L0.79
4	0.60	R0.39
.	.	.
.	.	.

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Procedure

- Determine lot size and number of sublots per lot from PTM
- Select a set of consecutive numbers from random number table--one for each sublot
- For roadway sampling, values in X and Y columns give coordinates of sample
- Otherwise, use only values in X column, as stated in PTM

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AASHTO T 40 – 02 (2012)

Method of Test for SAMPLING BITUMINOUS MATERIALS

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Introduction

- Proper sampling is as important as good test practice in the laboratory
- This test describes procedures for sampling liquid, semisolid, and solid bituminous materials
- Suitable methods are given for sampling from tanks, vehicles, containers, and stockpiles

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Sample Size for Lab Testing

- Liquid materials: one quart (one liter) minimum
- Semisolid and solid materials: 2 to 3 lbs. (1 to 1.5 kg) minimum
- Containers should not be much bigger than sample
  - for liquid materials, use double friction-top cans, or square screw-top cans
  - for liquid emulsions, use wide-mouth jars or plastic bottles

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Sample Handling

- Use only clean, new containers
- Tightly seal immediately after sampling
- Do not clean container after filling with excessive amounts of solvent
- Keep emulsion samples from freezing in cold weather
- Clearly mark all samples for identification, on the body container and not on the lid

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Sampling Liquid Materials from Bulk Storage

- Tank taps at top, middle, and lower one-third; purge 1 gallon before sampling
- Thief sampler for emulsions
- Throw-away container method
- Test three samples individually to check for stratification
- Test blended material for average results
- If tanks have mechanical agitators, only one sample is needed

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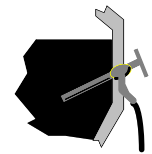
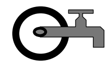
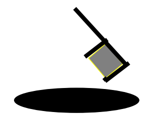
Sampling from Delivery Vehicles & Agitated Tanks

- Each vehicle should have a sampling valve; purge 1 gal. (4 liters) before sampling
- At purchaser's option, other sampling methods may be used:
  - Dip method
  - Detachable fitting with valve; again, remember to purge before sampling







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Semi-Solid and Solid Materials

- Drums, barrels, cartons, bags
- If material is clearly from one lot, select one package at random
- If material is not from one lot, number of packages depends upon packages in shipment.
- Take sample at least 3 in. (75 mm) from surface and container sides

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Number of Samples for Semi-Solid or Solid Materials

Number of Packages in Shipment	No. of Samples	Number of Packages in Shipment	No. of Samples
2 - 8	2	217 - 343	7
9 -27	3	344 - 512	8
28 - 64	4	513 - 729	9
65 - 125	5	730 - 1000	10
126 - 216	6	1001 - 1331	11

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Crushed or Powdered Materials

- For materials from bulk storage, follow ASTM D 346, Sampling Coke for Analysis. Select a 2 to 3 lb. (1 to 2 kg) sample.
- For materials in drums, bags, etc., select a number of packages at random as for semi-solid/solid materials.
  - select 1 to 1-1/2 lb. (0.7 kg) from each
  - blend a 50 lb. (25 kg) composite sample
  - select a 2 to 3 lb. (1 kg) final sample

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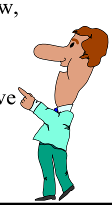
General Precautions

- Sample bituminous materials as soon as possible after material has arrived.
- Always avoid contamination of samples; use new, clean containers.
- Always try to obtain a sample truly representative of the material under consideration.



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PA Test Method No. 746

Method of Test for SAMPLING BITUMINOUS PAVING MIXTURES

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Purpose of PTM 746

- Describe procedure for sampling bituminous mixtures
- Samples taken according to this method can be used for acceptance testing
- Samples can also be used for quality assurance testing

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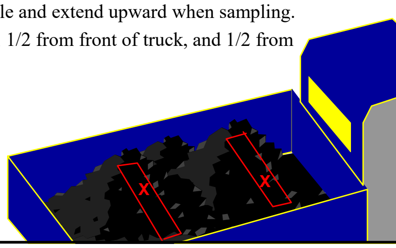
Acceptance Sampling at Plant

- Dig a furrow, roughly 3 to 4 inches deep and 2 feet long.
- Use flat-bottom high-sided scoop to obtain samples. Start low on the pile and extend upward when sampling.
- Take two samples, 1/2 from front of truck, and 1/2 from rear.
- Blend thoroughly.
- Form into flat pile
- Quarter



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Sampling at Plant

- Purpose of Sampling?
  - Quality Control (as specified in QC Plan), or
  - Quality Assurance (QA)
- For QC:
  - Need Random Numbers (PTM 1, Table 1, Column X)
  - Use production tonnage
- For QA
  - Need Random Numbers (PTM 1, Table 1, Column X)
  - Use duration of plant production (time)

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Selecting Random Samples at Plant (QC Samples, based on Tonnage)

- For QC samples at plant, use random numbers from column "X" only.
- Select consecutive random numbers from the table, one for each QC test required, based on estimated production tonnages.
- Multiply the number in column "x" by the tons for the sample point under consideration.
- Take the sample from the truck containing this level of tonnage.

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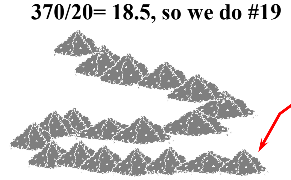
Selecting Random Samples (QC Samples, based on Tonnage)

500 Tons = One Sublot
500 x 0.74 =370 Tons
370/20= 18.5, so we do #19



Each Load = 20 Ton Loads

	X	Y
1	0.29	R0.66
2	0.74	R0.49
3	0.89	L0.79
4	0.60	R0.39
.	.	.
.	.	.

30

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Selecting Random Samples at Plant (QC Samples, based on Tonnage)

- Example 1:
  - Plant scheduled to ship 400 tons
  - Sampling sublot (lot): 400 tons

Random Number	Sampling Tonnage	
	sublot	lot
0.59	0.59*400=236	236

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Selecting Random Samples at Plant (QC Samples, based on Tonnage)

- Example 2:
  - Plant scheduled to ship 3,000 tons
  - Sampling sublots: 1,000 tons each

Random Number	Sampling Tonnage	
	Sublot	Lot
0.71	0.71*1,000=710	710
0.26	0.26*1,000=260	1000+260=1260
0.63	0.63*1,000=630	2000+630=2630

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Selecting Random Samples at Plant (QC Samples, based on Tonnage)

- Example 3:
  - Plant scheduled to ship 1,800 tons in a district requiring the first sample within 500 tons and one test per 1000 tons thereafter.
  - Sampling sublots: 500, 1000, and 300

Random Number	Sampling Tonnage	
	Sublot	Lot
0.61	0.61*500=305	305
0.87	0.87*1000 =870	500+870=1370
0.34	0.34*300 =102	1500+102=1602

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Selecting Random Samples at Plant (QC Samples, based on Tonnage)

- Example 4:
  - Plant scheduled to ship 4,000 tons in a district requiring the first sample within 500 tons and one sample per1,000 tons thereafter.
  - Sampling sublots: 500, 1000, 1000, 1000, and 500

Random Number	Sampling Tonnage	
	Sublot	Lot
0.61	0.61*500=305	305
0.87	0.87*1000 =870	500+870=1370
0.34	0.34*1000 =340	1500+340=1840
0.37	0.37*1000=370	2500+370=2870
0.97	0.97*500=485	3500+485=3985

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Selecting Random Samples at Plant (QA Samples, based on Time)

Conducted by Department's Representative

- Take three samples per normal full day or half-day, as applicable.
- Divide the anticipated time into three roughly equal time periods.
- Select three consecutive random numbers.
- Multiply the time period in minutes by the random number, and add to the starting hour for that period.
- Sample first truck loaded after this hour.

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Selecting Random Samples (QA Samples, based on Time)

	X
1	0.27
2	0.39
3	0.57

Conducted by Department's Representative

Estimated Plant Operation Time:
Six Hours (8 am to 2 pm)
Each Time Interval:
Two Hours
Time Intervals:

8 am – 10 am	10 am- 12 noon	12 noon – 2 pm

Time	Sampling (Clock) Time
0.27×120 min. = 32 min.	8:32 am
0.39×120 min. = 47 min.	10:47 am
0.57×120 min. = 68 min.	1:08 pm

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Sampling on the Roadway

Sampling for acceptance

- One sample from each lot
- Sampling shall be based on random numbers
- Column "X" of random number table presents tonnage.
- The hauling units containing these random numbers shall be sampled.
- Sample directly from the uncompacted mixture placed by the paver

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Sampling on the Roadway

Quality Assurance Sampling

- Three samples for each day's production
- Divide the period of paving into three equal time intervals. One sample per interval.
- Sampling shall be based on random numbers
- Column "X" of random number table presents minutes.
- Column "Y" presents offset location for each sample.
- X times total minutes in each interval gives the time of sampling. Add this to clock time.
- Sample the first load placed by the equipment after the first computed sampling time.
- Sample directly from the uncompacted mixture placed by the paver

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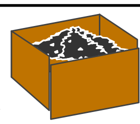
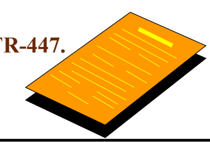
Keep in Mind....



- Size of all samples of bituminous mix should be about 8 lbs. (4 kg).
- Box dimensions of 3-3/4 x 4-3/4 x 9-1/2 in. work well for 19-mm and smaller NMAS mixtures.
- Box dimensions of 5 x 5 1/2 x 9 in. work well for 25-mm and larger NMAS mixtures.
- Identify all samples with **Form TR-447.**



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Keep in Mind....

- **For large NMAS mixes, Contractor may obtain larger size samples and then reduce in size. Here is the language in PTM 746**
  - 5.1.1: For 3/4" (19 mm) and larger NMAS mixtures, a sample larger than is required in Section 4.1 may be obtained and placed on a mixing board, thoroughly mixed, formed into a flat pile and carefully quartered to provide a representative sample of the required size. Scrape the INSIDE of the scoop at each transfer point to incorporate any fines sticking to the inside of the scoop.

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Asphalt Content Determination:

PTM 702: Extraction Method
PTM 742: Pycnometer Method
PTM 757: Ignition Method

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Why determine asphalt content?

- Asphalt content may be the single most important parameter relating to HMAC performance
- Asphalt content needed for contractor to control quality of HMAC
- Asphalt content also required for acceptance testing by PennDOT

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Methods for Determining Asphalt Content

- **PTM 702:** Quantitative Extraction
- **PTM 742:** Pycnometer Method
- **PTM 757:** Ignition Method

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PTM 757: Asphalt Content by Ignition Oven

- Ignition oven heats paving mixture to very high temperature, burning off asphalt binder
- Asphalt content determined from difference in weight before and after ignition
- Simple and accurate
- Allowed by Department for quality control; include in QC plan

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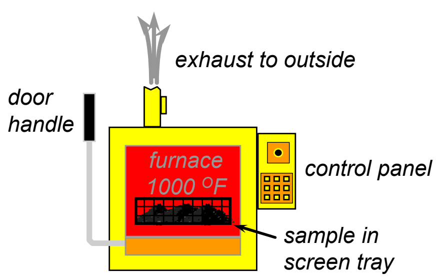
Binder Ignition System Schematic



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Asphalt Content by the Ignition Method

- Two oven types / methods
  - oven with built-in balance (method A)
  - oven without balance (method B)
- AASHTO Equivalent: T 308
  - (notice differences)
- Must calibrate aggregate for loss during ignition

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Sample Size - Table 1 (PTM 757)

Bituminous Mixtures	Minimum Mass of Specimen, g
SP 9.5, SP 12.5, FJ'S, ID2W, ID2WHD, FBIW, FB2W, FB2W, Ralumac, Nova Chip, All Cold Mixes	1200 g
SP 19, ID3W, ID2B, ATPBC, FB1B, FB2B, FBMod, SMA	1500 g
SP 25mm, SP 37.5mm, BCBC, ID2BHD	2000 g

Max. Mass < Min. Mass + 200 grams

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Method A Procedure

- Preheat furnace to 540°C (1000°F)
- Weigh sample, sample tray and catch pan
- Place in furnace
- Heat until change in sample mass does not exceed 0.01 percent
- Determine change in sample mass
- Calculate asphalt content

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Method B Procedure

- Preheat oven and determine mass of sample, tray, and catch pan
- Heat sample for 45 minutes, cool and weigh
- Heat sample for another 15 minutes, cool and weigh
- Continue until change in mass is **less than 0.01 percent**
- Calculate asphalt content

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Ignition Test Calibration (Correction) Factors

- Calibration factors are very important
- Cal. factors can change and should be updated/checked periodically.
- Maintenance of testing equipment is important and can affect cal. factors.
- Accurate hand blending needed to meet the JMF for
  - aggregate blank sample
  - mixture burn samples

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Ignition Test Calibration Factors

- Calibration (Correction) Factors can be affected by
  - Oven set-up and efficiency
  - Oven type
  - Addition of other materials such as lime
- Verify Cal. Factors or Establish New Factors if
  - Source of aggregate changed
  - Source of binder changed
  - Hydrated lime added or removed from a mix
  - A new JMF is required
  - The oven location or venting set-up is changed

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Ignition Test Calibration Factors

- As part of JMF, Producer is to provide correction factors for
  - Percent asphalt content (C_f)
  - Percent passing the 75 µm (No. 200) sieve ($200C_f$)
- Producer should
  - Document the process used in establishing correction factors
  - Submit the documented process to PennDOT as part of JMF.
  - Determine the frequency of establishing correction factors
  - Identify the criteria that triggers when a new or revised factor needs to be established.

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Ignition Mix Calibration Process

- Butter mix to coat the bowl with asphalt and fines.
- Discard butter mix.
- Use a "blank" aggregate batch and find gradation according to AASHTO T 30 (washed sieve).
- Prepare two calibration samples.
- Conduct ignition burn.
- Difference between AC of two samples > 0.15%? Then do two more and discard high and low results.
- **Establish Cf for asphalt (measured – actual).**
- **Establish Cf for #200 sieve (measured – "blank").**

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Some Other Relevant PTMS

004	Treatment of Extreme Values
005	Evaluating Testing Repeatability
006	Determination of Percent Within Limits (PWL) for Construction Aggregate
616	Sieve Analysis of Coarse and Fine Aggregate
702	Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
703	Calibration for Volumeter
704	Calibration for Bitumenometer
705	Marshall Criteria for Compacted Bituminous Paving Mixtures
709	Effective Asphalt Content of Bituminous Paving Mixtures
715	Determination of Bulk Specific Gravity of Compacted Bituminous Mixtures
716	Determination of Bulk Specific Gravity of Compacted Bituminous Mixtures, water abs>3%
739	Sieve Analysis of Extracted Aggregate
743	Determination of Combined Gradation of Aggregates from Hot Bins
757	Determination of Asphalt Content and Gradation of Bituminous Mixtures by the Ignition Method

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Plant Technician Certification Program

Module 10

PennDOT Bulletin 27

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1

PennDOT Bulletin 27

Bituminous Concrete Mixtures,

Design Procedures, and Specifications

For Special Bituminous Mixtures

2

Bulletin 27

- **Chapter 1 – Specs for Asphalt Production Plants**
- **Chapter 1A – Specs for Cold-Mix Plants**
- **Chapter 2 – HMA Design - Modified Marshall**
- **Chapter 2A – HMA Design - Superpave**
- **Chapter 2B – HMA Design - SMA**
- **Chapter 3 – Bituminous Patching Materials**
- **Chapter 4 – Glossary**

3

Bulletin 27

- Appendix A – Selection and Preparation of Aggregates
- Appendix B – Aggregate Blending
- Appendix C – Computation Examples for Agg. Blend.
- Appendix D – Worksheets and forms
- Appendix F – Printed Tickets
- Appendix G – Surge/Storage System Approval
- Appendix H – Hot Mix RAP
- Appendix I – Volumetric Properties During Production
- Appendix J - Annual Asphalt Mix Design Submittal Procedure
- Appendix K – Asphalt Concrete Mix Design Naming System

4

PennDOT Bulletin 27

- Change 1 was issued on **12/19/2003**.
- Change 2 was issued on 03/14/2006.
- Change 3 was issued on 03/31/2008.
- Change 4 was issued on 11/15/2010.
- Change 5 was issued on 01/19/2011.
- SOL 4/13/2016 (481-16-04)
- SOL 10/28/2016 (481-16-06)
- SOL 1/21/2022 (481-22-01)

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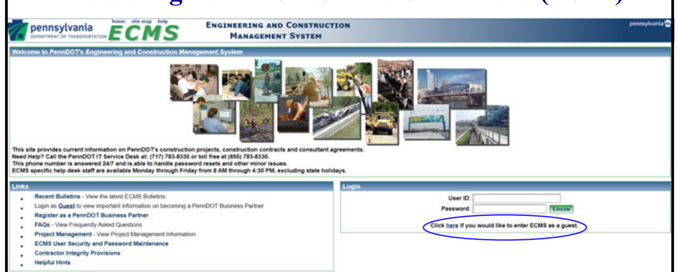
Accessing PennDOT Strike-Off Letters (SOLs)



- ECMS - https://www.ecms.penndot.gov/ECMS/

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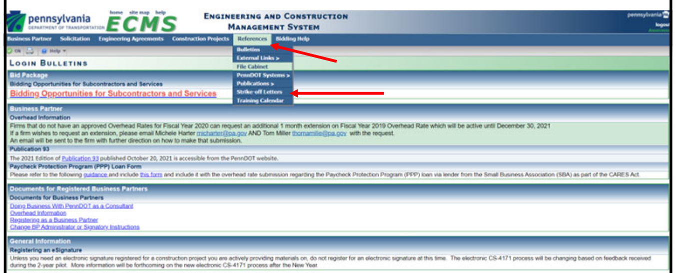
Accessing PennDOT Strike-Off Letters (SOLs)



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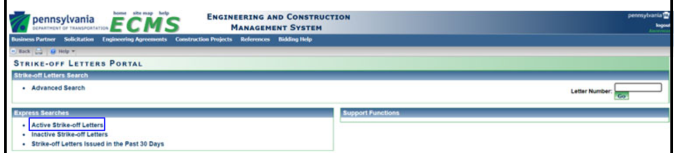
Accessing PennDOT Strike-Off Letters (SOLs)



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Chapter 1
SGC Calibration & Verification

- Internal angle calibrated according to ASTM D7115
- Set to 1.16 ± 0.03 degrees
- Recalibrate at least every two years or as directed.
- Specimen molds satisfy AASHTO T 312

- **ASTM D7115:**
  Standard Test Method for Measurement of Superpave Gyratory Compactor (SGC) Internal Angel of Gyration Using Simulated Loading

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Chapter 1
Superpave Gyratory Compactor Specific Gravities

- Difference in Gmb from two SGC's must be
  ≤ 0.03 at N_{des}
- If greater than 0.03, then prepare four specimens in each compactor for evaluation of difference
- DME/DMM could request evaluation at any time if SGC data questionable or variable

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Chapter 1
Plants Shall Be Equipped to Perform Any Alternate Methods for Asphalt Content

- PTM 757: Ignition Method
- PTM 702: Quantitative Extraction
- PTM 742: Pycnometer Method

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Chapter 1
Minimum Calibration Frequencies

- Balances and scales: once every year
- Volumeters and pycnometers: twice a year
- Asphalt pump or meter: every four months
- Calibration of Agg. Belt Scale: Bi-Weekly
- Drum Plants: at the Beginning of the Paving Season
- Additional Calibration of Drum Plants if 3 consecutive QC tests outside limits

12

Chapter 1

Plant Automation and Recordation/ Use of Printed Ticket

- All plants must be automated/recordated and maintain listing in Bulletin 41.
- Plants may use printed ticket for asphalt content acceptance when approved in accordance with Appendix F.

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Chapter 2A

Superpave Asphalt Mix Design

- **AASHTO R 30-02 (2019)**
  - Standard Practice for Mixture conditioning of HMA
- **AASHTO R 35-17**
  - Standard Practice for Superpave Volumetric Design for HMA
- **AASHTO M 323-17**
  - Standard Specification for Superpave Volumetric Design for HMA
- **AASHTO T 312-19**
  - Standard Method of Test for Preparing and Determining the Density of HMA Specimens by Means of the SGC
- **AASHTO T 283-14 (2018)**
  - Standard Method of Test for Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage

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Chapter 2A

Aggregate Gradation Control Points
(Compare with AASHTO M 323)

Only change is the circled numbers are shown as 90 in M 323

	Nominal Maximum Aggregate Size-Control Points									
	37.5 mm		25.0 mm		19.0 mm		12.5 mm		9.5 mm	
Sieve Size	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
50.0 mm	100	--	--	--	--	--	--	--	--	--
37.5 mm	90	100	100	--	--	--	--	--	--	--
25.0 mm	--	89	90	100	100	--	--	--	--	--
19.0 mm	--	--	--	89	90	100	100	--	--	--
12.5 mm	--	--	--	--	--	89	90	100	100	--
9.5 mm	--	--	--	--	--	---	--	89	90	100
4.75 mm	--	--	--	--	--	--	--	--	--	89
2.36 mm	15	41	19	45	23	49	28	58	32	67
0.075 mm	0	6	1	7	2	8	2	10	2	10

Change was made to match definition of NMAS

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Chapter 2A

Materials Selection

- **Asphalt Binder (No physical testing required)**
  - Determined by the Department (Specified in Contract)
  - Typical grades
    - **PG 58 – 28**
    - **PG 64 – 22**
    - **PG 76 – 22 (typically polymer modified)**

NOTE: After SOL 481-22-01, Bulletin 27 has the following as the binders:
PG 58S-28 (equivalent to PG 58-28)
PG 64S-22 (equivalent to PG 64-22)
PG 64E-22 (equivalent to PG 76-22)

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Chapter 2A

Materials Selection

- **Aggregates**
  - **Make sure you understand Aggregate Requirements**
  - **You must be able to perform the aggregate tests (M 323-Table 5).**
    - Fine Aggregate Angularity -AASHTO T 304
    - Sand Equivalent Value– AASHTO T 176
    - Thin and Elongated Pieces – ASTM D 4791
    - Crushed Fragments – ASTM D 5821
    - Abrasion – AASHTO T 96 (Bulletin 27, Chapter 2A, Table 5A)

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Chapter 2A

Design Aggregate Structure

- Design Aggregate Structure: developed by a Level 2 technician
- Or by a Level 1 technician under the supervision of a Level 2 technician
- Initial job mix formula reviewed and submitted by a Level 2 Technician.

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Chapter 2A

Design Binder content. (cont.)

- Utilizing SGC:
- Level 1 technician must be familiar with
  - Superpave Gyratory Compactor
  - Various levels of compaction
  - Role of SGC in the development of the optimum asphalt content.

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Chapter 2A

Design Binder content. (cont.)

- Establish the optimum asphalt content at 4.0% air voids at $N_{des.}$
- The volumetric test results at N_{des} must meet the criteria.
- The design aggregate structure at the optimum asphalt content is checked at the maximum number of gyrations (N_{max}).
- If Air Voids ≤ 2% at N_{max}, the pavement may be susceptible to rutting. The aggregate gradation may need to be adjusted.

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Chapter 2A

- **Chapter 2A mostly follows AASHTO R 35 and M 323**.
- Bulletin 27, in many parts of Chapter 2A, makes reference to different sections of AASHTO R 35 and M 323.
- Make sure you are familiar with AASHTO R 35 and M 323 and have a good understanding of the content.
- The reference to the sections of R 35 and M 323 is with respect to the revisions that must be considered to satisfy PennDOT specifications when using those sections.

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Chapter 2A

- **Examples of Revisions to R 35:**
  - Section 4.1: Follow PennDOT's Appendix H for RAP/RAS mixes.
  - Section 8, Table 1: Modification to Gyration Levels of ESALs ≥ 30 Million
  - Moisture Damage Issues/Criteria

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Chapter 2A – R 35 Modification

Section 6: Preparing Aggregate Trial Blends

- Vary trial blends on primary control sieve by 4 to 5%.
- Perform FA quality tests on combined aggregate blend rather than estimate mathematically.

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Chapter 2A – R 35 Modification

Section 8: Compacting Specimens of Each Trial Gradation

- SGC Compaction Effort for **Binder/Wearing Courses** **(SOL of January 2022)**
  - For Design ESAL < 0.30 Million, N_{des} =50
  - For Design ESAL ≥ 0.30 Million, N_{des} =75
- SGC Compaction Effort for **Base Course Mixtures** **(SOL of January 2022)**
  - For All Traffic Levels, N_{des} =50

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Chapter 2A – R 35 Modification

Section 10: Selecting the Design Binder Content

- Evaluate Aggregate Breakdown due to Compaction
  - (Check gradation after compaction against Table A of Spec 408, Section 409)

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Chapter 2A – R 35 Modification

Section 10: Selecting the Design Binder Content

- Rationale for Breakdown Requirement:
  - Check on blend and proportions to meet JMF
  - Check on possible aggregate breakdown during compaction – harsh mixtures or poor-quality aggregate
  - Forensic investigation found finer gradations and Districts reporting fractured aggregate under roller

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Chapter 2A – R 35 Modification

Section 11: Evaluating Moisture Sensitivity

- See the table of proper vacuum readings
- Min. avg. dry tensile strength : **80 psi**
- Min. avg. dry tensile strength for PG 58-28 : **65 psi**
- Min. avg. wet/freeze tensile strength: **50 psi**

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Vacuum Application to Induce Partial Saturation (Chapter 2A)

Understanding Vacuum Gauge Pressure Readings

Vacuum Gauge Type	Unit of Measure	Vacuum Reading with no Vacuum Applied	Vacuum Reading with weakest Vacuum Applied	Vacuum Reading with strongest Vacuum Applied
Partial/ Relative	Inches of Mercury (Hg)	0 (Zero)	10	26
Partial/ Relative	mm of Mercury (Hg)	0 (Zero)	254	660
Absolute	Inches of Mercury (Hg	Approx. 29.9	19.9 i	3.9
Absolute	mm of Mercury (Hg)	Approx. 760	506	97.5

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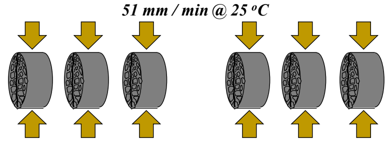
AASHTO T 283

Evaluating Moisture Sensitivity

51 mm / min @ 25 °C



Avg Dry Tensile Strength   Avg Wet Tensile Strength

Wet: Specimens after moisture conditioning

$$TSR = \frac{\text{Avg. Wet Strength}}{\text{Avg. Dry Strength}} \geq 80\ \%$$

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Chapter 2A – R 35 Modification

Section 11: Evaluating Moisture Sensitivity

- **Coefficient of Variation for Dry Group ≤ 12%**
- **Coefficient of Variation for Wet Group ≤ 24%**

$$C.V. = \frac{\text{STD. DEV.}}{\text{AVERAGE}} \times 100$$

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Chapter 2A – R 35 Modifications

Section 12 – Adjusting Mixture to Meet Properties

- See requirement to calculate apparent asphalt film thickness
- Use method in NAPA Hot Mix Asphalt Materials, Mixture Design and Construction book, for film thickness calculation
- Desirable thickness range: 9 to 12 microns
  - If mix does not meet, evaluate other mixture properties
  - Should not be used as the sole parameter to reject a mix design

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Chapter 2A – R 35 Modifications

- Section 13 – Report JMF and Gradations.
- Ignition Oven Correction Factor.
  - See requirement to provide ignition furnace correction factor (C_f) with JMF
  - C_f documentation using form in ESB
  - HMA Producer responsible for establishing frequency or criteria that triggers reevaluation of C_f.
  - Correction factors that best represent current raw material components and JMF targets
  - Address problematic aggregates
    - Documentation
    - District and MTD review

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Chapter 2A

Superpave Volumteric Mix Design (AASHTO M 323)

- Three (preferably Five) Random Samples from single day's production
- Gradation and Asphalt Content
  (Pub 408, Sections 106 and 409.2)
- If PWL ≤ 85%: Need Corrective Action

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Chapter 2A

Superpave Volumetric Mix Design (AASHTO M 323)

- Evaluate Gmm in accordance with Appendix I
- Evaluate VMA, VFA, and F/A for conformance to AASHTO M 323
- Evaluate Voids for conformance to PENNDOT's Specs
- If not met, Perform Additional Tests
- Report to DME before further work

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Chapter 2A – M 323 Modifications

- Table 6 – Change in Aggregate Consensus Properties
- Supported by APQITF

	Design ESALs (Millions)	Fractured Faces, Coarse Aggregate Percent Minimum Depth from Surface		
		≤ 100 mm	> 100 mm	
From	>30	100/100	100/100	⇨ In M 323
To:	>30	95/90	95/90	⇨ In CH 2A

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Chapter 2A – M 323 Modifications

Table 7 – Superpave HMA Design Requirement

Design ESALs (Millions)	VMA Percent Minimum Nominal Maximum Aggregate Size						VFA Range %
	37.5	25.0	19.0	12.5	9.5	4.75	
<0.3	12.0	13.0	14.0	15.0	16.0	16.0	70-78
0.3 to <3	12.0	13.0	14.0	15.0	16.0	16.0	65-78
3 to <10	12.0	13.0	14.0	15.0	16.0	16.0	65-75
10 to <30	12.0	13.0	14.0	15.0	16.0	16.0	65-75
≥30	12.0	13.0	14.0	15.0	16.0	16.0	65-75

See Table 7 of Bulletin 27 for footnotes regarding VFA

IMPORTANT NOTE:
SOL of January 2022: Increased these VMAs by 0.5% except for NMAS 4.75. Numbers in this table are after this increase.

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Chapter 2A – Minimum Effective Asphalt

Table 8 – Minimum Pbe for 9.5-mm and 12.5-mm Superpave Asphalt Mixtures

Combined Agg. Bulk Sp. Gr. (Gsb)	9.5-mm	12.5-mm	Combined Agg. Bulk Sp. Gr. (Gsb)	9.5-mm	12.5-mm
2.250 to 2.274	6.2	5.8	2.675 to 2.724	5.3	4.9
2.275 to 2.324	6.1	5.7	2.725 o 2.774	5.2	4.8
2.325 to 2.374	6.0	5.6	2.775 to 2.824	5.1	4.7
2.375 to 2.424	5.9	5.5	2.825 to 2.874	5.0	4.6
2.425 to 2.474	5.8	5.4	2.875 to 2.924	4.9	4.5
2.475 to 2.524	5.7	5.3	2.925 to 2.974	4.8	4.4
2.525 to 2.574	5.6	5.2	2.975 to 3.024	4.7	4.3
2.575 to 2.624	5.5	5.1	3.025 to 3.074	4.6	4.2
2.625 to 2.674	5.4	5.0			

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Chapter 2A – Performance Tests

Table 9 – Performance Testing Limits: Rutting

Specification	AASHTO T 324 – Hamburg Wheel Track			
Property	Traffic Level (Millions of ESALs)	Max. Rut Depth at 20,000 Passes (mm)	SIP (min. passes)	Min. passes at 12.5-mm Rut Depth
Rutting & Moisture Susceptibility	<3	≤ 15	N/A	N/A
		≤ 20	14,000	10,000
		≤ 25	16,000	12,000
	3 to <10	≤ 10	N/A	N/A
		≤ 15	14,000	12,000
		≤ 20	16,000	14,000
	≥10	≤ 10	N/A	N/A
		≤ 12	16,000	15,000

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Chapter 2A – Performance Tests

Table 9 – Performance Testing Limits: Cracking

Specification		ASTM D8225	AASHTO PP 78
Property	Traffic Level (Millions of ESALs)	CT_{Index}	ΔTc
Cracking	<3	>70	
	3 to <10	>80	
	≥10	>90	
High RAP/RAS (≥ 0.35 RBR)	All		>-5.0C

ASTM D8225 CT_{index} Tests with an average tensile strength of less than 75 psi is a failing test.

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Chapter 2A – Performance Tests

Table 10 – Exceptions to JMF when Meeting Table 9 Requirements

Property	AASHTO Specification	Existing PA Specification Requirement	Specification Requirement if Table 9 Limits are Met
Percent Air Voids at N_{design}	R 35 Table 2	4.0	3.0 to 4.1
Moisture Susceptibility	R 35 - Sect. 4.4, M 323-Sect. 7.3, & T 283	<0.8 AASHTO T 283 TSR, mandatory anti-strip	AASHTO T 283 and mandatory anti-strip waived
Asphalt PG	M 323 Sect. 5. and as specified	As specified	PG bumping of all performance testing limits allowed

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Chapter 2A – M 323 Modifications

- Section 7 – HMA Design Requirements
- Section 7.5 – QC Requirements for Mix Designs During Production
  - Requirement to regularly monitor and maintain ignition furnace correction factors to QC plan
  - Procedure for submission of changes
    - Changes cannot negate failing test results
    - Changes cannot be used for retests
    - Immediately notify DME/DMM of any issues

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Chapter 2A – M 323 Modifications

- Section 7.5 – QC Requirements for Mix Designs During Production
  - Test Method Due to Problematic Aggregates
    - Immediate notification to DME/DMM
    - Submit request to change with comprehensive documentation
    - List of specific conditions to ID problematic aggregates
    - District investigation
    - MTD review
    - QC plan - periodic checks to ensure problematic aggregate still exists

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Chapter 2B – Stone Matrix Asphalt (SMA)

- Mix Design Procedure for SMA
- Based off AASHTO R 46 with modifications
- Supports new Pub. 408 Section 419 – SMA
- Refers to AASHTO Specification M 325

AASHTO R 46: Std. Practice for Designing SMA
AASHTO M 325: Std. Specification for Designing SMA

NOTE: We will discuss SMA in a Separate Module (Module 14)

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Chapter 4 - Glossary

- List of Frequently Used Acronyms Related to Materials, Tests, Design, Pavement Structure and Pavement Courses

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Appendix G Surge/Storage System Approval

- Covers sampling requirements for samples sent to MTD for HMA Surge/Storage System Approval
  - Job-Mix Formula, Forms
  - Binder – 1 one-quart can
  - Mix – Six one-gallon storage cans
    - Two cans at 0 storage time
    - Two cans at 24 hr storage time
    - Two cans at 48 hr storage time

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Appendix H – RAP and RAS

- Guidelines for Using RAP and RAS
- List of BMP publication references including the following
  - NAPA QIS-124 - Designing HMA Mixtures with High RAP Content
  - NAPA SR 179 – Waste Asphalt Shingles-Uses in HMA, State of the Practice

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Appendix H – Hot Mix RAP

- Design guidelines for using RAP
  - Tier 1 Designs - ≤ 15% RAP
    - Criteria for reduced testing provided
    - RAP Gradation and Asphalt Content needed
    - RAP Aggregate Bulk Sp. Gr.
  - Tier 2 Designs - > 15% RAP
    - PG Binder Grade Evaluation
    - Consensus properties of RAP aggregate used as well as the virgin aggregate
    - RAP and Binder Samples to MTD

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Appendix I – AASHTO T 209

- Past forensic investigations identified Gmm issues
- FHWA Stewardship Review – Gmm verification
- PASIN LSOP Committee standardization
- Confusion on conditioning – AASHTO R 30
  - Conditioning temperatures
  - Conditioning times

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Appendix I – HMA Volumetric Properties

- AASHTO T 209 as method for determining Gmm
  - Equipment & Procedure Highlights:
    - Metal or Glass pycnometers Only
    - Plastic pycnometers are not allowed.
    - Manual agitation is not allowed
  - Sample size based on "Largest aggregate size"
  - Mixture conditioning

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Appendix I – Mixture Conditioning

- LSOP procedure clarifications
  - Pans = slight asphalt coating, but no particles.
- Conditioning oven temperatures
  - AASHTO R 30 Midpoint Compaction Temps ±3°C (±5°F)
  - DME Survey – Temps from 105-160°C (221-320°F)
  - Added table to address each PG binder grade
- Conditioning Time
  - 2 h ± 5 minutes (non-absorptive aggregates)
  - 6 h ± 5 minutes (absorptive aggregates > 1.5%)

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Appendix I
Maximum Specific Gravity

- Covers QC testing requirements for production
- Uses AASHTO T 209 method

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Appendix I
Maximum Specific Gravity [Cont.]

- Check Gmm during Production
- Follow AASHTO 209 Test Procedure (Gmm)
- PTM No. 1 and PTM No. 746: Sample Increments
- Oven Conditioning: Two Hours (AASHTO R 30)
- Water Absorption ≥ 1.5%: Six Hours in Oven

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Appendix I
Maximum Specific Gravity [Cont.]

- First Day Gmm to check compaction
- If: First Day Gmm – JMF Gmm ≥ 0.03
  - Then: Run 3 Gmm's on First Day and Use Average
- If: First Day Avg. Gmm – JMF Gmm ≥ 0.02
  - Then: Investigate and Adjust
- Second day, run Gmm once daily,
- For small quantities once per 400 tons,
- Never less then once a week.
- Control charting used to identify significant changes in the mix

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Appendix I
Voids in the Mineral Aggregate

$$VMA = 100 - \frac{G_{mb} \times P_s}{G_{sb}}$$

G_{mb} = Mix Specific Gravity
G_{sb} = Aggregate Bulk Specific Gravity
P_s = Percent Aggregate in the mix

Question:
What value to use for G_{sb}?

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Appendix I
Voids in the Mineral Aggregate

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}}$$ From QC Data

$Cfg = (G_{se} - G_{sb})$ Establish Offset (Cfg)

$Gsb \approx G_{se} - Cfg$ During Production

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Appendix J
Annual Asphalt Concrete Mix Design Submittal Procedure

Table J-1 of Appendix J, Bulletin 27

Material	Test Method	Min. No. of Tests to Determine Producer Avg. Gsb	Max. Diff. between Producer and MTD Avg. Gsb
Fine Aggregate	AASHTO T 84	3	0.038
Coarse Aggregate	AASHTO T 85	2	0.027

- If difference is too large, new testing required, and results from follow-up testing will be used to develop JMF.

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Appendix J
Annual Asphalt Concrete Mix Design Submittal Procedure

- Details on Submittal Process for New Mix Design
- Details on Submittal Process for Existing Mix Design

Table J-2 of Appendix J, Bulletin 27
Acceptable Ranges of Va for Lab Specimens for Evaluating JMF from the Previous Calendar Year

Condition	Range of Va for each single lab. specimen	Range of Va for avg. of multiple lab. specimens
A	4.0± 0.5	4.0± 0.2
B	4.0± 1.0	4.0± 0.5
C	N/A	< 3.5 or > 4.5

- Action depends on which condition is met.

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Appendix K
Asphalt Concrete Mix Design Naming System

- Intended for JMF/Mix Design Number field in eCAMMS
- Up to 10 Characters

EXAMPLE for Gyrator Mix Design: **W95221G1**

- W: Mix Type is WMA
- 95 = NMAS is 9.5 mm
- 2: Traffic Level ESALS is between 0.3 and 3 Million
- 2: Asphalt Binder is PG 64S-22
- 1: RAP/RAS is at Tier 1
- G: Aggregate SRL is G
- 1: Mix Design Version

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Appendix K
Asphalt Concrete Mix Design Naming System

EXAMPLE for Non-Gyratory Mix Design: **ATPBC201**

- ATPBC: Class is Asphalt Treated Permeable Base Course
- 2: Asphalt Binder is PG 64S-22
- 1: RAP/RAS is at Tier 1
- 0: SRL-NA
- 1: Mix Design Version

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SOL# 481-16-04 – issued on 04/13/2016

- **General:**
  - Changes to reduce the number of annual JMFs submitted for review and approval
  - Bulletin 27, Appendix J – Revisions
  - Bulletin 27, Appendix K – New
    - Standardized JMF Naming (Numbering) System
  - Bulletin 27, Chapter 2A – Revisions
  - Bulletin 27, Chapter 2B – Revisions

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SOL# 481-16-04 – Appendix J Revisions

- Submit JMFs meeting following conditions:
  - Existing JMFs produced and placed for a PennDOT or Municipal Project (Liquid Fuels Funds) during previous construction year
    - QC results must be in eCAMMS ESB
  - New JMFs producer identifies will be used on an awarded PennDOT or Municipal Project (Liquid Fuels Funds)
  - In select cases, new JMFs the DME/DMM elects to review after receiving request in writing from Producer

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SOL# 481-16-04 – Appendix J Revisions

- Existing Mix Design – Submittal Process
  - Revised From:
    "0 to ≤ 4 Production Quality Control Volumetric Analysis Test Results from the Previous Calendar Year"
  - To:
    "Archived or 1 to ≤ 4 Production Quality Control Volumetric Analysis Test Results from the Previously Approved JMF"

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SOL# 481-16-04 – Chapter 2A Revisions

- Bulletin 27, Chapter 2A, Modifications to AASHTO R 35, Section 13. Report
  - Assign a JMF number by using the naming convention shown in Appendix K – Table 1
  - No other changes
  - Does not include changes from the Bulletin 41 Producer Letter issued on 10/20/2014
    - No moisture susceptibility changes/revisions

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SOL# 481-16-04 – Chapter 2B Revisions

- Bulletin 27, Chapter 2B, Modifications to AASHTO R 46, Section 4. Summary of the Practice
  - Subsection 4.6 Review of the Job Mix Formula (JMF)
  - Assign a JMF number by using the naming convention shown in Appendix K – Table 1
  - No other changes
  - Does not include changes from the Bulletin 41 Producer Letter issued on 10/20/2014
    - No moisture susceptibility changes/revisions

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SOL# 481-16-04 – Chapter 2B Revisions

- Bulletin 27, Chapter 2B, Modifications to AASHTO R 46, Section 4. Summary of the Practice
  - Subsection 4.6 Review of the Job Mix Formula (JMF)
  - Assign a JMF number by using the naming convention shown in Appendix K – Table 1
  - No other changes

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SOL# 481-16-06 – issued on 10/28/2016

- General:
  - All JMFs (HMA and WMA) approved after December 30, 2016 required to contain a minimum amount of anti-strip (AS) additive
  - Existing AS requirements associated with WMA JMFs have been deleted from Pub. 408, Section 311 and Section 411
    - i.e., WMA Categorized as Mechanical Foaming requiring minimum 0.25 percent AS
  - JMFs containing both coarse and fine aggregate types that are highly moisture susceptible
    - required to be evaluated for moisture susceptibility or contain a higher dosage of AS

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SOL# 481-16-06 – Chapter 2A Revisions

- AASHTO R 35, Section 4.4 (Page 2A-7)
  - 1st paragraph – AASHTO T 283 mixture conditioning according to Bulletin 27, Appendix I
    - i.e., 2 hours or 6 hours at 140, 145, or 153°C (285, 293, or 308°F)

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SOL# 481-16-06 – Chapter 2A Revisions

- AASHTO T 283 Mixture Conditioning
  - AASHTO T 283, Section 6.4 (LMLC) - After mixing:
    - Mixture cooled at room temperature for 2 ± 0.5 h
    - Mixture placed in a 60 ± 3°C (140 ± 5°F) oven for 16 ± 1 h for curing
    - Place the mixture in an oven for 2 h ± 10 min at the compaction temperature ±3°C (5°F) prior to compaction
  - AASHTO T 283, Section 7.4 (FMLC):
    - No loose-mix curing as described in Section 6.4 shall be performed on the field-mixed samples
    - Next, place the mixture in an oven *for 2 h ± 10 min at the* compaction temperature ±3°C (5°F) prior to compaction

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SOL# 481-16-06 – Chapter 2A Revisions

- AASHTO R 35, Section 4.4 (Page 2A-7)
  - All mixtures shall include either:
    - compatible, heat stable, amine-based liquid anti-strip (AS),
    - hydrated lime, or
    - another alternate compatible AS additive
  - Include AS additive at minimum dosage on manufacturer's tech data sheet (typ. 0.25% by mass AC)
  - Mixtures containing both CA and FA classified as type of sandstone, siltstone, slag, quartz, shale, or gravel
    - Include AS, hydrated lime, alternate AS at dosage one level higher than minimum dosage rate (typ. 0.50% by mass AC)

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SOL# 481-16-06 – Chapter 2A Revisions

- AASHTO R 35, Section 4.4 (Page 2A-7)
  - Mixtures containing both CA and FA classified as type of sandstone, siltstone, slag, quartz, shale, or gravel
    - Producer may elect to conduct AASHTO T 283 testing at minimum dosage rate (e.g., 0.25%) and at dosage one level higher (e.g., 0.50%)
    - If all true, set AS, hydrated lime, or alternate AS dosage rate at the higher dosage rate:
      - TSR of higher dosage mixture is higher than TSR of minimum dosage mixture
      - Conditioned and unconditioned tensile strengths of all AASHTO T 283 tests are above the minimum strengths in Bulletin 27, modifications to AASHTO R 35, Section 11.3

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SOL# 481-16-06 – Chapter 2A Revisions

- AASHTO R 35, Section 11.3 (Page 2A-16)
  - For virgin mixtures or mixtures falling under Appendix H, Tier 1 design
    - Compute required minimum AS or alternate AS dosage rate based on virgin asphalt binder content
      - Note: Versions of Pub. 408 prior to 408/2016, Change 2 in Section 411.2(h) specify to add minimum AS dosage based on total bituminous content
  - For mixtures falling under Appendix H, Tier 2 design
    - Compute required minimum AS or alternate AS dosage rate based on the total asphalt in the mixture

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SOL# 481-16-06 – Chapter 2A Revisions

- AASHTO R 35, Section 11.3 (Page 2A-16)
  - All WMA versions of same parent HMA JMF must have separate moisture susceptibility evaluations
  - If HMA JMF requires anti-strip (AS), the WMA version of that JMF, produced by WMA Technology categorized as foaming or foaming process, must contain the minimum dosage of AS required in the HMA JMF.

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SOL# 481-16-06 – Chapter 2A Revisions

- AASHTO R 35, Section 11.3 (Page 2A-16)
  - If Producer elects to use an alternate AS (not typical amine-based AS), contact DME/DMM
    - If directed by DME/DMM, perform moisture testing using alternate AS at manufacturer's recommended minimum dosage rate
    - If directed by DME/DMM, provide other documentation of successful use of alternate AS

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SOL# 481-16-06 – Chapter 2A Revisions

- AASHTO R 35, Section 13, Report (Page 2A-19)
  - Does not include reference to Appendix K [JMF/Mix Design Naming (Numbering) System]
  - Must use SOL 481-16-04
    - Assign a JMF number by using the naming convention shown in Appendix K – Table 1

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SOL# 481-16-06 – Chapter 2B Revisions

- AASHTO T 283 Mixture Conditioning
  - AASHTO T 283, Section 6.4 (LMLC) - After mixing:
    - Mixture cooled at room temperature for 2 ± 0.5 h
    - Mixture placed in a 60 ± 3°C (140 ± 5°F) oven for 16 ± 1 h for curing
    - Place the mixture in an oven for 2 h ± 10 min at the compaction temperature ±3°C (5°F) prior to compaction
  - AASHTO T 283, Section 7.4 (FMLC):
    - No loose-mix curing as described in Section 6.4 shall be performed on the field-mixed samples
    - Next, place the mixture in an oven *for 2 h ± 10 min at the* compaction temperature ±3°C (5°F) prior to compaction

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SOL# 481-16-06 – Chapter 2B Revisions

- AASHTO R 46, Section 4.4 (Page 2B-2)
  - All mixtures shall include either:
    - compatible, heat stable, amine-based liquid anti-strip (AS),
    - hydrated lime, or
    - another alternate compatible AS additive
  - Include AS additive at minimum dosage on manufacturer's tech data sheet (typ. 0.25% by mass AC)
  - Mixtures containing both CA and FA classified as type of sandstone, siltstone, slag, quartz, shale, or gravel
    - Include AS, hydrated lime, alternate AS at dosage one level higher than minimum dosage rate (typ. 0.50% by mass AC)

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SOL# 481-16-06 – Chapter 2B Revisions

- AASHTO R 46, Section 4.4 (Page 2B-2)
  - Mixtures containing both CA and FA classified as type of sandstone, siltstone, slag, quartz, shale, or gravel
    - Producer may elect to conduct AASHTO T 283 testing at minimum dosage rate (e.g., 0.25%) and at dosage one level higher (e.g., 0.50%)
    - If all true, set AS, hydrated lime, or alternate AS dosage rate at the higher dosage rate:
      - TSR of higher dosage mixture is higher than TSR of minimum dosage mixture
      - Conditioned and unconditioned tensile strengths of all AASHTO T 283 tests are above the minimum strengths in Bulletin 27, modifications to AASHTO R 35, Section 11.3

77

77

SOL# 481-16-06 – Chapter 2B Revisions

- Bulletin 27, Chapter 2B, Modifications to AASHTO R 46, Section 4. Summary of the Practice
  - Subsection 4.6 Review of the Job Mix Formula (JMF) (Page 2B-2)
  - Does not include reference to Appendix K (JMF/Mix Design Numbering/Naming System)
  - Must use SOL 481-16-04
    - Assign a JMF number by using the naming convention shown in Appendix K – Table 1

78

78

SOL# 481-16-06 – Chapter 2B Revisions

- Attached Chapter 2B (SMA)
  - AASHTO R 46, Section 11.3 (Page 2B-7)
    - Moisture susceptibility must be re-evaluated, at a minimum, once every 5 years (when JMF material sources, proportions, & targets remain same)
    - Moisture susceptibility must be re-evaluated when material sources change or, material proportions or JMF targets significantly change, as determined by the DME/DMM

79

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SOL# 481-16-06 – Chapter 2B Revisions

- AASHTO R 46, Section 11.3 (Page 2B-7)
  - Compute required minimum AS or alternate AS dosage rate based on total asphalt in the mixture

80

80

SOL# 481-16-06 – Chapter 2B Revisions

- AASHTO R 46, Section 11.3 (Page 2B-7)
  - All WMA versions of same parent HMA JMF must have separate moisture susceptibility evaluations.
  - If HMA JMF requires anti-strip (AS), the WMA version of that JMF, produced by WMA Technology categorized as foaming or foaming process, must contain the minimum dosage of AS required in the HMA JMF.

81

81

SOL# 481-22-01 – Chapter 2A Revisions

- All mixes need antistripping agent or hydrated lime.
- Balanced Mix Design: Do tests for rut performance and crack performance
- Revised Table of gyrations for use in SGC.
  - For ESALs < 0.3 million, Design Number of Gyrations =50
  - For ESALs >= 0.3 million, Design Number of Gyrations =75

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1

Documents Relevant to QC/QA

- **Specification 408, Section 106**
- **Specification 408, Section 413**
- **Pub 2 (Project Office Manual) – Section B.7**
- **Pub 25 (Quality Assurance Manual)**

2

2

Plant Quality/Process Control

- **Asphalt mix producers** must submit a **quality control (QC) plan** to DME annually, at least 3 weeks before production.
- **Two plans** must be submitted at the start of each project
  - **Producer's QC plan (material and mixture)**
  - **Paving operations QC plan**
- Should also consider general good practice, and quality assurance checklists
- **Specific requirements given in Sections 106, 413 of Pub 408, and in Project Office Manual (Pub 2)**

3

3

General Approach in Developing QC Plan

- Specific requirements for QC plans are somewhat depending on the applicable PennDOT section.
- Should try to develop a comprehensive QC plan that meets all requirements
- Should also communicate with DME and QA team members in developing your QC plan
- A good/comprehensive QC plan will help you produce a better product at a lower cost

4

4

Requirements of a "Complete" QC Plan

MUST COVER

- Organization Chart
- Testing Plan
- Materials Storage & Handling
- Documentation
- Equipment Calibration/Verification Procedures

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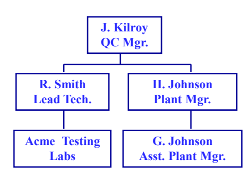
QC Organization Chart

- Personnel responsible for quality control
- Each person's area of responsibility
- List of outside agencies, such as testing labs, and services provided by each



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Testing Plan With Action Points

- List of all tests to be performed
- Frequency of testing
- Sample time/location--test one sample during early production, then select according to PTM No. 1
- Action points
- Description of corrective action to be taken when action points are reached

7

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Quality Control Testing

- Asphalt Content
- Aggregate Gradation (% passing):
  - check for all sieves
- Air Voids and VMA

8

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Normal Minimum Frequency of Testing

Test	PTM/AASHTO	Frequency
Aggregate Stockpile Gradation	T 27	weekly
Hot Bin Gradations	PTM 743	weekly
Extraction/Gradation of Extracted Aggregate	PTMs 702, 739, 743	daily

9

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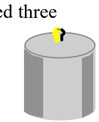
Density and Voids Analysis

- Perform one theoretical maximum specific gravity (AASHTO T 209) on the first day. If the value varies more than (0.030) from JMF value, run at least 3 tests the first day.
- Starting 2nd day run once daily. For small quantities may be reduced to once per 500 tons/ not less then once per week.
- Density and voids analysis are normally performed three times per day, on all QC samples



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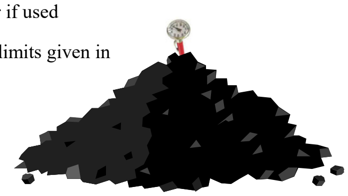
Mix Temperature

See PennDOT Pub 2 (Project Office Manual)

- Check temperature of **first load** and minimum of **five other loads** daily
- Monitor recording pyrometer if used
- Temperature must be within limits given in the specifications.



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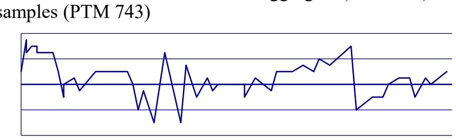
Control Charts (Straight Line Analysis Charts)

(See PennDOT Pub 25 (Quality Assurance Manual)

- Control charts are used to determine if production is in trouble
- Key is to check **uniformity** of production
- Running average of five samples for asphalt content, aggregate gradation, or density
- Gradation determined from extracted aggregate (PTM 757) or hot-bin samples (PTM 743)



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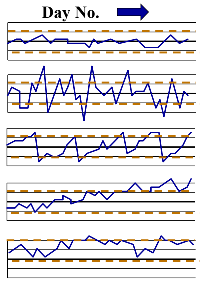
Using Control Charts

For example, binder content versus days of production

Day No.

- Process in control (Uniform)
- process out of control (Over control, or limits too narrow)
- process out of control (Daily/weekly variation)
- process out of control (Slow drift up or down)
- process out of control (Many values on one side of target)



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Minimum Action Limits: From Section 413 (Standard) Job-Mix Tolerances

- Must be at least at job-mix tolerances specified in Section 413 [standard] (for average of 3 to 7 samples):
  - passing 4.75 mm sieve and larger: ±6%
  - passing 2.36 mm to 150 µm sieves: ±4%
  - passing 75 µm sieve: ±2%
  - bitumen, 19.0 mm and smaller: ±0.4%
  - bitumen, 25.0mm and larger: ±0.5%
- **NOTE:** tolerances are different for single samples

14

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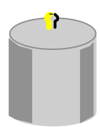
Action Limits for Voids and VMA

- Air voids for plant samples should be within 2 % of JMF, but always between 2 % and 6 %
- Minimum VMA (During Production):
  - 9.5 mm: 15.0 %
  - 12.5 mm: 14.0 %
  - 19.0 mm: 13.0 %
  - 25.0 mm: 12.0 %
  - 37.5 mm: 11.0 %



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Action Required When Mix is Outside Section 413 Specification Tolerance

- Make changes in plant process
- After taking corrective actions, sample within 150 tons.
- Provide test results within the next 500 tons. If fail, then suspend operations
- Production may not resume until the Engineer has reviewed corrective action

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For best control of plant process...

- Action limits should be set **inside** Section 413 spec tolerances
- This will minimize chances of test values falling outside of tolerances and possible halt in production
- As quality control improves, action limits can be narrowed

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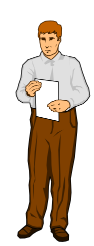
Comparison of Test Data

- As part of quality control plan, LTS QA test data should be compared with data for companion samples at plant.
- Data should be plotted on music bar charts.
- Significant discrepancies should be investigated.
- These comparisons are a good check on laboratory test procedures.



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Equipment Calibration/Verification

Equipment	Frequency
Cold feed settings	for each JMF
Hot bins	weekly
Scale check	at start of season, then biweekly
Fluidometer	twice a year
Weighing devices	yearly certification
All other equipment	at start of season, then as needed

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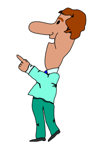
Equipment Calibration/Verification

- **Your quality control plan must also include written <u>calibration & verification procedures</u> when the tests are performed in-house.**



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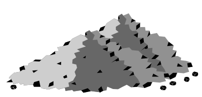
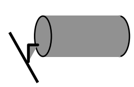
Materials Storage and Handling Plan

- Aggregate/RAP stockpiles
- Cold-feed systems
- Additives & modifiers
- Asphalt & additive storage tanks
- Surge/storage silos
- Measuring/conveying devices, including calibration procedures
- Haul truck loading procedure





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Documentation Required for Good Quality Control

- Data should be stored in central location in an organized fashion
- Test reports, including QA/DQA test results and daily moisture contents
- Control charts
- Daily order and releases
- Project summaries
- Daily bituminous concrete certifications
- Delivery tickets, AC Bill of Lading

22

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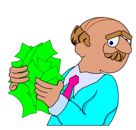
Conclusion: Plant Quality Control

- **A well-developed comprehensive quality control plan should address several needs**
  - producer's annual QC plan
  - contractor's project material QC plan
  - quality assurance checklists
  - general good practice
- **More importantly, quality control means production of a better quality product at a lower cost, and everyone wins!**



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Objectives

- What Is Segregation?
- How Does Segregation Affect Pavement?
- How Does It Happen?
- How Can It Be Prevented?
- What Action Needs To Be Taken?

2

2

What Is Segregation?

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Webster defines *Segregation* as: “to separate from the main mass and collect together in a new body.”

4

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Applied to Asphalt Mixture:

Segregation is the separation of the course and fine aggregate in the mix, collecting and distributing these fractions so that the Mix Asphalt is no longer uniformly textured.

5

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Can Mix Design Cause Segregation?

- Dense grades mixes are less prone to segregation compared to gap-graded mixes.
- Gap-graded mixes are unforgiving, and errors in plant production or loading are hard to fix during the placement.
- The use of higher binder content and fibers in gap-graded SMA mixes reduces the segregation potential.

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What Is the Effect of Segregation on Pavement?

- Premature Distress
  - Raveling
  - Frost Damage
  - Potholes

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Why Do Premature Failures Occur Due To Segregation?

- **Weaker Aggregate Structure and Gradation**
- **Weaker Mix**
- **Higher Voids**

8

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NOTE:
A large portion of material presented in the next section are developed based on the information from the following source:

Technical Paper T-117, Segregation Causes and Cures
By J. Don Brock, James G. May and Greg Renegar, 1997

9

Sources of Segregation

- Stockpiling
- Plant Operation
  - Cold Feed Bins
  - Hot Bins on Batch Plant
  - Drum Mixer
  - Surge & Storage Bins
- Truck Loading

Plant Technicians Responsibility

- Truck Unloading
- Paver
  - Hopper
  - Slat Conveyer
  - Hopper gates
  - Auger
  - Screed

Field Technicians Responsibility

10

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How Does It Happen?

Stockpiling

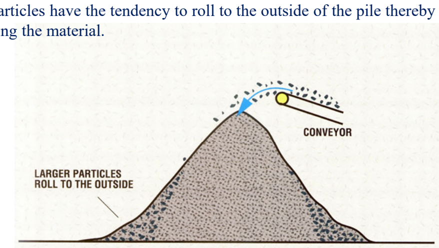
- Overlapping Aggregate Sizes (**Contamination**)
- Large Stockpiles (**More Segregation Potenti**al)

11

How Does It Happen?

In Stockpiling

Larger particles have the tendency to roll to the outside of the pile thereby segregating the material.



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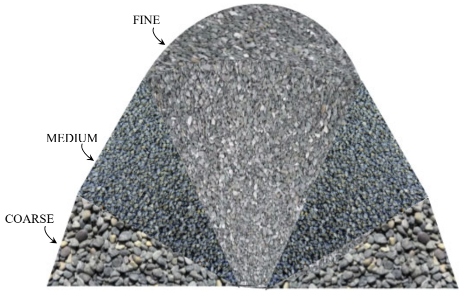
Stockpile Size Separation



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How Does It Happen?

- **Stockpiling-Dumping Over the Edge!**

- **Avoid dumping over the edge.**
- **High potential for segregation due to increased drop height**

14

How Is It Prevented?

Stockpiling

- Different-sized Material
- Separate Piles
- Build Horizontal Layers
- Build Sloped Layers

15

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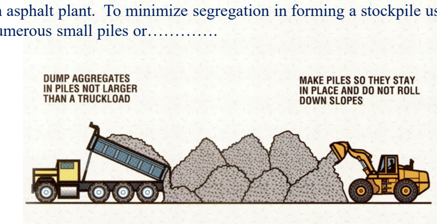
How Is It Prevented?

Stockpiling

Limit Stockpile Height & Separate Sizes

Generally, different-sized materials are stockpiled separately for feeding to an asphalt plant. To minimize segregation in forming a stockpile use numerous small piles or…………



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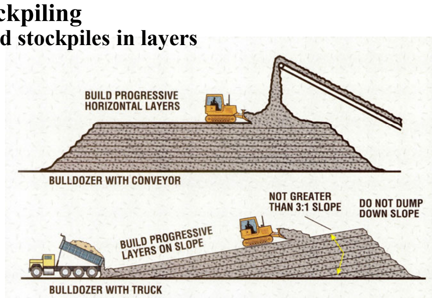
How Is It Prevented?

Stockpiling

Build stockpiles in layers



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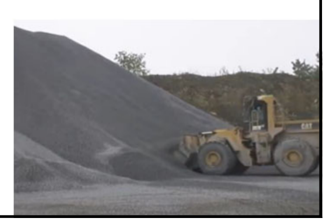
How Is It Prevented?

Working the Stockpile

A good front-end operator can take a segregated pile and by working the pile minimize the problem. By the same token, he can take a good pile and mess it up.

Keep the bucket up and don't dig up to prevent contamination

Every time the loader bucket touches the stockpile, more fine material is produced (as a general rule, 1 percent -#4 sieve)



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How Is It Prevented?

In Loadout from Stockpile

- Mix the material in stockpile
- Consider three or more vertical cuts around the pile.
- Take loads from each cut
- Use bucket low without touching the ground
- **Push** the bucket into the stockpile and pull upwards (remember coarse material is on the outside and fine material inside)

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Safety around Stockpiles!

Stockpiles may inhibit visibility around corners!

Dump truck going over the edge???

- **Maybe use a berm as visual reference point for operator**
- **Stockpile pad must be clean and sturdy**
- **Make dump area slightly graded for better control (gives better drainage too!)**

https://www.worksafenb.ca/hazard-alerts/en/safe-driving-techniques-around-stockpiles.html

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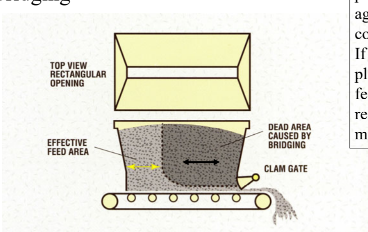
How Does It Happen?

In Feeding Cold Feed Bins

- Bridging



Segregation in cold feed bins is usually not a problem unless the aggregate material consists of several sizes. If material bridging takes place non-uniform feeding takes place, resulting in a segregated mix.

21

How Is It Prevented?

In Feeding Cold Feed Bins

- Reconfigure Opening

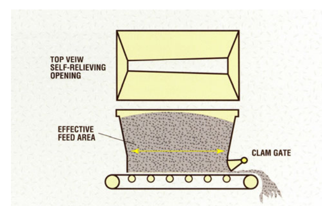
Make bin opening variable size

Make bin sides at different angles

Use compressed air to separate the fines from the bin wall

Keep bin full (don't pull empty)

Also, by utilizing a self-relieving bottom, uniform feeding will occur all along the opening of the cold feed bin, eliminating bridging as a source of segregation.



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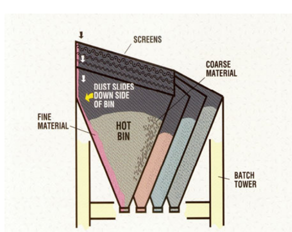
How Does It Happen?

In Feeding Hot Bins on a Batch Plant

- Range of Materials
- Size of Bin
- Shape of Bin
- No. 1 Bin

Segregation often occurs in the No.1 hot bin due to the size and shape of the large bin and the wide size range of materials in that bin. The ultra-fine dust may lay on the sloping bin wall and then break loose in large slugs, producing an ultra-fine mix that is segregated and uncoated.



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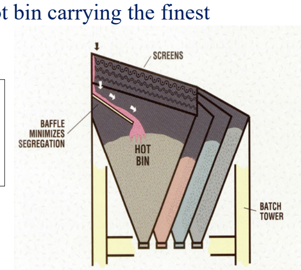
How Is It Prevented?

In Feeding Hot Bins on a Batch Plant

- Install Baffle in the hot bin carrying the finest material

The metal plate (baffle) welded part-way across the number one hot bin helps prevent segregation by directing fine material toward the center



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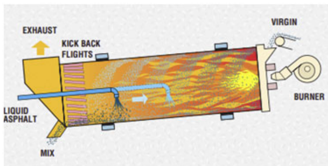
How Does It Happen?

In a Drum Mixer

Mixture speed: Large Aggregates move faster than Fine Aggregate during initial start up and plant shut-down.

When gap graded mixes are processed in drum mixers, it becomes more difficult to achieve a thorough coating with a uniform thickness. The uncoated or thinly coated coarse materials are more likely to segregate.



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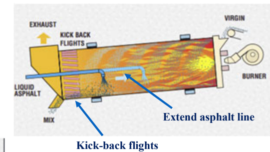
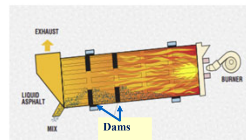
How Is It Prevented?

Adjusting the start/stop time intervals between the cold feed bins.

Increase Mixing Time

- Kick-back flights
- Extend asphalt line
- Install a dam (donut)





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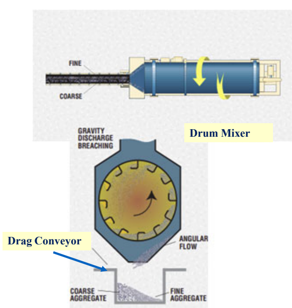
How Does It Happen?

In a Drum Mixer

Coarse Material discharges to one side and fine Material to the other side

Mix discharged from drums by gravity feed is more sensitive than mix discharged from drums with a high lift where the material is required to make a 90-degree turn prior to discharge. The segregated material drops directly on a drag conveyor and continues to segregate right on through the plant.



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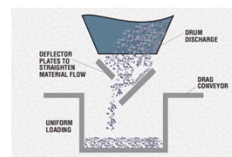
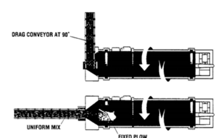
How Is It Prevented?

- **Deflector Plates**



- **Discharge at 90-degree angle**
- **Install a Plow at Point of Discharge**



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How Is It Prevented?

See previous slide:

The problem can be improved by restricting the discharge chute from the drum to a smaller opening, forcing the mix into the center of the drag conveyor. Adding deflector plates or straightening vanes is also an effective way to ensure the drag conveyor is properly loaded. Another solution is to install a plow or single discharge point in the drum forcing the mix to come out at one point. However, it is difficult to design and install an effective plow on most of drum mixers. When possible, it is best to set the drag conveyor at a 90-degree angle to the drum discharge to create a right-angle change in material flow. This setting reduces or eliminates drum discharge segregation.

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How Does It Happen?

Filling Surge and Storage Bins

- Drag Conveyor
- Rotating Chute
- Bin Loading Batchers

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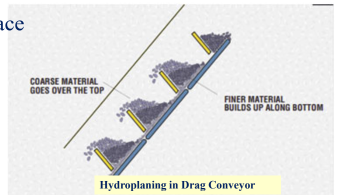
How Does It Happen?

Drag Conveyors

- Hydroplaning (material buildup at bottom of the conveyor) – startup issue (cold)
- High Friction Drag Surface
- Partially Full



Hydroplaning in Drag Conveyor

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31

How Does it Happen?

See previous slide:

Segregation will usually not occur in a drag conveyor unless it is "hydroplaning". Hydroplaning occurs as a result of material build up in the bottom of the drag conveyor. Cold conveyors that do not have floating hold-downs are prone to build-up on the bottom liners. The build-up creates a high friction drag surface that results in material spilling backwards over the drag flights, even at very low production rates. This condition is easily observed. Material falls backward down the drag conveyor instead of moving uniformly in one mass with full material from flight-to-flight.

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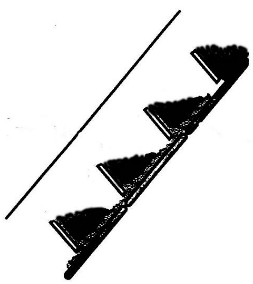
How Is It Prevented?

Drag Conveyors
Equipped with

- Floating hold downs
- Heated bottoms
- Full slats



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How Is It Prevented?

See previous slide:

Drag conveyors should be equipped with floating hold downs and heated bottoms for cold start-ups. Segregation is minimized when the drag conveyor is as full as possible. When the slats are only partially filled, the large aggregate is apt to roll to each side within the drag conveyor. It is better to run at higher production rates to keep the drag conveyor full. When producing a segregation prone mix at production rates higher than the rate used by paving operations, store the extra mix.

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How Does It Happen?

One of the most sensitive area for segregation in a hot mix plant is in surge and storage bins. A study in the early 70's revealed two good devices for eliminating segregation in surge and storage bins. One was a bin loading batcher at the top of the bin and the other was a rotating type chute in the top of the bin.

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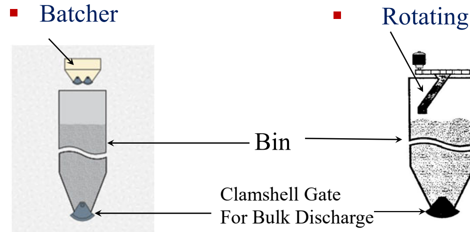
How Does It Happen?

In Loading Storage or Surge Bins

- Batcher
- Rotating Chute



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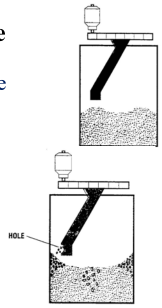
How Is It Prevented?

Rotating Chute

- Must Rotate
- Not worn



It is essential that the rotating chute **does actually rotate** and that the material dropping from the chute turns directly downward.
When the **chute gets older and the end wears out, considerable segregation can occur**.

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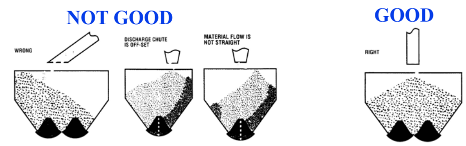
How Is It Prevented?

Batcher:

- Loaded in Center
- Filled to Capacity before each drop



The batcher should be filled to its maximum capacity (at least 5,000 lbs.) and a relatively large diameter gate opening to insure **rapid** discharge into the storage bin. The batcher must be loaded directly in the **center** and the material should have no horizontal trajectory.

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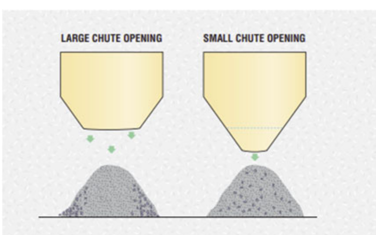
How Is It Prevented?

Batcher: A smaller chute opening minimizes segregation



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The Rules for Correct Batcher Operation

Batcher Rules

1. Batch size should be at least 5,000 lbs.
2. Batcher should be loaded in the center.
3. Material should flow straight down into the batcher.
4. Batcher gate timers should be adjusted so that gates shut with 6-8 inches of material left in batcher. Do not allow any free flow through the batcher.
5. Batcher should be maintained so that the mix drops out rapidly as a slug.
6. Do not keep material level consistently near the top.

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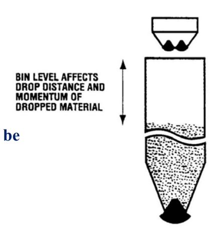
How Does It Happen?

In Loading from a Surge or Storage Bins

Bins: the most sensitive areas for segregation in asphalt plant

With gap-graded material, material should not be allowed to drop below the cone.



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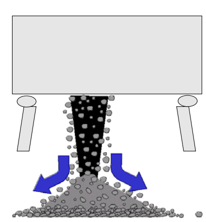
How Is It Prevented?

Rapid Discharge

Rapid discharge from the silo gate. In cold weather, bins should be insulated, at least on the cone.



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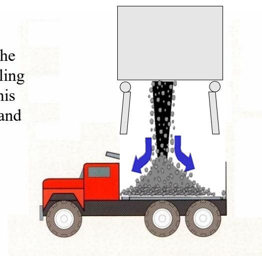
How Does It Happen?

In Loading the Truck

- Dribbling the material

Segregation can be caused by not loading the truck in mass, but rather loading it by trickling or dribbling the material into the truck. This will cause the larger aggregate to separate and fall into the truck first.



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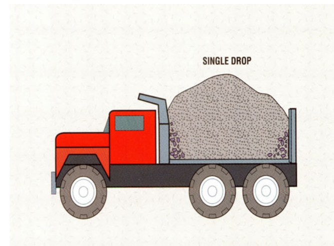
How Does It Happen?

In Loading the Truck

- Single Drop

Single drop will cause the larger stones to roll to the front of the truck, to the rear, and to the side, resulting in the coarse material being the first and last material to be discharged from the truck bed.



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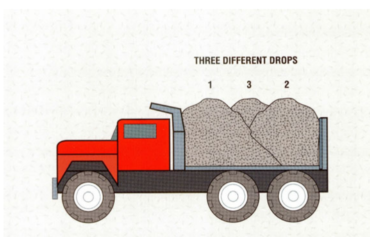
How Is It Prevented?

In Loading the Truck

- Three Drops
  - first drop: very near the front,
  - second drop: very close to the tail gate, and
  - third drop: in the center



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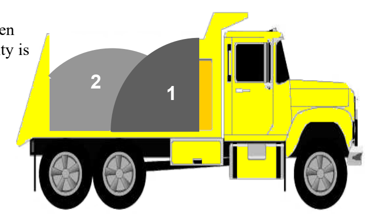
How Is It Prevented?

In Loading the Truck

- Two Drops

Two drops could be used when the truck is small, and capacity is limited.



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Segregation Trouble Shooting

- **What is Wrong?**

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Segregation Source And Cause

- **Nothing!**
- **This is one beautiful mat.**
- **Not all pavement are segregated or have segregated areas.**

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So, we discussed

- What Is Segregation?
- How Does Segregation Affect Pavement?
- How Does It Happen?
- How Can It Be Prevented?
- What Action Needs To Be Taken?

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PENNSTATE

Thank You!

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Plant Technician Certification Program

Module 14

SMA Design & Specifications

Northeast Center of Excellence for Pavement Technology

NECEPT

Plant Technician Certification Program

Module 14

SMA Design, Construction & Specifications

Northeast Center of Excellence for Pavement Technology
NECEPT

1

Outline

- Background on SMA
- SMA Design Considerations
- SMA Specifications
- SMA Construction

2

Background on SMA

- Originated in Germany in 1960's
  - splittmastixasphalt
  - Splitt: Crushed Stone
- US Terminology
  - Stone Matrix Asphalt
  - Stone Mastic Asphalt
  - SMA

3

Background on SMA

- Used in USA Since 1990's
  - Pioneers: Maryland and Georgia
  - Many states currently use it
  - Many projects built using SMA
  - Used as Surface Course and Binder Course
  - Part of most perpetual pavement design projects
  - Higher cost due to the use of fibers, higher binder content, and higher filler content

4

SMA Design Considerations

- Gap Graded Mix
  - Rock-to-Rock Contact – Coarse Aggregate
  - Missing Fine Size Sand (Little mid-size)
  - Includes Mineral Filler
  - High Binder Content
  - Durability and Rut Resistance
  - Tire-Pavement Interaction Noise?
    - 2.5 to 5 decibels noise reduction

5

SMA Design Considerations

6

SMA Rock to Rock Contact

The proportion of coarse aggregate is higher in SMA mixtures compared with typical dense-graded mixtures, creating more opportunity for the rocks to be in contact with one another.

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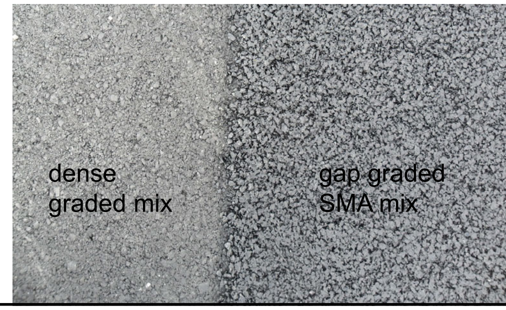
Dense Graded vs. SMA (Gap Graded)



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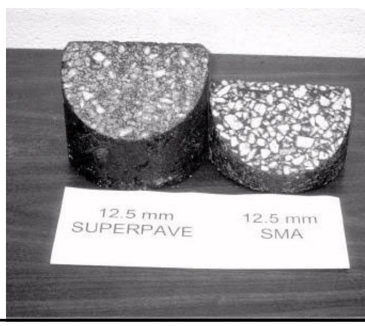
Dense Graded vs. SMA (Gap Graded)



Source of Photo:
NAPA, 2001

9

SMA Mixture

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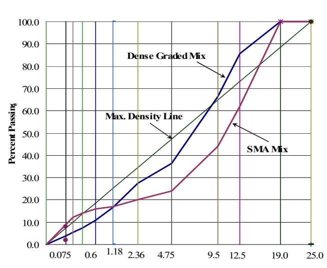
SMA Gap Gradation



Here we see the difference between dense gradation and gap gradation (SMA). Notice that the example for SMA gradation shows little material in the sand-size region.

11

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Design Procedure

1. Select materials
2. Select aggregate structure
3. Select design binder content
4. Perform moisture resistance testing

➢ ***Follow SMA requirements in each step***

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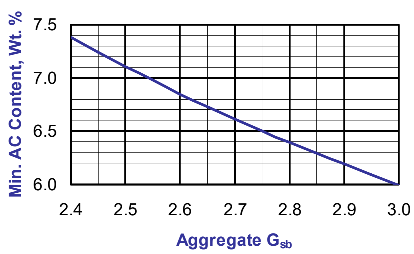
Minimum Asphalt Content for SMA



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Min. Asphalt Binder Requirements (Section 419)

Combined Aggregate Bulk Sp. Gr.	Minimum Asphalt Content, % by Total Mix Weight
2.400 – 2.449	7.4
2.450 – 2.499	7.2
2.500 – 2.549	7.1
2.550 – 2.559	7.0
2.600 – 2.649	6.8
2.650 – 2.699	6.7
2.700 – 2.749	6.6
2.750 – 2.799	6.5
2.800 – 2.849	6.4
2.850 – 2.899	6.3
2.900 – 2.949	6.2
2.950 – 2.999	6.1
3.000 – 3.049	6.0

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VCA Evaluation for Coarse Aggregate Contact:

- For SMA, stone-on-stone contact important
- Proper coarse aggregate structure can be ensured by evaluating voids in the coarse aggregate (VCA):

$$VCA_{mix} < VCA_{DRC}$$

So, one requirement is to ensure the voids in the coarse aggregate in the asphalt mix is smaller than the voids in the coarse aggregate when compacted according to AASHTO T 19 (Dry-Rodded)

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What is Coarse Aggregate Fraction?

In other words, what is cumulative mass retained on the dividing sieve as a percent of total aggregate blend?

Example:

- NMAS: 12.5 mm, and 65% of material is larger than 4.75 mm. So, coarse aggregate fraction is **65 percent**.
- 4.75 mm sieve is the dividing sieve (i.e. the sieve separating the coarse material from the fine material).

Deciding the Dividing Sieve:

NMAS, mm		Dividing Sieve
mm	inch	
9.5	3/8	2.36 (#8)
12.5	1/2	4.75 (#4)
19.0	3/4	4.75 (#4)

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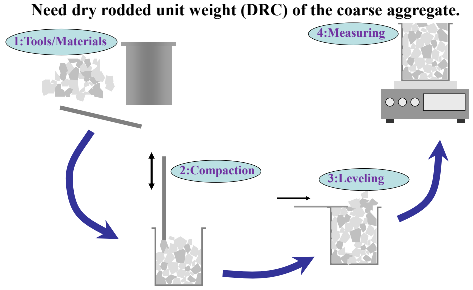
Dry-Rodded Unit Weight (AASHTO T 19)

Need dry rodded unit weight (DRC) of the coarse aggregate.



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Dry-Rodded Unit Weight Calculations

- Dry-rodded unit weight, γ_s, kg/m³ =

$$\frac{\text{Mass of stone in bucket, kg}}{\text{Volume of bucket, m}^3}$$

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Voids in Coarse Aggregate Calculations

- Dry-rodded voids in coarse aggregate (VCA_{DRC}) (as percent of total volume of bucket)

$$VCA_{DRC} = \frac{G_{CA}\gamma_W - \gamma_S}{G_{CA}\gamma_W} \times 100\ \%$$

G_{CA} = coarse aggregate bulk Sp. Gr.

γ_W = unit weight of water (about 1,000 kg/m³)

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Calculation of VCA_{MIX}

- Voids in coarse aggregate in compacted mixture (VCA_{MIX}), as percent of total volume of mix

$$VCA_{MIX} = 100\ \% - (G_{mb} / G_{CA})\ P_{CA}$$

G_{mb} = Bulk Sp. Gr. compacted mix

P_{CA} =percentage of coarse aggregate in mix

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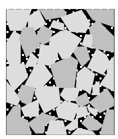
Check VCA

- Proper coarse aggregate structure, to deliver stone-to-stone contact, can be checked by making certain that VCA_{MIX} is less than VCA_{DRC}:



$$VCA_{mix} < VCA_{DRC}$$

- If VCA_{mix} is too high, increase proportion of coarse aggregate.

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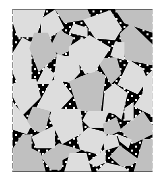
Selection of Optimum Gradation

- Among the three (or more) trial gradations, select the one with the lowest percent of coarse aggregate satisfying minimum VMA and giving:



$$VCA_{mix} < VCA_{DRC}$$

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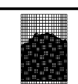
SMA and Draindown



- ***Draindown*** occurs when asphalt and mineral filler separates from the coarse aggregate during transport, usually flowing to the bottom of the load.
- ***Draindown*** is a form of segregation
- Because of high asphalt and mineral filler content, SMA mixes can be prone to draindown.

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Draindown Test

- Procedure given in ***AASHTO T 305***
- Hot, uncompacted mix is placed in a wire-mesh basket on a plate
- Basket/plate with mix is kept hot in an oven for 1 hour
- Amount of asphalt binder draining down to plate is determined as % of total mix
- ***Draindown must be 0.3 % or less***

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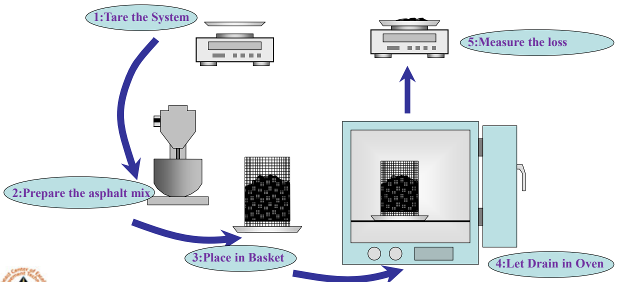
Draindown Test: AASHTO T 305

Done at Expected Plant Temperature



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What if Draindown is High?

- Increase fiber content
- Decrease mixing temperature
- Change fiber type
- Increase amount of filler
- Increase fine aggregate

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SMA Mix Design Summary

- Strong coarse aggregate structure
  - 100 % crushed high-quality aggregates
  - Very coarse gradation
  - $VCA_{MIX} < VCA_{DRC}$
- Large amount of mastic
  - 6 to 7+ % high-performance binder
  - 8 to 13 % mineral filler
  - Cellulose or mineral fibers used as stabilizers
  - Draindown test (to ensure asphalt retention)

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SPECIFICATIONS

- AASHTO M 325
- PennDOT 408/ Section 419

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SMA Related AASHTO Spec & Practice

- AASHTO M 325-08 (2017), Standard Specification for Designing Stone Matrix Asphalt (SMA)
- AASHTO R 46 (2017), Standard Practice for Designing Stone Matrix Asphalt (SMA)
- AASHTO T 305-14 (2018), Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures

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Pennsylvania's SMA Spec

- VMA: 18% minimum
- Design air voids: 3.5 to 4.0%
- Binder: PG 64E-22 (previously 76-22)
- NMAS: 9.5mm and 12.5mm
- Design # of Gyrations: N_{design} = 100
- Fiber Content, % by total mix weight:
  - 0.2 to 0.4% cellulose fibers
  - 0.3 to 0.4% mineral fibers
- Crumb Rubber: 0.3 to 1 % by total mix wt.
- Draindown: 0.3% maximum
- **NO RAP in the Mix**

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Pennsylvania's SMA Spec (Section 419)

Coarse Aggregate Quality Requirements

Characteristic		Required Values
Abrasion Loss, Max. %		35
Flat & Elongated Particles, Max. %	3 to 1 Ratio	20
	5 to 1 Ratio	5
Absorption, Max. %		2
Crushed Fragments, Min. %	One fractured face	100
	Two fractured faces	90

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Fine Aggregate Requirements

- Fine Agg. Angularity requirement: 100% crushed materials
- Sand equivalent: 45% minimum - same as most Superpave wearing course mixtures
- Sodium sulfate loss: 15% maximum after 5 cycles

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Aggregate Size and PG Grade

- Aggregate NMAS
  - For lift thickness of 1-1/2", use 9.5-mm
  - For lift thickness > 1-1/2", use 12.5-mm
- Binder grade: PG 64E-22 (previously PG 76-22)

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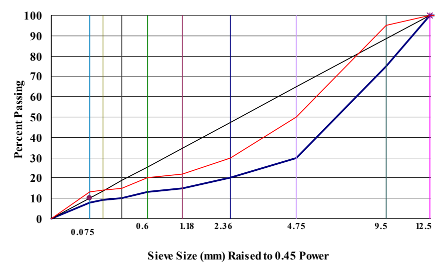
SMA Gradation Range – 9.5 mm



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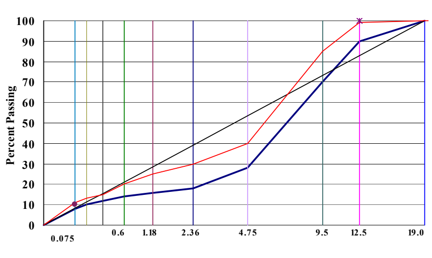
SMA Gradation Range – 12.5 mm



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Crumb Rubber (CR) Gradation (Section 419)

CR Gradation	
Sieve Size	Percent Passing
4.75 mm (No. 4)	100
2.36 mm (No. 8)	98-100
75 mm (No. 200)	0-3

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Cellulose Fibers for SMA

- Sufficient fiber to prevent draindown
- Fiber length: 6 mm maximum
- Oil absorption: 4.0 to 6.0 X fiber weight (400 to 600% by weight)
- Cellulose Pellets is allowed
  - Must satisfy requirements
- Typically less expensive than mineral fiber

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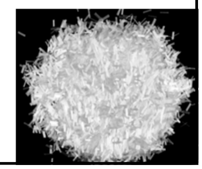
Mineral Fibers for SMA (Section 419)

- Mesh screen analysis
  - 85 to 95% passing 250 μm (No. 60)
  - 60 to 80% passing 63 μm (No. 230)
- Mainly silicate rock such as basalt fiber



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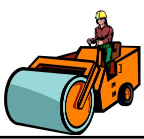
Weather Limitations (Section 419)

- NO SMA Paving during certain periods
  - from October 1 to March 31
  - from October 16 to March 31
  - when surfaces are wet
  - when the air or surface temperature is 10°C (50°F) or lower



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SMA Quality Control

- Similar to Superpave
- QC plan as required for Superpave
- Production tolerances for gradation, asphalt, voids and VMA
- Mix temperature: 260 to 330°F

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Quality Control Tolerances (Section 419)

Property	Single Sample (n = 1)	Multiple Sample (n ≥ 3)
Aggregate gradation	*Mix or hot-bin*	*Mix only*
Passing 9.5 mm	± 5%	± 4%
Passing 4.75 mm	± 4%	± 3%
Passing 75 µm	± 3.0%	± 2.0%
Asphalt Content		
Asphalt Binder	± 0.7%	± 0.4%

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Quality Control Tolerances (Section 419)

Property	Design Value	Single Specimen (n = 1)	Multiple Specimens (n ≥ 2)
Air voids at N_{design}	3.5 to 4.0%	± 2.0%	± 1.5%
VMA	≥ 18.0%	≥ 17.0%	---

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Payment

- RPS specification—similar to Superpave Asphalt Mix (Section 413)
- Payment based on testing cores
  - Asphalt content
  - Mineral filler content
  - Mat density
- Full payment or PWL
- 2,500 ton lots with 5 sublots

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Limits for 100 % Payment

based on deviation from JMF

Test Criteria	Single Sample (n = 1)	Multiple Sample (n ≥ 3)
Asphalt content	± 0.7%	± 0.4%
Passing 75 µm	±3.0%	±2.0%

Mat Density: all individual results for the lot must be ≥ 93% and ≤ 98% for 100% Pay

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Upper and Lower Limits for Calculating Percent Within Limits

Test Criteria	Lower Limit	Upper Limit
Asphalt content	- 0.4%	+ 0.4%
Passing 75 µm	- 2.0%	+ 2.0%
Mat density*	92%	98.0%
* As percent of theoretical max. density		

Once PWL is determined, use Table I to establish payment for the lot.

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Construction

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Materials Handling: Aggregates

- Coarse aggregate is a significant portion of the blend (example: 60 to 70% retained on #4 sieve for 12.5-mm mix)
- Handling of coarse aggregate is very important!
- May need to feed a single aggregate through more than one cold feed bin

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Materials Handling: Mineral Filler

- SMA usually about 10 % mineral filler
- Typically must add extra 5% filler compared to dense graded mixes
- Addition of extra filler must be consistent and accurate

SMA Mineral Filler Gradation	
Sieve Size	Percent Passing
600 mm (#30)	100
300 um (#50)	95-100
75 mm (#200)	70-100

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Materials Handling: Mineral Filler

- Production rate often limited by mineral filler addition
- 500 tons/hour mix = up to 25 tons/hour filler
- Silo storage with vane feeder and auger conveyor often necessary
- Should add filler to pugmill/drum so that it is immediately "captured"

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Materials Handling: Fibers

- Fibers can be loose or pelletized
- Loose fibers delivered bulk or in bags
- Bags can be added directly to pugmill
- Loose fibers and pellets added using machine supplied by fiber manufacturer
- Should make sure fiber flow can be checked visually

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Materials Handling: Mixture Production

- Similar to conventional hot-mix
- Make sure filler delivery and fines recovery systems are working properly
- Mix temperature of 260 to 330°F
- For batch plants, increase dry and wet mixing time for 5 to 15 seconds each
- Don't store SMA for too long

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Transport

- SMA is "sticky"
- Use approved release agent
- Clean truck beds often
- Don't use fuel oil!
- Mix temperature:
  - 260°F (127°C) to 330°F (166°C)

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Section 419 of Spec 408 Stone Matrix Asphalt, RPS Construction

- **Demonstration**
  - Before paving, perform trial demonstration outside projects limits by placing minimum of 100 tons.
  - Simulate actual hauling time for project
  - Obtain & test 3 loose mixture samples at plant for asphalt content, gradation, & draindown & 3 cores from demo pavement for density
  - If vibration is to be used, demo vibratory rolling

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Placement

- Similar to placement methods used for conventional mix, but greater care needed
- Place the mix at temperature between 260°F and 330°F
- Keep paving train moving smoothly
  - Speed dictated by compaction
  - MTV required
- Minimize handwork

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Compaction

- SMA is more difficult to work with
- At least three 10-ton steel-wheel rollers (Min. 10 tons)
- No pneumatic or rubber-tired rollers
- SMA is open-textured and cools quickly
- Keep breakdown rollers close to paver
  - 1 or 2 breakdown rollers
  - 6 to 8 passes
- No Rolling in vibratory mode unless aggregate breaking or flushing shown not to occur
- If doing Echelon paving, typically no finish rolling needed

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Compaction

IF using vibratory roller:

- Set at low amplitude and high frequency
- Watch for aggregate breaking (any white spots on the surface after rolling?)
- Is drum bouncing?
- Vibration more problematic if the mat is on a very rigid base and thin lift
- Potential for aggregate break goes down when vibration is used on thick lift and more flexible base.

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Compaction

- Watch for Fat Spots
  - Sticky mastic picked up by equipment and released.
  - Roller must be equipped with watering or soapy watering system

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Localized fat spots of SMA

Source: NCAT Report No, 97-1: PERFORMANCE OF STONE MATRIX ASPHALT (SMA) MIXTURES IN THE UNITED STATES, January 1997

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Fat Spots, Flushing, Bleeding

- Possible causes:
  - Excessive binder during production
  - Drain down in silos/trucks
  - Uneven distribution of stabilizing fiber (cellulose)
  - Insufficient amount of stabilizing fiber
  - Excessively high mix temperature
  - Excessive vibration

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PennState

Thank You!

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SECTION 106—CONTROL OF MATERIAL

106.01 GENERAL—Use material complying with the requirements of these specifications. At the pre-construction conference, submit a list of material to be sampled and tested by the Contractor and a list of material to be sampled and tested by the Department.

Comply with the provisions of the Pennsylvania Trade Practices Act, 71 P.S. Section 773.101, et seq., concerning the purchase of aluminum and steel products produced in a foreign country. On Federal-Aid projects, also comply with the provisions specified in Section 106.10.

Comply with the provisions of the Steel Products Procurement Act, 73 P.S. Section 1881, et seq. in the performance of the contract or any subcontract.

Following contract execution, furnish to the Department a complete statement of the project construction material's origin, composition, and manufacture.

For Fabricated Structural Steel materials, as identified in Section 1105.01(a) and inspected in accordance with Section 1105.01(e), and any other fabricated aluminum, precast or prestressed concrete products inspected during manufacturing, stamped and approved for shipment by the Department's Representative, furnish Form CS-4171 to the Inspector-in-Charge. Certified mill test reports for any steel included will be reviewed by the Department's Inspector and retained by the fabricator.

For all other steel products or products containing steel that will be permanently incorporated in the project, provide the Inspector-in-Charge the following when the product is delivered to the project site:

- For any "identifiable" steel products, certification that Section 4 of the Steel Products Procurement Act, 73 P.S. Section 1884, has been complied with. Identifiable steel products are steel products which contain permanent markings which indicate the material was both melted and manufactured in the United States.
- For all other "unidentifiable" steel products, documentation such as invoices, bills of lading, and mill certification that positively identify that the steel was melted and manufactured in the United States.

The provisions of the Steel Products Procurement Act will not be waived unless the Secretary has determined, under authority granted in Section 4(b) of the act, that a certain steel product or products is not produced in the United States in sufficient quantities to meet contract requirements. Such a determination will be set forth in a proposal for the Department's review and response. Include with the proposal a comprehensive list of sources, including names and contact information, for verification. The Secretary does not have the authority to waive the provisions specified in Section 106.10.

Steel products are defined as products rolled, formed, shaped, drawn, extruded, forged, cast, fabricated, otherwise similarly processed, or processed by a combination of two or more of these operations from steel made in the United States by the open hearth, basic oxygen, electric furnace, Bessemer, or any other steel-producing process. Included are cast iron products and machinery and equipment as listed in United States Department of Commerce Standard Industrial Classification 25, 35, and 37 and made of, fabricated from, or containing steel components. If a product, as delivered to the project, contains both foreign and United States steel, such product is considered to be a United States steel product only if at least 75% of the cost of the articles, materials, and supplies have been mined, produced, or manufactured, as the case may be, in the United States. On Federal-Aid projects, comply with the provisions specified in Section 106.10.

No payment will be made on the contract if unidentified steel products are supplied, until the hereinbefore requirements are met.

Any payments made that should not have been made may be recoverable from a manufacturer or supplier as well as from a contractor or subcontractor.

Any person who willfully violates the Steel Products Procurement Act will be prohibited from submitting bids for any contract for a period of 5 years from the date of determination that a violation has occurred. If a subcontractor, manufacturer or supplier, violates the Steel Products Procurement Act, such person will be prohibited from performing any work or supplying any materials to the Department for a period of 5 years from the date of determination that a violation has occurred.

If steel products are used as a construction tool or appurtenance and will not serve a permanent functional use in the project, compliance with the Steel Products Procurement Act is not required.

When standard manufactured items are specified and these items are identified by unit mass (unit weight), section dimensions, or similar characteristics, their identification will be considered to be nominal masses (weights) or dimensions. Unless more stringently controlled by specified tolerances, industry established manufacturing tolerances will be accepted.

106.02 MATERIAL—

(a) Preliminary Acceptance and Approval. Have each material and material source of supply listed on Form CS-200 (Source of Supply – Materials) or Form CS-201 (Source of Supply – Traffic Control Devices) and approved before delivery to project. Department Bulletin listed material and material sources are available for use by the Contractor. If non-Bulletin material or material sources are proposed for use, the requirements specified in 106.02(a)2 must be met before these materials are delivered to the project. The Department reserves the right to obtain samples of any material provided by the Contractor for laboratory testing to verify compliance with specifications.

1. Bulletin Material, Material Application, and Material Source. Defined as any of the following:

- Any material and material source listed in Bulletin 14 and used in the material application as specified in the Bulletin, Publication 408, or a Special Provision.
- Any material and material source listed in Bulletin 15 and used in the material application as specified in the Bulletin, Publication 408, or a Special Provision.
- Any asphalt material and material application specified in Publication 408 and produced at a source listed in Bulletin 41.
- Any cement concrete material and material application specified in Publication 408 and produced at a source listed in Bulletin 42.

Submit a CS-200 or CS-201 to the Representative with the following information: contract item number, item description, material description/type/class, product name, manufacturer/producer plant location, applicable Bulletin supplier code, Bulletin number, and Publication 408 or Bulletin Section.

If a previously submitted Bulletin material source no longer provides the specified material, submit a change in material to the Representative as outlined on Form CS-200 or CS-201. Once written acceptance is received, furnish material from another Bulletin material source listed in Bulletin 14, 15, 41, or 42.

2. Non-Bulletin Material, Material Application, or Material Source. Defined as any of the following:

- Any material, product, or material source not listed in Bulletin 14 or Bulletin 15.
- Any material, product, or material source listed in Bulletin 14 or Bulletin 15 being used in an application not intended or specified in the Bulletin, Publication 408, or a Special Provision.
- Any asphalt material or product not produced at a source listed in Bulletin 41.
- Any asphalt material or product not specified in Publication 408 or a Special Provision.
- Any ready-mixed, cement concrete material or product not produced at a source listed in Bulletin 42.
- Any ready-mixed, cement concrete material or product not specified in Publication 408 or a Special Provision.

2.a. Construction-Aid Material. A necessary, temporary, or ancillary material that is not specified for use as part of a contract item or extra work item, but used by the Contractor only to aid in the completion of the work. The material is typically not a permanent part of the specified work (example: wood and nails for temporary formwork). The material need not be listed on Form CS-200 and does not require any Department approval for delivery to or use on the project. The Representative reserves the right to determine whether a material is a construction-aid material. Note temporary traffic control items are not construction-aid materials and do need listed on Form CS-201 since these items must be from Bulletin 15 listed sources and are specified for use as part of contract items or extra work items.

2.b. Project-Specific, LTS Approved Material. Non-Bulletin material proposed for use on a particular project as part of a contract item or extra work item, which requires approval by the LTS. Use of material is not meant to circumvent the use of available material sources listed in Bulletin 14, 15, 41, or 42. Have each material and material source listed on Form CS-200 or Form CS-201. The material is defined as any material, product, or material source that meets one or more of the following criteria:

- Meets specified requirements in Publication 408 or Special Provision, for the material and material application.
- Meets specified requirements in AASHTO or ASTM Standard for the material and material application.
- Meets specified requirements in project Special Provision for the material and material application.

Submit material to the LTS for evaluation and testing a minimum of 90 days before planned delivery to the project. Submit the following information to the LTS, with a copy to the Representative: source, description, specified use, QC Plan, independent lab test data showing material meets all specified requirements as determined on a single lot of material, and material samples of the kind and quality specified. Do not deliver material to the project until written acceptance is received from the Representative.

2.c. Project-Specific, Locally Approved Material. Non-Bulletin material proposed for use on a particular project as part of a contract item or extra work item, which does not require LTS approval because of the low risk to constructed Project performance, but does require local approval by the Representative (i.e. at the District or project level). This category of material is not meant to circumvent the use of available material sources listed in the Bulletins, or the requirements of Project-Specific, LTS Approved Materials. These materials must meet specification requirements and will be clearly identified in the specification as only needing local approval by the Representative. Have each material and material source listed on Form CS-200 or Form CS-201. Submit for local approval by the Representative all required information for the material, as indicated in the specification.

Examples of locally approved materials are project specific items, such as Section 860 (inlet filter bags), Section 867 (compost filter socks), and Section 868 (compost blanket and compost filter berms) where the specification indicates that these materials are to be locally approved. Bulletin 15 will reference specific Publication 408 Sections that apply to Locally Approved Materials. Bulletin 15 will not list actual materials or material sources for this category of materials as they will be accepted for use on a project-specific basis by local approval.

(b) Inspection. Inspect material delivered to the project and stockpile the material passing inspection for use. Do not incorporate questionable material, until material is tested by LTS and accepted in writing by the Representative. The Department reserves the right to reject questionable material delivered to the project when the LTS test results are not according to the specifications. Furnish assistance to the Inspector, as required to obtain samples.

Allow designated Department representatives to inspect material being used, or intended to be used, at any time before, during, or after material preparation, while being used during the progress of the work, or after the work has been completed. Furnish or arrange with producers or manufacturers to provide necessary material, labor, tools, and equipment for such inspection.

Inspections and tests, if made at any point other than the point of incorporation in the work, will not guarantee acceptance of the material. Inspection and testing performed by the Department will not relieve the Contractor's responsibility for QC.

106.03 TESTS AND ACCEPTANCE OF MATERIAL—

(a) Restricted Performance Specifications.

1. Responsibility. The Department will be responsible for determining the acceptability of the material and construction. Material will be reviewed for acceptance through the Department's specified acceptance procedures. Sample locations for acceptance testing will be determined by the Department.

Perform sampling and testing for acceptance in the presence of the Inspector, unless otherwise specified. Lot size will be specified. In the event that operational conditions cause work to be interrupted before the specified lot size has been achieved, the lot may be redefined by the Inspector. It is the intent of these specifications that each lot be evaluated based on the same number of samples. Transport acceptance samples from sampling point to testing site or other designated location in the presence of the Inspector.

The Contractor is responsible for the control and quality of the material and construction.

Prepare a QC Plan as specified in Section 106.03(a)2.a and submit it to the Inspector-In-Charge for review at the start of the project. Include QC sampling and testing frequencies and action points to initiate corrective measures. Notify the Inspector before performing QC sampling and testing. Perform QC sampling and testing and report results to the Inspector.

Obtain and test samples according to the Department's PTMs. If the required test method is not specified, use methods described in the AASHTO Standard Specifications for Transportation Materials and Methods of Sampling and Testing, and Supplements, Standards and/or Tentatives of ASTM, or other testing procedures adopted by the Department.

Verification sampling and testing will be performed by the District, unless otherwise specified.

QA sampling and testing will be performed or witnessed by the BOPD.

Independent Assurance sampling and testing will be administered by the CQAS.

2. QC.

2.a Maintain a QC system that provides reasonable assurance that materials, products, and completed construction, submitted for acceptance, conform to contract requirements whether self-manufactured, processed, or procured from subcontractors or vendors. When specified, submit for review, a plan of the QC system to be used. Have performed or perform the inspections and tests required to substantiate product conformance to contract requirements. Make the inspection and test results available for review throughout the contract life. Procedures will be subject to the review of the Department before the work is started. Charts and records documenting QC inspections and tests are the property of the Department. Submit a QC Plan for use in compliance with the following guidelines, as a minimum:

2.a.1 Raw Materials. List the source of material along with methods of documentation and testing performed to assure the material quality.

2.a.2 Production Control. List lot size and samples required; include sample selection, labeling and test procedure; also include manufacturing phase.

2.a.3 Product Testing. List type and frequency of tests to be performed, along with method of documenting and reporting test results. List test equipment and calibration procedure (frequency) required. List procedure for retesting or rejecting items failing the tests. List the disposal methods and location for test samples and rejected lots.

2.a.4 Personnel. List the personnel in charge of QC and define their areas of responsibility.

2.a.5 Packaging and Shipping. List method of identifying, storing, loading, transporting, and unloading to assure safe delivery of acceptable material and products.

2.a.6 Documentation. List the procedures used for documentation and certification.

The QC Plan and process are subject to periodic review and inspection by the Department.

2.b Promptly record conforming and non-conforming inspection and test results on acceptable forms or charts. Keep these records complete and keep them available for inspection at all times during the performance of the work.

2.c Promptly correct any errors, equipment malfunctions, process changes, or other assignable causes which have resulted or could result in the submission of material, products, and completed construction not conforming to specification requirements.

2.d When required, provide or have provided and maintain measuring and testing devices necessary to ensure that material and products conform to contract requirements. In order to ensure continued accuracy, calibrate these devices at established intervals against Department standards.

2.e When required, make the measuring and testing equipment available to the Representative for use in determining conformance of material, products, or completed construction with contract requirements. In addition, make personnel available for the operation of such devices and for verification of the accuracy and condition of the devices. Have calibration results available at all times. The Department reserves the right to conduct periodic inspections of the measuring and testing devices to confirm both calibration and condition of operation.

2.f Failure to comply with the QC Plan may result in suspension of approval to provide material for Department use and/or removal from the approved list of material suppliers in the applicable bulletins.

3. Acceptance Plans.

3.a Percent Within Limits. The percentage of each lot within the specified limits will be determined by the following procedures:

3.a.1 The "n" sampling positions on the lot will be located by use of the table of random numbers found in PTM No. 1.

3.a.2 A measurement will be made at each location, or a test portion taken and the measurement made on the test portion.

3.a.3 The lot (X) measurements are averaged to find $\overline{X}$.

$$\overline{X} = \sum_{i=1}^{n} \frac{X_i}{n}$$

3.a.4 The Standard Deviation, "s," of the lot measurements will be determined as follows:

$$s = \sqrt{\sum_{i=1}^{n} \frac{(X_i - \overline{X})^2}{n-1}}$$

3.a.5 The Quality Index (Q_U) is found by subtracting the average (X) of the measurements from the upper specification limit (U) and dividing the result by "s."

$$Q_u = \frac{(u - \overline{X})}{s}$$

3.a.6 The Quality Index (Q_L) is found by subtracting the lower specification limit (L) from the average and dividing the result by "s."

$$Q_L = \frac{(\overline{X} - L)}{s}$$

3.a.7 The percentage of material that will fall within the upper limit (U) is estimated by entering Table A or Table B with Q_U, using the column appropriate to the total number of measurements (n). Use Table A if Q_U has a negative value, or use Table B if Q_U has a positive value.

3.a.8 The percentage of material that will fall within the lower limit (L) is estimated by entering Table A or Table B with Q_L, using the column appropriate to the total number of measurements (n). Use Table A if Q_L has a negative value, or use Table B if Q_L has a positive value.

3.a.9 In cases where both upper (U) and lower (L) limits are concerned, the percentage of material that will fall within limits is found by adding the percent (P_U) within the upper limit (U) to the percent (P_L) within the lower limit (L) and subtracting 100 from the sum.

Total percent within limits = (P_U + P_L) - 100

3.a.10 When determining the percentage within limits when the calculated Quality Index (Q.I.) value is between two tabular values in Table A or Table B, the following procedure is used:

- The difference between the tabular Q.I. values on either side of the calculated value Q.I. value will be determined.

- The difference will be divided by 2 and the quotient added to the lower tabular Q.I. value, resulting in the interpolated Q.I. value.
- If the calculated Q.I. is equal to or greater than the interpolated value, the higher listed percent within limits will be used.
- If the calculated Q.I. is less than interpolated value, the lower listed percent within the limits will be used.

TABLE A
Estimating Percent of Lot Within Limits
(Standard Deviation Method)
Negative Values of Q_U or Q_L

Percent Within Limits	n=3	n=4	n=5	n=6	n=7
50	0.0000	0.0000	0.0000	0.0000	0.0000
49	0.0361	0.0300	0.0281	0.0272	0.0267
48	0.0722	0.0600	0.0562	0.0545	0.0535
47	0.1083	0.0900	0.0843	0.0818	0.0802
46	0.1444	0.1200	0.1124	0.1091	0.1070
45	0.1806	0.1500	0.1406	0.1364	0.1338
44	0.2158	0.1800	0.1689	0.1639	0.1608
43	0.2510	0.2100	0.1972	0.1914	0.1878
42	0.2863	0.2400	0.2256	0.2189	0.2148
41	0.3215	0.2700	0.2539	0.2464	0.2418
40	0.3568	0.3000	0.2823	0.2740	0.2689
39	0.3912	0.3300	0.3106	0.3018	0.2966
38	0.4252	0.3600	0.3392	0.3295	0.3238
37	0.4587	0.3900	0.3678	0.3577	0.3515
36	0.4917	0.4200	0.3968	0.3859	0.3791
35	0.5242	0.4500	0.4254	0.4140	0.4073
34	0.5564	0.4800	0.4544	0.4426	0.4354
33	0.5878	0.5101	0.4837	0.4712	0.4639
32	0.6187	0.5401	0.5131	0.5002	0.4925
31	0.6490	0.5701	0.5424	0.5292	0.5211
30	0.6788	0.6001	0.5717	0.5586	0.5506
29	0.7076	0.6301	0.6018	0.5880	0.5846
28	0.7360	0.6601	0.6315	0.6178	0.6095
27	0.7635	0.6901	0.6619	0.6480	0.6395
26	0.7905	0.7201	0.6919	0.6782	0.6703
25	0.8164	0.7501	0.7227	0.7093	0.7011
24	0.8416	0.7801	0.7535	0.7403	0.7320
23	0.8661	0.8101	0.7846	0.7717	0.7642
22	0.8896	0.8401	0.8161	0.8040	0.7964
21	0.9122	0.8701	0.8479	0.8363	0.8290
20	0.9342	0.9001	0.8798	0.8693	0.8626
19	0.9555	0.9301	0.9123	0.9028	0.8966
18	0.9748	0.9601	0.9453	0.9367	0.9315
17	0.9940	0.9901	0.9782	0.9718	0.9673
16	1.0118	1.0201	1.0125	1.0073	1.0032

TABLE A (continued)
Estimating Percent of Lot Within Limits
(Standard Deviation Method)
Negative Values of Q_U or Q_L

Percent Within Limits	n=3	n=4	n=5	n=6	n=7
15	1.0286	1.0501	1.0469	1.0437	1.0413
14	1.0446	1.0801	1.0819	1.0813	1.0798
13	1.0597	1.1101	1.1174	1.1196	1.1202
12	1.0732	1.1401	1.1538	1.1592	1.1615
11	1.0864	1.1701	1.1911	1.2001	1.2045
10	1.0977	1.2001	1.2293	1.2421	1.2494
9	1.1087	1.2301	1.2683	1.2866	1.2966
8	1.1170	1.2601	1.3091	1.3328	1.3465
7	1.1263	1.2901	1.3510	1.3813	1.3990
6	1.1330	1.3201	1.3946	1.4332	1.4562
5	1.1367	1.3501	1.4408	1.4892	1.5184
4	1.1402	1.3801	1.4898	1.5500	1.5868
3	1.1439	1.4101	1.5428	1.6190	1.6662
2	1.1476	1.4401	1.6018	1.6990	1.7615
1	1.1510	1.4701	1.6719	1.8016	1.8893

TABLE B
Estimating Percent of Lot Within Limits
(Standard Deviation Method)
Positive Values of Q_U or Q_L

Percent Within Limits	n=3	n=4	n=5	n=6	n=7
99	1.1510	1.4701	1.6719	1.8016	1.8893
98	1.1476	1.4401	1.6018	1.6990	1.7615
97	1.1439	1.4101	1.5428	1.6190	1.6662
96	1.1402	1.3801	1.4898	1.5500	1.5868
95	1.1367	1.3501	1.4408	1.4892	1.5184
94	1.1330	1.3201	1.3946	1.4332	1.4562
93	1.1263	1.2901	1.3510	1.3813	1.3990
92	1.1170	1.2601	1.3091	1.3328	1.3465
91	1.1087	1.2301	1.2683	1.2866	1.2966
90	1.0977	1.2001	1.2293	1.2421	1.2494
89	1.0864	1.1701	1.1911	1.2001	1.2045
88	1.0732	1.1401	1.1538	1.1592	1.1615
87	1.0596	1.1101	1.1174	1.1196	1.1202
86	1.0446	1.0801	1.0819	1.0813	1.0798
85	1.0286	1.0501	1.0469	1.0437	1.0413
84	1.0118	1.0201	1.0125	1.0073	1.0032
83	0.9940	0.9901	0.9782	0.9718	0.9673
82	0.9748	0.9601	0.9453	0.9367	0.9315
81	0.9550	0.9301	0.9123	0.9028	0.8966
80	0.9342	0.9001	0.8798	0.8693	0.8626
79	0.9122	0.8701	0.8479	0.8363	0.8290
78	0.8896	0.8401	0.8161	0.8040	0.7964
77	0.8661	0.8101	0.7846	0.7717	0.7642
76	0.8416	0.7801	0.7535	0.7403	0.7320
75	0.8164	0.7501	0.7227	0.7093	0.7011
74	0.7905	0.7201	0.6919	0.6782	0.6703
73	0.7635	0.6901	0.6619	0.6480	0.6395
72	0.7360	0.6601	0.6315	0.6178	0.6095
71	0.7076	0.6301	0.6018	0.5880	0.5846
70	0.6788	0.6001	0.5717	0.5586	0.5506
69	0.6490	0.5701	0.5424	0.5292	0.5211
68	0.6187	0.5401	0.5131	0.5002	0.4925
67	0.5878	0.5101	0.4837	0.4712	0.4639
66	0.5564	0.4800	0.4544	0.4426	0.4354
65	0.5242	0.4500	0.4254	0.4140	0.4073

TABLE B (continued)
Estimating Percent of Lot Within Limits
(Standard Deviation Method)
Positive Values of Q_U or Q_L

Percent Within Limits	n=3	n=4	n=5	n=6	n=7
64	0.4917	0.4200	0.3968	0.3859	0.3791
63	0.4587	0.3900	0.3678	0.3577	0.3515
62	0.4252	0.3600	0.3392	0.3295	0.3238
61	0.3912	0.3300	0.3106	0.3018	0.2966
60	0.3568	0.3000	0.2823	0.2740	0.2689
59	0.3215	0.2700	0.2539	0.2464	0.2418
58	0.2863	0.2400	0.2256	0.2189	0.2148
57	0.2510	0.2100	0.1972	0.1914	0.1878
56	0.2158	0.1800	0.1689	0.1639	0.1608
55	0.1806	0.1500	0.1406	0.1364	0.1338
54	0.1444	0.1200	0.1124	0.1091	0.1070
53	0.1083	0.0900	0.0843	0.0818	0.0802
52	0.0722	0.0600	0.0562	0.0545	0.0535
51	0.0361	0.0300	0.0281	0.0272	0.0267
50	0.0000	0.0000	0.0000	0.0000	0.0000

3.b Resampling of Lot. It is the intent of these specifications that lots will meet specification requirements at the time of submission. If permitted, nonconforming lots that can be corrected may be reworked and sampled.

3.c General Basis of Adjusted Payment. The related adjusted percentage of contract price will be determined by the method designated in the appropriate specification section.

(b) Specifications, Other than Restricted Performance.

1. Responsibility. The Department will be responsible for determining the acceptability of the material and construction. Material will be reviewed for acceptance through the Department's specified acceptance procedures. Sample locations for acceptance testing will be determined by the Department.

Perform sampling and testing for acceptance in the presence of the Inspector, unless otherwise specified. Transport acceptance samples from sampling point to testing site or other designated location in the presence of the Inspector.

The Contractor is responsible for the control and quality of the material and construction.

Prepare a QC Plan as specified in Section 106.03(a)2.a and submit it to the Inspector-In-Charge for review at the start of the project. Include QC sampling and testing frequencies and action points to initiate corrective measures. Notify the Inspector before performing QC sampling and testing. Perform QC sampling and testing and report results to the Inspector.

Do not incorporate any material into the work that is determined to be outside the specification limits.

Obtain and test samples according to the Department's PTMs. If the required test method is not specified, use methods described in the AASHTO Standard Specifications for Transportation Materials and Methods of Sampling and Testing, and Supplements, Standards and/or Tentatives of ASTM, or other testing procedures adopted by the Department.

Verification sampling and testing will be performed by the District, unless otherwise specified.

QA sampling and testing will be performed or witnessed by the BOPD.

Independent Assurance sampling and testing will be administered by the CQAS.

2. QC. Section 106.03(a)2. and as follows:

Provide a plan of the QC system to be used for all construction work requiring acceptance testing by the Department, including QC test frequencies and action points to initiate corrective measures. Submit a copy of the QC Plan to the Project Engineer, to be maintained at the Department's project field office, before the start of work. A QC Plan is not required for items specified in Section 901.

3. Compliance Certification of Bulletin Materials. The Contractor is responsible for the control and quality of all materials, both Bulletin and non-Bulletin materials, arriving at the project. Each Bulletin material must be certified to be from a Bulletin source and to be in compliance with the specification requirements for the material. A properly completed and submitted Form CS-4171, Certificate of Compliance, is the means for certification of Bulletin materials. Bulletin materials are defined in Section 106.02(a)1.

The Department reserves the right to sample and test any material for verification that specification requirements are met. Materials of questionable quality delivered to the project will be sampled, tested, and approved by LTS before incorporation in any work. Materials on a reduced certification level may be required to be sampled, tested, and approved by LTS before incorporation in any work. Random field verification samples of the material may be taken by the Representative at the material source, from delivered project material, or at the place of the last manufacturer, fabricator, or producer before delivery. Random QA samples may also be taken by the Representative from delivered project material, at the place of supply, or at the place of the last manufacturer, fabricator, or producer before delivery. The random samples will be sent to the LTS for testing.

3.a Form CS-4171 Completion. Form CS-4171 is completed by the manufacturer, fabricator, or producer (Producer) of Bulletin material provided to the project. The Producer maintains the original Form CS-4171 and provides a copy of Form CS-4171 with each direct shipment to the project.

When a Producer sells a Bulletin 15 material to a distributor/supplier (shipper), the Producer provides a copy of Form CS-4171 with each delivery to the shipper. When a shipper provides Bulletin 15 material directly to the project, the shipper completes and signs a new Form CS-4171 and provides a copy with each direct shipment to the project. The shipper will maintain the copy of the Producer's Form CS-4171that they have received.

Form CS-4171 must be properly signed by a legally responsible company official.

3.b Form CS-4171 Submission for Project Shipments. Ensure that Form CS-4171 is received for each project shipment of Bulletin material. Submit to the Representative a properly completed and signed copy of Form CS-4171 for each project shipment. Do not incorporate any Bulletin material in the work until certification arrives on the project, unless otherwise approved by the Representative. Payment for material will be withheld until proper certification documentation is received.

Form CS-4171 may be submitted to the Department either in hard copy format or electronically. Contractors who wish to submit certification documentation to a project electronically, e.g. via e-mail, facsimile or through a PennDOT Project Collaboration Site, must notify the Department at the preconstruction meeting.

3.c Supplemental or Alternate Certification. Certain Bulletin materials require the submission of supplemental CS-4171 certification in addition to Form CS-4171, to provide traceability of materials in multi-step manufacturing processes.

- Epoxy coated or galvanized reinforcement steel requires the submission of supplemental certification Form CS-4171C (Epoxy Coating or Galvanizing Facility) and/or Form CS-4171F (Fabrication Facility).
- Structural steel, aluminum, or precast/prestressed concrete products, produced in a Bulletin 15 approved facility with an on-site Inspector or a Representative, must be stamped with an approved inspection stamp at the plant and certified with a Form CS-4171.
- Steel products containing foreign steel require the submission of supplemental Form CS-4171S.

Certain Bulletin materials require a form of certification other than the Form CS-4171, as identified in the particular material specification.

- Section 701 and Section 702 materials require a properly completed vendor bill of lading.
- Certification of daily asphalt mixtures by submission of Form CS-4171B.

- Certification of locally approved non-Bulletin materials by submission of Form CS-4171LA.

Organize and submit only Forms CS-4171 and supplemental or alternate certifications for material supplied to the project. Submissions containing irrelevant forms or documentation for materials not incorporated into the project will not be accepted.

3.d CS-4171 Record Retention. Retain Form CS-4171 and supplemental and alternate certifications as defined in Section 106.03(b)3.c, for a period of not less than 3 years from the date of the last project shipment. Make files available for inspection and verification by the Department.

Notify shippers that a certification file must be maintained for purchased Bulletin materials to provide an audit trail to the Producer. Certifications for purchased Bulletin materials must be maintained at their place of business for a period of not less than 3 years from the date of the last shipment to the project and must be available for inspection by the Department.

Notify Producers that all component certifications for purchased Bulletin materials must be maintained at their place of business for a period of not less than 3 years from the date of the last shipment to the project and must be available for inspection by the Department.

3.e Levels of Certification for Bulletin 15 Producers. The BOPD determines the Level of Certification for each Producer based on the Producer's ability to comply with the material specifications. The Levels of Certification are defined in Table C. Bulletin 15 will indicate if a Producer is at a certification level other than Level 1. Material provided by Producers listed in Bulletin 15 is approved for use only in its intended application(s).

TABLE C

Levels of Certification for Bulletin 15 Producers		**Producer Material Shipment Procedure**	**Producer Additional Requirements**
Level 1	Standard Certification	Ship on Certification with Form CS-4171*	None
Level 2	Standard Certification - Reduced	Ship on Certification with Form CS-4171*	See Section 106.03(b)3.e.2
Level 3	Lot Approval Certification	Ship only after Material Lot Approval using Modified Certification, with Form CS-4171*	See Section 106.03(b)3.e.3
Suspension or Removal	According to the State's Contractor Responsibility Program: • Producer may be suspended or removed from Bulletin 15 for any of the reasons stated in the Bulletin 15 Preface, regardless of Producer certification level. • Failure of Producer to advance above Certification Level 3 will result in PennDOT's initiating action for suspension or removal from Bulletin 15.		

* Certain Bulletin materials require supplemental or alternate forms of certification, as specified in Section 106.03(b)3.c.

3.e.1 LEVEL 1 (Standard Certification).

- Initial Level of Certification typically issued to Bulletin 15 listed Producers.
- Material is produced and tested in accordance with the Producer's approved QC Plan.
- No known material performance or quality issues exist that warrant a reduced level of certification.
- Material is shipped on certification using Form CS-4171.

3.e.2 LEVEL 2 (Standard Certification - Reduced).

- Reduced Level of Certification issued to Bulletin 15 listed Producers who have exhibited minor/moderate material performance or quality issues.

- Producer is required to work with PennDOT on submission of an improvement plan that may include, but is not limited to, any or all of the following items: a revised QC Plan, a failure analysis/action plan to assess why failures are occurring and how to prevent these failures from occurring in the future, correlation testing between in-house and independent lab testing to assist with validating results.
- Material is produced and tested in accordance with the improvement plan approved by PennDOT.
- Material is shipped on certification using Form CS-4171.

3.e.3 LEVEL 3 (Lot Approval Certification).

- This Level of Certification is issued to Bulletin 15 listed Producers who have exhibited major material performance or quality issues.
- Producer is required to work with PennDOT on an improvement plan as defined in Level 2.
- Material cannot be shipped to projects using the standard CS-4171 certification process.
- Producer must arrange for independent, in-plant acceptance testing (IPAT) that will be conducted side-by-side with "in-house" Producer testing at the designated frequencies in the revised QC plan. IPAT will be at the Producer's expense. PennDOT's LTS must approve the Producer's proposed IPAT provider, before it begins.
- Any material lot to be used on a project must be tested and approved by the IPAT as meeting the required PennDOT specification prior to shipment to the project.
- Each material lot meeting the specification may be shipped to a project using a modified certification process as follows: submit, to both the Project Representative and LTS, Form CS-4171 along with a signed letter from the IPAT (on their official letterhead) indicating that the material lot meets testing and specification requirements.
- Correlate results from parallel "in-house" Producer testing and IPAT testing, and submit to the LTS on a monthly basis.

106.04 USE OF MATERIALS FROM WITHIN THE PROJECT—With written permission, material found in the excavation areas and meeting the Department's specifications may be used in the project construction. Material used will be paid for, as specified in Section 110.01. However, replace any portion removed with suitable material, if required to complete the embankments. The replaced quantity will be 110% of the volume of stone or gravel removed and 100% of the volume of sand and other material removed. Do not use reserved material, as specified in Section 104.06, or as indicated in the proposal.

106.05 STORAGE OF MATERIAL—

(a) General. Store material to assure preservation of specified quality and fitness for the work.

Stored material, even though accepted before storage, may again be inspected before use in the work. Locate stored material to facilitate prompt inspection and control.

Adhere to the restrictions below for the storage of construction materials with known physical hazards (explosive, flammable, or combustible) or storage of any motorized equipment under any structure with vertical clearance measured:

- Less than 16 feet – No storage is allowed.
- Between 16 feet and 24 feet – Short term operational storage will be allowed provided the materials are stored in an enclosure which meets all ANSI and OSHA requirements for said material(s) and a fire prevention plan has been submitted for the short term operational storage. Short term operational storage is limited to the amount of material and/or equipment required for a 24-hour period.
- Greater than 24 feet – No restriction.

Vertical clearance is measured from the lowest structure member to the ground level below that member.

Do not use private property for storage purposes without written permission of the owner or lessee. Make copies of this permission available to the Department. Restore storage sites to conditions acceptable to property owners and the Department.

(b) Storage of Aggregates. Provide a separate stockpile for each aggregate size and type at cement concrete plants. Do not use aggregates that become segregated or mixed with earth or foreign material.

If divided aggregate bins are used for storage or for proportioning, take measures to prevent mixing of aggregates.

Provide an area for storage of aggregates for use in Portland cement concrete and asphalt concrete. Store aggregates on one of the following constructed according to standard practice:

- Asphalt concrete base course, 4 inches minimum depth.
- Class C concrete, or better, 4 inches minimum depth.

(c) Control of Aggregates. Have aggregates available for use in cement concrete at the proportioning plant in enough time before batching to allow inspection and testing. Handle the aggregates so they may be field tested and accepted, before storing them with previously accepted aggregates. Batch fine and coarse aggregates separately. Properly control uniformity of moisture and uniformity of gradation. Provide a system of water sprays, then use when required, to maintain coarse aggregate moisture control.

During cool and cold weather concrete production, maintain aggregates required for individual concrete placements, whether stored in proportioning bins or stockpiles, at a temperature of not less than 40F before and during batching operations, for a sufficient length of time to eliminate the presence of frost in or around the aggregate particles.

(d) Storage of Reinforcement. Satisfactorily store reinforcement above ground, in a clean and dry condition on a platform, in an orderly manner, plainly marked to facilitate inspection.

106.06 HANDLING AND TRANSPORTATION OF MATERIAL—

(a) General. Carefully handle material to preserve quality and fitness for the work and to prevent loss, segregation, or inconsistency in quantities after weighing or measuring for incorporation in the work.

(b) Aggregates. In dry batching operations, measure aggregates or weigh before placing in the compartments of the vehicle, unless otherwise specified or permitted. Clean the vehicles and provide tight batch partitions at least 4 inches higher than the batched aggregate level being hauled, to prevent any spillage from one compartment to another.

(c) Bulk Cement. Bulk cement may be used, as specified in Section 701.

If bulk cement is used, transport to the mixer in acceptable metal, rubber, or plastic, watertight containers or compartments.

(d) Bag Cement. If bag cement is used, dump the contents of the correct number of bags required for each batch into the mixer skip. If permitted, bag cement may be transported from storage to the mixer by placing the correct number of bags per batch on the batched aggregate in the aggregate compartments. When transported, the bag cement may be dumped on the aggregate after having been checked by the inspector, and if done not more than 100 feet from the mixer. Bag cement that is allowed to lie on the batched aggregates longer than 2 hours, or cement dumped on the batched aggregate longer than 1 hour, will be rejected.

106.07 UNACCEPTABLE MATERIAL—

(a) Restricted Performance Specifications.

1. Acceptance or Rejection. Following the application of the appropriate acceptance plan, the Representative's decision will be final as to the acceptance, rejection, or acceptance at an adjusted price of sampled lots.

2. Disposition of Lots. If permitted, lots not conforming to specifications may be reworked and resubmitted for acceptance sampling. For nonconforming lots that are not adaptable to correction by reworking, remove and replace them, have them accepted without payment, or have them accepted at an adjusted price as stated in the specifications or, if not stated, as directed.

(b) Specifications, Other than Restricted Performance. Material not conforming to the requirements of the specifications, whether in place or not, will be rejected. Remove such material promptly from the site of the work, unless otherwise directed. Do not return rejected material to the work site until defects have been corrected and the material has been accepted for use.

(c) Serviceable Precast or Prestressed Concrete, Fabricated Structural Steel and Aluminum Products. Plant produced fabricated materials or products having materials substitutions, dimensional deviations, specifications deficiencies, or damage which result in materials or products which may be serviceable but, do not meet all contract requirements will be addressed as follows:

1. Minor Deficiency or Defect. For materials or products with one or more minor deficiencies or defects, resolution of the deficiencies or defects will be made directly by the precaster or fabricator with the BDTD's Structural Materials Section. Minor defects and deficiencies are generally defined as those which will not require:

- engineering design review
- revisions to approved installation or erection plans or methods
- anticipated premature maintenance or rehabilitation

The Structural Materials Section may determine that one or more of the minor deficiencies or defects are actually significant deficiencies or non-conformances and require the precaster or fabricator to resolve the deficiency or defect as a significant deficiency or non-conformance as specified in Section 106.07(c)2.

2. Significant Deficiency or Non-Conformance. For materials or products having one or more significant deficiencies or non-conformances, which cannot be corrected to meet the contract specifications and which the Department determines may require one or more of the bulleted items listed in Section 106.07(c)1., submit documentation to support acceptance of the material or product (provided by the precaster or fabricator) and a request for Department evaluation and final disposition of the materials or products.

Where visible defects are present, or when otherwise requested, include detailed sketches, drawings, or photographs along with the supporting documentation form the precaster or fabricator to support acceptance of the material or product. Include a detailed repair procedure to correct the deficiency, if applicable.

For requests submitted for acceptance of the material or product "as is", provide supporting justification to demonstrate that the significant deficiency or non-conformance will not result in additional constructability issues during erection or construction or unanticipated premature maintenance work. Obtain approval of any revisions required to the shop drawings to reflect as built conditions prior to shipment.

Submit engineering calculations, when required or requested, to support the acceptability of the significant deficiency or non-conformance, sealed by a registered Professional Engineer that is licensed in the State. Submittals must include a statement by the Engineer that the defect will not compromise either the structural capacity or service life of the original design.

Submit the above to the District Assistant Construction Engineer with copies to the following:

- Chief Structural Materials Engineer, Bridge Design and Technology Division, Bureau of Project Delivery
- District Structural Control Engineer
- District Bridge Engineer
- Chief Bridge Engineer, Bridge Design and Technology Division, Bureau of Project Delivery (when calculations are required or requested).

Include the following minimum information on a cover page, attached to the submission:

- ECMS or other contract identification including State Route, Section and County
- Structure Number, if applicable
- Specific identification of the affected unit(s), i.e. girder-beam-culvert number, etc.
- Anticipated shipping date
- Detailed sketches, drawings or photographs of the defect, if visible or when requested.

After evaluation, the disposition of the material or product, including any conditions of acceptance, will be provided by the Chief Structural Materials Engineer from information provided by the Engineering District. Replace materials or products which are rejected via this policy with those complying with the contract specifications and requirements.

106.08 DEPARTMENT FURNISHED MATERIAL—The Department will furnish material, if specified in the proposal, in the quantities required. Material will be delivered or made available at the point specified.

The cost of handling and placing material after delivery will be included in the contract price for the item.

After delivery and acceptance by the Contractor, the cost of replacing material due to shortages, deficiencies, or damage, including demurrage charges, will be deducted from money due or to become due.

106.09 PENNSYLVANIA TRADE PRACTICES ACT—This section does not apply to projects which are partially or totally financed with Federal funds.

(a) General. Pursuant to the PA Trade Practices Act, Act 226-1968, the Department will not specify, purchase, or permit to be furnished or used in any contract aluminum or steel products as set forth below made in the countries set forth below.

The Department may utilize the discretionary waiver provision of Act 3-1978 as to steel products. As to aluminum products, if the sole source is from a banned country relief may be permitted under the Statutory Construction Act, 1 PA C.S. 1901 et seq.

1. Brazil. Welded carbon steel pipes and tubes; carbon steel wire rod; tool steel; certain stainless steel products including hot-rolled stainless steel bar; stainless steel wire rod and cold-formed stainless steel bar; pre-stressed concrete steel wire strand; hot-rolled carbon steel plate in coil; hot-rolled carbon steel sheet; and cold-rolled carbon steel sheet.

2. Spain. Certain stainless steel products, including stainless steel wire rod, hot-rolled stainless steel bars, and cold-formed stainless steel bars; pre-stressed concrete steel wire strand; certain steel products, including hot-rolled steel plate, cold-rolled carbon steel plate, carbon steel structural shapes, galvanized carbon steel sheet, hot-rolled carbon steel bars; and cold-formed carbon steel bars.

3. South Korea. Welded carbon steel pipes and tubes; hot-rolled carbon steel plate; hot-rolled carbon steel sheet; and galvanized steel sheet.

4. Argentina. Carbon steel wire rod and cold-rolled carbon steel sheet.

106.10 BUY AMERICA PROVISIONS AND CONVICT PRODUCED MATERIALS—This section only applies to projects partially or totally financed with Federal funds.

(a) Buy America Provisions. Furnish steel or iron materials, including coating for permanently incorporated work according to 23 CFR 635.410 and as follows:

- Pig iron and processed, pelletized, and reduced iron ore manufactured outside of the United States is acceptable for use in domestic manufacturing process for steel and/or iron materials.
- All manufacturing processes of steel or iron materials in a product, including coating; and any subsequent process that alters the steel or iron material's physical form or shape, or changes its chemical composition; are to occur within the United States. This includes rolling, extruding, machining, bending, grinding, drilling, and coating. Coating includes all processes that protect or enhance the value of the material, such as epoxy coatings, galvanizing or painting.
- Provide certification to the Inspector-in-Charge, that all manufacturing processes for steel and iron materials in a product, including coating, have occurred in the United States; certify as specified in Section 106.01.

Products manufactured of foreign steel or iron materials may be used, provided the cost of such products as they are delivered to the project does not exceed 0.1% of the total contract amount, or $2,500, whichever is greater.

(b) Convict Produced Materials. Pursuant to 23 CFR 635.417, materials produced by convict labor after July 1, 1991 may not be used for Federal-aid highway construction projects, unless produced at a prison facility which had been producing convict-made materials for Federal-Aid construction projects before July 1, 1987.

Material produced by convicts who are on parole, supervised release, or probation from a prison may be incorporated in a Federal-Aid highway construction project.

SECTION 312—CRUSHED AGGREGATE BASE COURSE, TYPE DG

312.1 DESCRIPTION—This work is construction of a dense graded stone, gravel, or slag base course, uniformly premixed with a predetermined quantity of water. When placed on subgrade, it includes the preparation of subgrade, as specified in Section 210.

312.2 MATERIAL—

(a) Aggregate. Type A or Type B, Section 703.2. Crush the gravel, if used, as required for asphalt surface courses. Acceptable granulated blast-furnace slag, as specified in Section 350.2, meeting the gradation requirements specified in Table A, may be used.

(b) Calcium Chloride. Section 721

(c) Asphalt Material. Emulsified Asphalt Class E-1, meeting the requirements of Section 702.

(d) Water. Section 720.2

(e) Composition of Mixture. Uniformly combine materials with a predetermined quantity of water, so the final compacted mixture meets the specified gradation within limits of the reviewed job-mix formula.

1. JMF. Establish the JMF within the limits of Table A, when tested in accordance with AASHTO T 27
Add sufficient water to the mixture to provide optimum moisture content at the time of compaction. Do not vary this quantity by more than 2 percentage points from the optimum moisture, as determined in accordance with PTM No. 106, Method B.

2. Uniformity. The composition limits are shown in Table A.
To maintain specified criteria throughout the progress of work, at least twice daily analyze samples of the completed mixture taken at the plant or after spreading. Unsatisfactory results or changes in the supply source may require a change in the JMF. The supply source may be changed, if permitted. Maintain accuracy of control so at least 90% of test samples fall within the tolerance limits of Table A. Remove and replace material failing to meet this requirement.

TABLE A
COMPOSITION OF MIXTURE
(Weight Percent Passing Square Openings Based on Laboratory Sieve Tests)

SIEVE SIZE	PERCENT PASSING	TOLERANCE LIMITS OF THE APPROVED JMF
2 inches	100	
3/4-inch	52-100	± 8%
3/8-inch	36-70	± 8%
No. 4	24-50	± 6%
No. 16	10-30	± 6%
No. 200	0-10	± 3%

3. Testing. Section 313.2

312.3 CONSTRUCTION—

(a) Equipment.

1. Plant. Obtain acceptance of the processing and mixing plant and its operation, before start of work.

Measure the coarse and fine material separately, by either volume or weight, and feed into the mixer in proper proportions and at a rate to insure correct blending. Measure added water by weight, volume, or a metering device, and uniformly distribute in the mix.

Use mixing plants equipped with automatic cutoff devices, which stop the feed to the mixer if delivery of any component of the mix stops.

Provide means to check and verify the accuracy of the proportioning and measuring devices.

Stockpile aggregates for proportioning, by any acceptable method, in a manner that will prevent segregation and degradation of aggregates.

Use mass-proportioning plants, equipped with separate bins for each size aggregate.

2. Spreaders. Section 320.3(a)3

3. Compaction Equipment. Sections 108.05(c)3.a, 3.b, 3.f, and 3.h.

(b) Preparation of Mixture. Before adding water, proportion and uniformly blend required quantities of materials. Distribute measured water uniformly by means of a spray system and continue mixing until materials have been combined into a homogeneous mixture. Do not place materials containing either frost or frozen pieces into the mixture.

When directed, add calcium chloride to the mixture, before adding water, to maintain required moisture. Proportion and uniformly blend calcium chloride, at the rate of 7 pounds per ton of mixture for Type 1 and 5.7 pounds per ton of mixture for Type 2.

(c) Delivery. Handle and transport mixture without segregation or loss of moisture. Use clean hauling vehicles, free of harmful material. To prevent loss of moisture during transportation, cover mixture with suitable covers, if necessary, until deposited in the spreader. Frequent moisture control tests will be made at the point of delivery on the project, as directed.

(d) Replacement Areas. Areas will be marked where base course is required for existing pavement replacement. Remove pavement in these areas to neat lines, as specified in Section 203.

(e) Preparation of Subbase or Subgrade and Shoulders.

1. Subbase or Subgrade. Before placing base course, complete and maintain subbase or subgrade at least 1,500 feet in advance of the leading spreader; keep free of ruts, irregularities, and loose materials.

2. Shoulders. Either build up and compact shoulders for full width, to or above the elevation of each layer of base course, before placing base course or build up and roll shoulders simultaneously with compaction of each layer.

(f) Spreading Mixture. If base course is more than 6 inches in compacted depth, construct in two or more layers of approximately equal depth, with no layer less than 3 inches nor more than 6 inches in depth. Place mixture to provide positive bond and uniform compaction between abutting lanes. Accomplish this by working spreaders in echelon or by alternating spreaders frequently between lanes, to minimize moisture loss.

In locations where machine spreading is impractical, spread manually or by other acceptable methods.

Supply sufficient equipment to spread, shape, and compact mixture at the rate produced by the mixing plant. Complete all operations relating to construction of base course during daylight hours. Do not place mixture on a frozen surface, when air temperature is below 40 F, or when freezing temperatures are forecast to occur within the next 24 hours.

To insure proper bonding between layers of base course, place succeeding layers as soon as practical. Keep base layers moist until covered by the next layer.

Do not cut into an underlying completed layer, except as directed for repairs or corrections. Maintain the proper moisture content in the mixture at all stages of construction, including vertical faces of part-width spread material, to assure positive bonding of abutting lanes.

(g) Overlay and Build Up. Where a base course is placed on existing pavement, construct layers, as specified in Section 312.3(f), unless otherwise directed.

(h) Compaction and Density. Compact each layer of base course to not less than 100% of maximum density, determined in accordance with PTM No. 106, Method B. Determine field density, in accordance with AASHTO T 191. When material is too coarse to use these methods, compaction will be determined, based on nonmovement of material under specified compaction equipment. Where density in any layer fails to meet specified requirements additional compaction will be required. If the density cannot be obtained by additional compaction, thoroughly loosen, remoisten, reshape, and recompact the entire area of the layer with low density. If required density cannot be obtained, remove and replace the affected area with a new mixture that can be compacted as required.

(i) Surface Tolerance. Use a template cut to the required cross section of the finished base course. Equip the template with metal or other vertical extensions attached to each end, so the bottom of the template will be at the elevation of the top of the base course. Furnish at least three templates. Test the cross section for surface irregularities at intervals of not more than 25 feet.

Install string lines with ample supports, offset along each side to control the elevation and depth of the base course. Maintain string lines until the base course is completed and the deficiencies have been corrected.

Use a 10-foot straightedge to test for longitudinal irregularities in the surface of the base course. Hold the straightedge parallel to the road centerline in contact with the surface. Move the straightedge from one side of the base course to the other. Advance along the base course in 5-foot increments.

For surface irregularities exceeding 1/2-inch, immediately correct as follows:

Blade off high spots, as directed, provided the surface is left in a uniformly smooth and dense condition. If high spots cannot be removed by blading, loosen the top layer through its full depth over the affected area, remove excess material, and provide moisture in proper quantity to reshape and recompact to the specified density. If high spots cannot be satisfactorily corrected by either of these methods, remove the top layer over the affected area and reconstruct with a new mixture.

Where it is necessary to add material to low spots, loosen the top layer over the affected area. Incorporate additional material, correctly graded, into the loosened material. Reshape and recompact the entire area at the proper moisture content. If the resulting surface is still unsatisfactory, remove the top layer over the affected area and reconstruct with a new mixture. Do not skin patch or fill low spots with small amounts of material.

Refer to Section 210.3(d) for GPS or Laser Controlled Equipment.

(j) Tests for Depth. Cut or dig one test hole to the full depth of the completed base course, where directed, for each 3,000 square yards or less.

The Representative will measure the depth of the base course. The initial bed and filler layer of fine material is considered part of the base course for determining the final compacted depth.

Remove and replace any area in which the depth is 1/2-inch or more deficient. Additional test holes may be required, if directed, to determine the limits of replacement areas.

After the depth has been measured, backfill test holes with acceptable material and compact.

(k) Construction Joints. Where additional base course is joined by the previous day's work, scarify and moisten the end of existing base course, blend with new mixture, and compact to form a continuous section, without a joint.

(m) Prime Coat. Use a distributor, as specified in Section 460.3(b). Broom the base course to produce a granular texture free of loose material and treat the surface with a single application of asphalt material, at a rate not to exceed 0.15 gallon per square yard of base course.

(n) Maintenance and Traffic. Until placement of the surface course, maintain the completed base course, as specified in Section 901.3(b).

Maintain and protect base course opened to traffic by authority of the Representative, as specified in Section 320.3(j).

Allow only necessary local traffic and essential construction equipment on the base course, unless otherwise directed. Repair or replace marred, distorted, or otherwise damaged pavement.

312.4 MEASUREMENT AND PAYMENT—

(a) Crushed Aggregate Base Course, Type DG. Square Yard or Ton

SECTION 360—ASPHALT TREATED PERMEABLE BASE COURSE

360.1 DESCRIPTION—This work is the construction of an asphalt treated permeable base course (ATPBC) on a prepared surface. When placed on subgrade, it includes the preparation of subgrade as specified in Section 210.

360.2 MATERIAL—

(a) Asphalt Material. Asphalt Cement, Class PG 64S-22, as specified in Section 702.

(b) Coarse Aggregate. Type A, Section 703.2. When using crushed gravel, provide a minimum of 75% crushed particles with at least three faces resulting from fracture.

(c) Fine Aggregate. Type A or Type B, Section 703.1.

(d) Additives.

1. Hydrated Lime. Before adding the asphalt cement, add hydrated lime to the aggregate to reduce stripping potential.

Furnish hydrated lime conforming to ASTM C 1097 and add the lime as follows:

- Add at least 1% hydrated lime by weight of the total dry aggregate.
- Provide a separate bin or tank and feeder system to store and accurately proportion the lime, in dry form, into the aggregate.
- Provide a convenient and accurate means of calibrating the proportioning device.
- Interlock the proportioning device with the aggregate feed or weight system.
- Mix the lime and aggregate to uniformly coat the aggregate with lime.
- Furnish aggregate containing at least 3% free moisture.
- Do not stockpile lime treated aggregate.
- Control the feeder system by a proportioning device accurate to within 10% of the specified amount.
- Provide a flow indicator or sensor and interlock with the plant controls such that production is interrupted if there is a stoppage of the lime feed.
- Before production, obtain approval of the method to introduce and mix the lime and aggregate.

2. Heat-Stable, Anti-Stripping Additive. The Contractor may use an anti-stripping additive other than hydrated lime. Blend the additive with the asphalt cement before adding the additive and asphalt cement to the mixture. Use the manufacturer's recommended dosage of the additive, but not less than 0.25% by weight of the asphalt. Select an additive that does not harm the completed asphalt concrete mixture and that is compatible with the aggregate and asphalt supplied for the project.

(e) Mixture Design and Production.

1. Design. Size, uniformly grade, and combine aggregate fractions according to Table A below. Marshall test requirements do not apply. Design a JMF with an initial target asphalt content of 2.5% by weight. If necessary, adjust the asphalt content within the range specified in Table A below to uniformly coat the aggregate and ensure the aggregate has no observable runoff of excess asphalt.

Test materials, proportions, and the mixture at the asphalt concrete plant laboratory. Verify conformance with the uniformity requirements specified in this Section. When required, the Department will perform the tests at the LTS. Provide a JMF that conforms to all Department requirements. Submit a copy of the JMF to the DME/DMM at least 3 weeks before the scheduled start of producing the mixture for the project. If the Department has not used the JMF on previous projects, provide test results from previous mixture production that show the mixture conformed to all JMF production tolerances.

2. QC Plan. Prepare and submit a QC Plan, as specified in Section 106, at the start of the project and at least annually thereafter. Do not start ATPBC production until after the Representative reviews the QC Plan.

3. Production. During the first day of production, take at least three asphalt content and gradation tests to verify the mixture conforms to the JMF. After the first day, perform tests for asphalt content and aggregate gradation according to the QC Plan and PTM No. 1. Produce ATPBC conforming to the gradation requirements in Table A and with a asphalt content within 0.8% of the JMF (n=1). Ensure the aggregate is uniformly coated with asphalt and no runoff of excess asphalt is observed.

4. Acceptance of the Mixture. Obtain material certification from the material producer using the results of QC tests for asphalt content and gradation. Provide the certification to the Inspector-in-Charge within 1 working day after taking QC tests.

TABLE A
Composition of Mixture
(Total Percent by Mass (Weight) Passing Square Openings Based on Laboratory Sieve Tests)

Sieve Size	Percent Passing
37.5 mm (1 1/2-inch)	100
25.0 mm (1-inch)	95 – 100
12.5 mm (1/2-inch)	35 - 65
4.75 mm (No. 4)	12 – 24
1.18 mm (No. 16)	6 - 16
75 µm (No. 200)	0 – 5
Asphalt Content	2.0% - 3.0%*

* For approved gravel and slag mixtures, the Representative may allow the Contractor to exceed the upper limit.

360.3 CONSTRUCTION— Section 413.3, with modifications as follows:

(b) Weather Limitations. Replace with the following:
Do not place ATPBC on surfaces that are unstable, frozen, or below a temperature of 35F. Do not place ATPBC when the air temperature is below 35F or during rain. If work is halted because of weather conditions, the Representative may allow the Contractor to place limited quantities of ATPBC that are en-route to the project.

(c) Asphalt Mixing Plant. Add the following:

3. Plant Requirements. The Contractor is not required to provide equipment for developing the design and control test.

4. Preparation of Mixture. Before mixing, dry the aggregate as necessary. Heat the asphalt material so that combining with aggregate produces a completed mixture. Coat the aggregate with the asphalt material to form a film of adequate thickness to provide the required binding properties. Produce ATPBC at a temperature below 320F that also provides suitable viscosity for adequate coating of aggregate particles, and that does not cause segregation of asphalt and aggregate during transportation.

Do not stockpile ATPBC. The ATPBC must be placed within 8 hours from when it is made.

(f) Rollers. Replace with the following:
Use steel-wheel power rollers with a manufacturer's certified metal weight of 8 tons to 10 tons.

(h) Spreading and Finishing. Replace with the following:
Use a slip form paver, as specified in Section 413.3(e), or a mechanical spreader. Spread and strike off the mixture for the entire lane width or as much lane as practical. Place the mixture in maximum 4-inch compacted lifts. Adjust screed assemblies to provide the cross section and depth indicated. Construct the profile to the design grade line. Use fully automated sensors to control profile and transverse grade. Allow the mixture to cool to 100F before placing subsequent layers or pavement courses. Perform handwork at locations directed by the Representative.

(i) Compaction. Replace with the following:
Perform rolling as soon as the mat has cooled sufficiently to avoid shoving or lateral movement of the ATPBC. Seat ATPBC using an 8 ton to 10 ton, steel-wheeled roller, or vibratory roller operated in the static mode only. Compact ATPBC by applying four roller passes. One roller pass is defined as one trip of the roller in one direction over any one spot. Additional passes are allowed only to eliminate any surface irregularities, or creases. Do not compact the material to the point that it is not free draining or the aggregate is crushed.

(j) Mat Density Acceptance. Delete this section.

(k) Joints. Replace with the following

1. Longitudinal Joints. Spread the ATPBC to overlap the edge of the lane previously placed by 1 inch to 2 inches. Maintain the uniform uncompacted depth adjacent to a compacted lane necessary to provide a smooth joint after compaction.

2. Transverse Joints. At the end of each day's work and when more than a 30 minute interruption occurs in ATPBC paving operations, install a temporary vertical bulkhead to form a straight transverse construction joint. The joint shall be the full depth and width of the ATPBC. Instead of a temporary bulkhead, the Contractor may saw construction joints.

(l) Surface Tolerance. Replace the requirements for correcting irregularities with the following:
Test the finished surface at locations the Representative suspects are irregular and at transverse joints and paving notches. Test the surface in stages using a 10-foot straightedge. At each stage, hold the straightedge in contact with the surface and parallel to the road centerline and, in successive positions, test the pavement surface from one side to the other. Advance the test location to the next stage by moving the straightedge along the pavement centerline by not more than 5 feet.

Correct irregularities of more than 1/2 inch by loosening surface mixture and removing or adding ATPBC. For irregularities that develop after compaction is completed, correct the irregularity by a method that does not produce contaminating fines or damage the base. Do not grind or mill the ATPBC. The area is defective if irregularities or defects remain after final compaction.

(m) Tests for Depth: Binder and Wearing Courses. Replace with the following:
Carefully dig or drill one 6-inch diameter test hole to the full depth of the ATPBC for each 3,000 square yards, or less, of completed base course. The Representative may require additional test holes in areas the Representative suspects are deficient in depth. The Representative will measure the depth of the base course. Using material acceptable to the Representative, backfill the test holes and compact the material to fill the test hole flush with the completed base course.

Remove and replace sections deficient in depth by 1/2 inch or more. Start correction at the point of determined deficiency and continue correction longitudinally and transversely until the depth is within 1/2 inch of the indicated depth.

(n) Protection of Courses. Replace with the following:

Section 105.13 and as follows: Traffic is not permitted on the asphalt treated permeable base material, except for trucks and equipment required to place the next layer. Replace areas damaged or contaminated, as directed and at no cost to the Department. If necessary, re-compact the ATPBC before starting subsequent paving.

Protect the surface from damage before and during the concrete paving process.

(o) Defective Work. Replace with the following:

Unless otherwise directed in writing by the District Executive, remove and replace ATPBC deficient in surface tolerance, deficient in depth, defective in asphalt content, or excessive in percent passing the 75 µm (No. 200 sieve). The ATPBC is defective in asphalt content if production tolerances are exceeded, percent of coated aggregate particles is less than 95%, or the mixture contains observable runoff of excess asphalt.

With written permission from the District Executive, the Contractor may fill low areas during construction of the next pavement course.

Acceptance testing and QA testing does not relieve the Contractor of responsibility for defective material or work.

360.4 MEASUREMENT AND PAYMENT—Square Yard or Ton

SECTION 410 – SUPERPAVE MIXTURE DESIGN, STANDARD AND RPS CONSTRUCTION OF PLANT-MIXED ASPHALT FINE-GRADED COURSES

410.1 DESCRIPTION—This work is the standard and RPS construction of a plant-mixed asphalt wearing course on a prepared surface using a volumetric mixture design developed with the Superpave Gyratory Compactor and modified to be a fine-graded (FG) mixture.

410.2 MATERIALS—Section 413.2 using the procedure and volumetric tolerances for the 9.5 mm nominal maximum aggregate size mixture and modified as follows:

(e) Mixture Composition for Standard and RPS Construction.

1. Virgin Material Mixtures. Submit a JMF meeting all of Bulletin 27 requirements for a 9.5 mm nominal maximum aggregate size mixture, except the JMF must have a minimum percent passing the No. 8 sieve of 47% and a maximum percent passing the No. 8 sieve of 67%.

410.3 CONSTRUCTION—Section 413.3 using the test procedures, limits and tolerances for a 9.5 mm nominal maximum aggregate size mixture except where procedures, limits and tolerances are specifically indicated for a 9.5 mm fine-graded nominal maximum aggregate size mixture and as modified as follows:

Revise Table G to include 9.5 mm Fine Grade Wearing Course as follows:

TABLE G
Mixture Minimum Compacted Depths

Mixture	Minimum Depth
9.5 mm Fine Grade Wearing Course	1 in.

410.4 MEASUREMENT AND PAYMENT—Square Yard or Ton

Paid as specified in Section 413.4 for a 9.5 mm Wearing Course.

SECTION 412—SUPERPAVE MIXTURE DESIGN, CONSTRUCTION OF PLANT-MIXED 6.3 MM THIN ASPHALT OVERLAY COURSES

412.1 DESCRIPTION—This work is the construction of a thin lift wearing course of plant-mixed, dense-graded asphalt concrete with 6.3 mm Nominal Maximum Aggregate Size (NMAS), placed on a prepared surface.

412.2 MATERIALS—Section 413.2 with additions and modifications as follows:

(a) Asphalt Material.

1. Virgin Mix. Furnish PG 64E-22, conforming to the requirements of Standard Specifications for Performance-Graded Asphalt Binder Using Multiple Stress Creep Recovery (MSCR) Test, AASHTO M 332, except as revised in Bulletin 25. Obtain material from a source listed in Bulletin 15 for the specified performance grade. Provide QC testing and certification as specified in Sections 106.03(b) and 702.1(b)1. Provide the Representative a copy of a signed Bill of Lading for asphalt binder material on the first day of paving and when the batch number changes.

1.a. WMA Technology Additives or Modifiers Blended at the Asphalt Material Supplier's Refinery or Terminal. Provide refinery or terminal blended asphalt material blended with an approved WMA Technology additive or modifier from an approved manufacturer and source listed in Bulletin 15. Include in the asphalt material Producer QC Plan, the WMA Technology additive or modifier manufacturer name, WMA Technology name, and source, dosage rates, blending method, QC testing, corrective action points, disposition of failed material, storage, handling shipping, and bill of lading information following the applicable requirements in Section 702. Include the WMA Technology additive or modifier and dosage rate on the bill of lading. Provide certification that the refinery or terminally blended asphalt binder, that when modified with the WMA Technology additive or modifier, meets the requirements for the specified performance grade.

1.b. WMA Technology Additives or Modifiers Blended at the Asphalt Mixture Producer's Plant. Provide a blended asphalt binder consisting of an approved WMA Technology additive or modifier from an approved manufacturer and source listed in Bulletin 15 that is blended with a base asphalt binder of the specified performance grade conforming to the requirements of Standard Specifications for Performance-Graded Asphalt Binder Using Multiple Stress Creep Recovery (MSCR) Test, AASHTO M 332, except as revised in Bulletin 25 and from an approved source listed in Bulletin 15, Section 702. Prepare a Producer QC Plan as specified in Section 106 and conforming to the Producer QC Plan requirements in Section 413.2(e)1.a and the additional Producer QC Plan requirements within this specification.

(b) Aggregate

1. General Requirements. Provide aggregate from approved producers and sources listed in Bulletin 14. Furnish aggregate that conforms to the quality requirements for Superpave Asphalt Mixture Design as specified in Bulletin 27 with modifications as specified in Section 412.2. Provide aggregate with at least the SRL designation specified. To achieve the specified SRL, the Contractor may provide a blend of two aggregates if the blend has an SRL designation equal to or better than that specified. Blends for SRL are 50% by mass (weight) of each aggregate. Blend the aggregates using an approved method.

2. Fine Aggregate. Section 703.1, except Table A gradation does not apply and as follows:

- Determine the uncompacted void content according to AASHTO T 304, Method A, or use the value listed in Bulletin 14, and ensure the uncompacted void content conforms to AASHTO M 323, Table 6.
- Determine the sand equivalent value according to AASHTO T 176 and ensure the sand equivalent value conforms to AASHTO M 323, Table 6.

All manufactured sand fine aggregates used in NMAS 6.3 mm mixtures must be from a source that has a coarse aggregate SRL rating listed in Bulletin 14 as specified. Manufactured sand fine aggregate must be manufactured from the same parent material(s) as the Bulletin 14 listed coarse aggregate and will have the same SRL rating as the listed coarse aggregate.

All natural sand fine aggregates, and manufactured sand fine aggregates without a coarse aggregate from the same source with an SRL rating listed in the Bulletin 14 used in NMAS 6.3 mm mixture must be submitted to the LTS for SRL determination.

3. Coarse Aggregate. Type A, Section 703.2, except Table C gradation does not apply and revise the following requirements of Table B:

- Abrasion, Maximum Percent Loss as specified in Bulletin 27, Chapter 2A, Table 5A
- Flat and Elongated Particles in Coarse Aggregate maximum percent as specified in ASTM D4791using material retained on the No. 4 sieve, Maximum 10 percent for 1:5 ratio, and Maximum 20 percent for 1:3 ratio.
- Crushed Fragments, Minimum Percent, as specified in AASHTO M 323, Table 6, for Fractured Faces, Course Aggregate using the material retained on the No. 4 sieve.

The coarse aggregate must satisfy specified SRL requirements. Do not use coarse aggregate or anti-skid aggregate in the mixture until the quality, type, and SRL, are determined.

(c) Recycled Asphalt Material. Do not use Reclaimed Asphalt Pavement (RAP) or Recycled Asphalt Shingles (RAS) in the 6.3 mm Wearing Course.

(d) Filler. Follow Section 703.1(c)1. Do not use fly ash if the design traffic is greater than or equal to 3 million Equivalent Single Axle Loads (ESALs). Hydrated lime is allowed as a filler and may constitute up to 2 % of the weight of total dry aggregate unless otherwise shown on the plans. Provide hydrated lime that conforms to the requirements of ASTM C977.

(e) Mixture Composition.

1. Virgin Material Mixtures. Design 6.3 mm NMAS mix that meets all Department requirements. Size, uniformly grade, and combine aggregate fractions, asphalt binder, and an approved WMA Technology in proportions to develop a JMF that conforms to the material, gradation, and volumetric Superpave Asphalt Mixture Design requirements as specified in Bulletin 27, Chapter 2A, except as modified in Table A.

The WMA Technology Manufacturer Technical Representative (Technical Representative) will address laboratory procedure modifications necessary to prepare, compact, and test WMA mixtures and to achieve a uniform blend. Develop a JMF and incorporate the WMA Technology additive, modifier, or process into that JMF during production. Do not develop a volumetric JMF based on incorporating the WMA Technology additive, modifier or process during the volumetric asphalt mixture design process. For all JMFs, perform moisture susceptibility analysis according to Bulletin 27 and ensure the asphalt mixture used for the analysis includes the WMA Technology. Ensure the WMA Technology additive, modifier, or process is not detrimental to the moisture resistance of the mixture.

Submit a complete copy of the JMF, including a Form TR-448A signed by a certified Asphalt Level 2 Plant Technician, to the DME/DMM at least 3 weeks before the planned start of mixture production. Include a list of all material sources and the asphalt mixture producer on the TR-448A. Provide the calibration factors (C_f for both asphalt content and 75 µm (No. 200) sieve) required by PTM No. 757 with the JMF on the TR-448A. Do not start mixture production until after the DME/DMM reviews the JMF.

Submit a completely new JMF, including a new Form TR-448A, with a change in material sources or if a new JMF is necessary to produce a mixture conforming to this specification.

TABLE A
Mix Design Requirements for Thin Lift 6.3 mm Asphalt Wearing Course

AGGREGATE GRADATION REQUIREMENTS, PERCENT PASSING	
Sieve Size	**Min. – Max.**
9.5 mm (3/8 inch)	100 Min.
6.3 mm (1/4 inch)	90-100
4.75 mm (No. 4)	0-85
2.36 mm (No. 8)	37-55
300 µm (No. 50)	8-25
75 µm (No. 200)	3-10
VOLUMETRIC DESIGN REQUIREMENTS	
Design Gyrations (N_{design}) for All Specified Ranges of Design ESALs	75
Voids in Mineral Aggregate (VMA), Min. %, for All Specified Ranges of Design ESALs	16.5
Design Air Voids (V_a), %, for All Specified Ranges of Design ESALs	3.5-4.0
Binder Draindown (AASHTO T 305), % Maximum, for mixture with greater than 7.0% Asphalt Content	0.3%
Binder Grade for All Specified Ranges of Design AASHTO M 332	PG 64E-22

1.a Producer QC Plan. Section 413.2(e)1.a

1.b Plant Technicians. Section 413.2(e)1.b

1.c Annual JMF Verification. Section 413.2(e)1.c except conform to the single and multiple sample tolerances in Section 412.2(e)1.d Tables B and C.

1.d Production. Section 413.2(e)1.d except as follows:

1.d.1 Apparent Moisture Content. Section 413.2(e)1.d.1

1.d.2 Asphalt Content. Include in the producer QC Plan a frequency of obtaining mixture samples according to PTM No. 1 and performing asphalt content tests to verify that the mixture conforms to the tolerances of Table B. Test the samples according to either PTM No. 757, PTM No. 702, or PTM No. 742. After obtaining a minimum of three test results, determine compliance with the multiple sample tolerances in Table B. After obtaining five or more test results, determine compliance with the multiple sample tolerances in Table B using the running average of the last five consecutive test results.

Printed ticket results may be used in place of laboratory test results for QC of asphalt content of the mixture if the producer is currently approved to use printed tickets according to Bulletin 27. During mixture production, maintain 90% of printed ticket results for each day of production within 0.2 percentage points of the JMF.

1.d.3 Gradation. Sample the completed mixture, the combined aggregate from the hot bins of a batch plant, or the combined aggregate belt of a drum plant, according to PTM No. 1 and at the frequency in the producer QC Plan. If mineral filler is used in the mixture, determine gradation by testing samples of the completed mixture.

- Test the completed mixture according to PTM No. 757 or according to PTM No. 702 and PTM No. 739.
- Test combined aggregate samples according to PTM No. 743.

Produce a mixture within the tolerances of Table B. Determine compliance with the multiple-sample tolerance after obtaining a minimum of three test results for the mixture. After obtaining five or more test results for the mixture, determine compliance with the multiple-sample tolerances using the running average of the last five consecutive test results.

1.d.4 Theoretical Maximum Specific Gravity. Section 413.2(e)1.d.4

1.d.5 Volumetric Analysis of Compacted Specimens. Sample the completed mixture according to PTM No. 1 and at the frequency in the producer QC Plan. Prepare a minimum of two specimens from each sample according to AASHTO T 312.

Produce a mixture with volumetric properties conforming to the tolerances of Table C. Determine the bulk specific gravity of the specimens as specified in AASHTO T 312 and calculate air voids (V_a) and Voids in Mineral Aggregate (VMA) at N_{design} according to AASHTO R 35 and as specified in Bulletin 27.

TABLE B
Composition Tolerance Requirements of the Completed Plant Mix

		Single Sample (n = 1)	Multiple Samples (n ≥ 3)
Gradation			
Passing 6.3 mm (1/4 inch) to 300 µm (No. 50) Sieves (Inclusive)		±6%	±4%
Passing 75 µm (No. 200) Sieve		±3.0%	±2.0%
Asphalt Content			
6.3 mm		±0.6%	±0.4%
Temperature of Mixture (F)			
Class of Material	**Type of Material**	**Minimum**	**Maximum**
PG 64E-22	Asphalt Cement	285	330
Job-Mix Tolerance Requirements for Combined Hot Bin Gradations			
Gradation		**Single Sample (n = 1)**	
Passing 6.3 mm (1/4 inch) to 300 µm (No. 50) Sieves (Inclusive)		±4%	
Passing 75 µm (No. 200) Sieve		±3.0%	

TABLE C
Volumetric Tolerance Requirements of the Plant Mixed, Laboratory Compacted Mixture

	Single Specimen (n = 1)	Multiple Specimens (n ≥ 2)
Air Voids at N_{design} (V_a) from Target	±2.0%	±1.5%
Minimum VMA %	16.0	-

1.e Corrective Actions. Immediately take corrective actions if one or more of the following occurs:

- QC test results on a single sample (n=1) for percent passing the 6.3 mm (1/4 inch) sieve, 2.36 mm (No. 8) sieve, 300 µm (No. 50) sieve, 75 µm (No. 200) sieve, or asphalt content are not within the tolerances in Table B.
- The average of multiple samples (n≥3) for percent passing any sieve or asphalt content, as determined according to Section 412.2(e)1.d, are not within the tolerances in Table B.
- QC test results on a single specimen (n=1) or on multiple specimens (n≥2) are not within the tolerances in Table C.
- Independent assurance (IA) or QA sample results tested at the producer's plant are not within the tolerances of Tables B or C.

After taking corrective actions, sample the completed mixture within 150 tons of production. After sampling, test the mixture and provide test results to the Representative. If less than three samples are tested for mixture composition, determine conformance with Table B by comparing each result to the multiple sample tolerances. If the mixture does not conform to the single and multiple sample tolerances in Table B and the single and multiple specimen tolerances in Table B, suspend production and shipping to the project and determine the cause of the problem. Provide a written explanation of the problem and a proposed solution to the Department. After the Representative reviews the proposed solution and authorizes production to continue, resume production and perform JMF verification according to the QC Plan. During corrective actions and JMF verification, mixture acceptance is according to the approved acceptance level of Section 413.2(f) Table C.

2. Draindown Sensitivity. For mixtures with greater than 7 percent total asphalt content determine the draindown sensitivity of the mixture using AASHTO T 305 at the maximum mixture temperature listed in Table B minus 5F. Use Fibers to reduce binder draindown if draindown exceeds the requirements of Table A. Use stabilizer types specified in Section 419.2(d) as needed to address draindown.

(f) Mixture Acceptance. Section 413.2(f) except as follows:

1. General. The Department will accept the mixture according to the certification acceptance in Section 412.2(f)2 or lot acceptance in Section 412.3(h)2.

2. Certification Acceptance. Acceptance by certification is appropriate for the following applications:

- Scratch Courses, Leveling courses and driveway adjustments.
- Mixtures used by Department maintenance forces.
- Mixtures purchased by local municipal governments.
- Mixture placed in quantities less than 350 tons in a continuous placement operation unless otherwise directed by the Representative.
- Other conditions, or applications as approved by the Representative.

2.b Certification of Mixture. Certify each mixture daily if QC test results conform to the single sample and multiple sample JMF production tolerances of Table B. The acceptance values will be:

- Asphalt Content
- Percent Passing the 75 µm (No. 200) sieve

If using printed ticket results in place of laboratory test results for asphalt content, certify that at least 90% of each day's printed ticket results for asphalt content are within 0.2 percentage points of the JMF.

If the mixture does not conform to the above requirements, do not certify the mixture. Instead, provide all QC test results to the Inspector-in-Charge. If using printed ticket results for asphalt content, provide the percentage of daily printed ticket results within 0.2 percentage points of the JMF to the Inspector-in-Charge. Payment will be determined according to Table D based on the QC test results.

If a day's production is interrupted by corrective action, material produced after the corrective action may be certified if QC test results conform to production tolerances.

(g) WMA Technologies (Additive(s), Modifier(s), or Processes) and WMA Manufacturers. Section 413.2(f)

(h) Anti-Strip Additives. Section 413.2(g)

(i) WMA Technology Manufacturer Technical Representative (Technical Representative). Section 413.2(h)

(j) 6.3 mm Mixture use with Membrane Systems Specified in Section 467 or Section 680. Do not use 6.3 mm wearing course paving mixture for material placed directly on top of membrane systems.

412.3 CONSTRUCTION—Section 413.3 with additions and modifications as follows:

(a) Preplacement Requirements. Provide asphalt courses as indicated for the entire project.

1. Paving Operation QC Plan. Prepare a paving operation QC Plan, as outlined on Form CS-413, for field control and evaluation of asphalt concrete paving operations. Submit the QC Plan to the Representative before or at the pre-construction conference. The QC Plan shall describe the construction equipment and methods necessary to construct and test the asphalt concrete courses as specified in Section 412.3. The WMA Technical Representative will provide all recommendations and direction specific to the WMA technology in the paving operation QC Plan. Do not start paving until after the Representative reviews the QC Plan.

2. Preplacement Meeting. At least 2 weeks before placing asphalt paving mixtures, schedule an asphalt preplacement meeting with the Representative to review at a minimum the specification, paving operation QC Plan, sequence of paving operations, mixture acceptance, density acceptance and the care and custody of asphalt acceptance samples.

(b) Weather Limitations. Do not place 6.3 mm wearing course paving mixtures from October 1 to March 31 in Districts 1-0, 2-0 (except Juniata and Mifflin Counties), 3-0, 4-0, 5-0 (Monroe and Carbon Counties only), 9-0 (Cambria and Somerset Counties only), and 10-0; and from October 16 to March 31 in Districts 2-0 (Juniata and Mifflin Counties only), 5-0 (except Monroe and Carbon Counties), 6-0, 8-0, 9-0 (except Cambria and Somerset Counties), 11-0 and 12-0. No exceptions to paving weather limitations will be allowed unless approved in writing by the District Executive. Do not place asphalt paving mixtures when surfaces are wet, when the air or surface temperature is 50F or lower. If work is halted because of weather conditions, the Representative may allow the Contractor to place limited quantities of mixture that are en route to the project.

1. Paving Season Extensions. Section 413.3(b)1. With the following addition:

If an exception to the Weather Limitation dates is approved by the District Executive for 6.3 mm wearing course, the minimum surface temperature of 50F, and an air temperature of 40F will be strictly enforced and compaction of the asphalt mixture completed as quickly as possible.

(c) Asphalt Mixing Plant. Section 413.3(c).

1. Batch Plant. Section 413.3(c)1.

2. Drum Mixer Plant. Section 413.3(c)2.

(d) Hauling Equipment. Section 413.3(d)

(e) Paving Equipment. Section 413.3(e)

(f) Rollers. Use an adequate number of steel-wheeled rollers, each weighing a minimum of 10 tons and as specified in Section 108.05(c)3 to keep up with the paving operation. Operate rollers according to manufacturer's recommendations. Use rollers equipped with a watering or soapy watering system that prevents material from sticking to the rollers. Do not use pneumatic wheeled rollers.

Do not use rollers in vibratory mode unless it can be demonstrated to the satisfaction of the Representative that no breaking of aggregate or flushing of asphalt binder results from the vibration. Monitor pavement cores for aggregate breakage on every lot. Discontinue vibration if aggregate breakage or flushing of asphalt binder occurs.

(g) Preparation of Existing Surface. Section 413.3(g) with the following modification:

1. Conditioning of Existing Surface. Before delivering asphalt mixtures, remove and dispose of loose and foreign material and excess joint sealer and crack filler from the surface of existing pavement or previously placed pavement courses. If necessary, use a power broom. Remove all thermoplastic pavement markings. If practical, do not allow traffic on the existing surface after cleaning, to prevent contamination.

Before placing a wearing course, correct irregularities in the binder course. Repair potholes and gouges greater than 1 inch in depth. Fill and seal all pavement cracks or joints that exceed 1/8 inches in width. Use fillers and sealants conforming to PennDOT specifications.

Paint all existing vertical surfaces of curbs, structures, gutters, and pavements that will be in contact with asphalt mixtures with a uniform coating of either emulsified asphalt, consisting of PennDOT Material Class TACK, or NTT/CNTT, applied in two or more applications or hot asphalt binder of the class and type designated for the asphalt course.

Before overlaying existing surfaces, apply a tack coat to the clean surface according to Section 460. Allow adequate time for tack to break completely prior to placing any material.

(h) Spreading and Finishing. Section 413.3(h) with the following modification:

1. General Requirements.

1.a Placing. Unless otherwise allowed, deliver, place, and compact 6.3 mm paving mixtures during daylight hours. Ensure the mixture does not contain lumps of cold material. Deliver and place 6.3 mm paving mixtures at the laying temperatures specified in Table B.

Utilize a Material Transfer Vehicle (MTV) as specified in Section 108.05(c)5 for 6.3mm paving mixtures unless otherwise approved by the Representative.

1.b Spreading and Finishing. Section 413.3(h)1.b with the following addition:

Plan and schedule operations to minimize hand work of 6.3 mm paving mixtures.

1.c Field Technician. Section 413.3(h)1.c

2. Mixture Lot Acceptance. Section 413.3(h)2 with the following modification:

2.a Lots and Sublots. 413.3(h)2.a.

2.a.1 Partially Completed Lots (n=2 or less). When process conditions change to an extent that a partially completed lot cannot be combined with the most recently completed lot, samples will be independently evaluated on the partially completed lot. For asphalt content and percent passing the 75 µm (No. 200) sieve, mixture acceptance samples will be evaluated individually as specified in Table B (n=1) criteria. For density, mat density acceptance samples will be evaluated individually using the criteria in Table E.

If samples tested for asphalt content and percent passing the 75 µm (No. 200) sieve meet the n=1 criteria of Table B, and samples tested for density meet the criteria in Section 413.3(h), Table E, payment will be 100% of the contract unit price. If samples tested for asphalt content and percent passing the 75 µm (No. 200) sieve do not meet the n=1 criteria of Table B, the material will be considered defective work.

Unless otherwise directed in writing by the District Executive, remove and replace defective work.

2.b Mixture Acceptance Samples. Section 413.3(h)2.b and add the following to the end of the first paragraph:

If a representative mixture acceptance sample cannot be obtained directly behind the paver, the loose mixture acceptance sample for each sublot may be taken from the paver hopper or from the paver screed representing the sample sublot location. Determine the approved mixture acceptance sample collection method for loose mixture acceptance samples at the preconstruction or prepaving meeting.

2.c Mixture Acceptance Sample Testing. LTS Testing will be utilized unless otherwise indicated in the proposal.

2.c.1 LTS Testing. The LTS will test the mixture acceptance samples according to PTM No. 757 or PTM No. 702, Modified Method D, if previously identified problematic aggregates are used in the mixture, to determine asphalt content and the percent passing the 75 µm (No. 200) sieve. The LTS will use the calibration factors (C_f and 200 C_f) provided with the JMF for PTM No. 757. The minimum sample size for PTM No. 757 is 1000 grams when 6.3 mm mix is used. For individual increment test results outside of the single sample (n=1) tolerances in Table B, the LTS will analyze the test results for extreme values according to PTM No. 4 at the 5% significance level. If discarding an extreme value reduces a lot to less than three remaining test results, the Department will accept the lot as specified in Section 412.3(h)2.a.1. The Department will accept lots with three or more test results as specified in Section 412.4(a)2.

If the asphalt content or the percent passing the 75 µm (No. 200) sieve is not within the single sample (n=1) or multiple sample ($n \geq 3$) tolerances in Table B for two consecutive lots or a total of three lots, stop all production of the JMF. Determine the cause of the problem and provide a proposed solution to the Department.

Do not resume production of the JMF until the Representative reviews the proposed solution and authorizes production to continue.

3. Pattern Segregation. Section 413.3(h)3.

4. Flushing. Section 413.3(h)4.

(i) Compaction. Begin rolling immediately after placement of mixture. Compact the 6.33 mm paving mixture to achieve the optimum rolling pattern requirements and to eliminate all roller marks. Compact the mixture while it is in proper condition and adjust roller speed, pattern, and roller size (and/or amplitude and frequency if vibratory rolling is approved by the Representative) to eliminate displacement, shoving, cracking, and aggregate breakage as specified in Section 412.3(f). Satisfactorily correct displacement resulting from reversing roller directions and other causes. Do not use pneumatic-tire rollers.

Without using excess water, maintain wheels of steel wheel rollers moist and clean to prevent the mixture from adhering to the wheels.

For areas inaccessible to rollers, compact with mechanical vibrating hand tampers.

Remove areas that are loose, broken, mixed with dirt, or show an excess or deficiency of asphalt material. Replace removed mixture with fresh, hot 6.3 mm paving mixture and compact the mixture even with the surrounding pavement surface.

(j) Mat Density Acceptance. The Department will accept the mat density based on non-movement and optimum rolling pattern.

1. Non-Movement. The Department will accept the density when the mixture does not move under the compaction equipment.

2. Optimum-Rolling Pattern. With the Representative and the Contractor's certified asphalt field technician present, determine density with an approved nuclear gauge according to PTM 402, or determine density with an approved electrical impedance gauge according to PTM No. 403. Nuclear gauges must be operated by a licensed nuclear gauge operator. In the presence of the Representative, follow the control strip technique specified in PTM No. 402 to construct at least one control strip to establish the optimum rolling pattern for each course. Document readings using the forms provided in PTM No. 402 and provide the completed forms to the Representative. Compact the course according to the optimum rolling pattern. During paving, the Representative may require the Contractor to construct a new control strip to verify the optimum rolling pattern.

Use one of the following gauges or approved equal:

- Troxler Electronics, Model 3411B or Model 4640B
- Campbell Pacific Nuclear, Model MC-2
- Seaman Nuclear, Model MC-2
- TransTech Systems, Inc., PQI™, Model 300 or Model 301
- Troxler Electronic Laboratories, PaveTracker™

Submit a copy of the certificate of nuclear gauge annual calibration according to ASTM D2950 and documentation of training of the nuclear gauge operator. Recalibrate any nuclear gauge that is damaged or repaired.

(k) Joints. Section 413.3(k)

(l) Surface Tolerance. Section 413.3(l)

(m) Tests for Depth: Wearing Courses. Section 413.3(m)

(n) Protection of Courses. Section 413.3(n)

(o) Defective Work. Section 413.3(o)

412.4 MEASUREMENT AND PAYMENT -

(a) Standard 6.3mm Asphalt Construction.

1. Asphalt Courses.

1.a Thin Lift 6.3 mm Asphalt Wearing Course. Square Yard or Ton

1.b Thin Lift 6.3 mm Asphalt Wearing Course (Scratch). Ton

2. Asphalt Tack Coat. Section 460.4

3. Mixture Acceptance by Certification and Density Acceptance by Non-Movement, Optimum-Rolling Pattern. The Representative will pay at the contract unit price, adjusted according to Table D. The total payment factor percentage is the sum of adjustments for each test criterion subtracted from 100%. The adjustment for an individual test criterion is the payment factor percentage subtracted from 100%. The pavement will be considered defective if the payment factor for asphalt content and percent passing the 75 µm (No. 200) sieve are both 85%.

TABLE D
Contract Unit Price Adjustments - Mixture Acceptance by Certification

Mixture NMAS	Test Criteria	Test Value		Payment Factor Percentage
Asphalt Content				
6.3 mm	Printed Tickets	At least 90% of Daily Printed Tickets Within 0.2% of JMF		100
		Less than 90% of Daily Printed Tickets Within 0.2% of JMF		85
6.3 mm	QC Sample Testing**	Single Sample (n=1)	Multiple Samples (n≥2)	
		±0.7%	±0.5%	100
		±0.8% to 1.0%	±0.6%	85
		> ±1.0%	≥ ±0.7%	*
Gradation				
		Single Sample (n=1)	Multiple Samples (n≥2)	
6.3 mm	QC Sample Testing for % Passing 75 µm (No. 200) Sieve**	±3.0%	±2.1%	100
		±3.1% to ±4.0%	±2.2% to ±2.7%	85
		> ±4.0%	≥ ±2.8%	*
Mat Density				
6.3 mm	Non-Movement	Section 412.3(j)1.		100
	Optimum-Rolling Pattern	Section 412.3(j)2.		100

* Defective pavement. Remove and replace or, when permitted by the District Executive in writing, leave in place and the Department will pay 70% of the contract unit price.

** For these test criteria, the daily Payment Factor Percentage will be determined by the single sample test result from the daily QC sample. If more than one QC sample test result is available for a day, the Payment Factor Percentage will be determined based on the average of the results using multiple sample tolerances. If corrective action is taken, Payment Factor Percentages will be separately determined for material placed before and after the corrective action.

4. Mixture Acceptance by Lot and Density Acceptance by Optimum Rolling Pattern. The Department will pay on a lot-by-lot basis at the contract price, adjusted for Payment Factor Percentages as specified in Table E. For the payment factor percentages based on percent within tolerance, the Department will determine the percent within tolerance according to Section 106.03(a)3, using the upper and lower specification limits in Table F.

TABLE E
Contract Unit Price Adjustments - Mixture Acceptance by Lots

Mixture NMAS	Test Criteria	Test Value	Payment Factor Percentage
Asphalt Content			
6.3 mm	Acceptance Sample Testing	All individual sublot acceptance sample test results for the lot (n=1) are within ± 0.6% and the lot average (n≥3) is within ± 0.4%*	100
		Percent Within Tolerance if any individual sublot acceptance sample test result for the lot is not within the n=1 tolerances or the lot average is not within the n≥3 tolerances listed above.	Table G
Gradation			
6.3 mm	Acceptance Sample Testing for % Passing 75µm (No. 200) Sieve	All individual sublot acceptance sample test results for the lot (n=1) are within ± 3.0% and the lot average (n≥3) is within ± 2.0%*	100
		Percent Within Tolerance if any individual sublot acceptance sample test result for the lot is not within the n=1 tolerances or the lot average is not within the n≥3 tolerances listed above.	, Table G
Mat Density			
6.3 mm	Optimum-Rolling Pattern	Section 412.3(j)2	100
* The Department may elect to randomly select and test only one sublot acceptance sample from each lot to determine conformance to the specifications. If only one sublot acceptance sample is tested, tighter tolerances will be used to determine conformance to the specifications for the entire lot. If the one sublot is within ±0.2% of the JMF for asphalt content and within ±1.0% of the JMF for percent passing the 75 µm (No. 200) sieve, the lot will be considered to conform with the specifications and the lot's payment factor percentage will be determined according to this table. If the one sublot fails to meet the tighter tolerances, all acceptance samples from the lot will be tested to determine the payment factor percentage according to this table.			

TABLE F
Upper and Lower Specification Limits for Calculating Percent Within Tolerance

	Testing Criteria	
Mixture NMAS	**Lower Specification Limit (L)**	**Upper Specification Limit (U)**
	Asphalt Content from JMF Value, %	
6.3 mm	-0.4	+0.4
	Percent Passing the 75 µm (No. 200) sieve from JMF Value, %	
6.3 mm	-2.0	+2.0

TABLE G
Payment Factor Based on Percent Within Tolerance

Percent Within Tolerance	Payment Factor Percentage
99	97
98	97
97	97
96	96
95	96
94	96
93	95
92	95
91	95
90	95
89	93
88	91
87	90
86	88
85	86
84	84
83	83
82	81
81	79
80	78
79	76
78	74
77	72
76	71
75	69
74	67
73	66
72	64
71	62
70	60
69	59
68	57
67	55
66	54
65	52
64	50
Less than 64	Defective Lot**

**Remove and replace the lot. If only one lot characteristic has a percent within tolerance less than 64, the District Executive may allow the Contractor to leave the defective lot in place. The Department will pay for the defective lot at 70% of the contract unit price.

4.a Payment. The Representative will compute the percent of the contract unit price paid as follows:

$$\text{Lot Payment} = C_P(2P_D + P_B + P_A)/400$$

C_P = Contract unit price per lot (unit price times lot quantity)

P_D = Payment Factor Percentage for density

P_B = Payment Factor Percentage for asphalt content.

P_A = Payment Factor Percentage for percent passing the 75 µm (No. 200) sieve

4.b Dispute Resolution. For mixture acceptance testing performed by the LTS, the Contractor may request in writing that the Department retest a lot if the initial test results indicated a defective lot (remove and replace). Provide written retest requests to the District Executive within 3 weeks of the date the LTS test results are released. Retests will not be allowed if a written retest request is not received within 3 weeks of the date the LTS test results are released. Provide quality control test results and control charts, companion sample test results (if available), test data trend evaluation, and any other pertinent information to justify the retest request. The Department will evaluate the information and may allow retesting if the information submitted provides a reasonable basis to conclude that the failing test results may not represent the in-place material. The LTS will perform the retest with the Contractor present, unless otherwise agreed to in writing with the Contractor.

For retesting of materials failing for asphalt content or percent passing the 75 µm (No. 200) sieve, the Inspector will identify the locations where the original box samples were collected. The Inspector will select retest sample locations 24 inches from the original sample locations longitudinally in the direction of traffic. If the 24 inch offset causes the retest sample location to fall outside of the sublot, the Inspector will select the retest sample location 24 inches from the original sample locations longitudinally in the opposite direction from traffic.

With the Inspector present, provide appropriate traffic control and drill two 6-inch diameter cores at each retest sample location for retesting purposes. Rinse all retest cores thoroughly with water immediately after drilling to remove all loose material on the core from the drilling operation. Within 24 hours after coring, backfill the holes with asphalt mixture of the same JMF or with asphalt mixture used for subsequent courses and compact and seal the asphalt mixture. Provide traffic control, core, and backfill the core holes at no cost to the Department. The test method used for asphalt determination during the original acceptance testing (PTM No. 757 or PTM No. 702) will be used for the retest, unless the (DME/DMM) grants written approval for a change in test method. The results of the retest cores will be used to calculate payment for both asphalt content and percent passing the 75 µm (No. 200) sieve for the lot.

The Department will deduct from the payment the cost per lot associated with conducting a retest as follows in Table H:

TABLE H
Dispute Resolution Retest Cost Table

Test Method	**Mixture Acceptance Retest Cost if Retest Results Indicate** **100% Pay Factor(s)***	**Mixture Acceptance Retest Cost if Retest Results Indicate** **<100% Pay Factor(s)**
PTM No. 702/739	$900	$3,500
PTM No. 757	$500	$2,000

SECTION 413—SUPERPAVE MIXTURE DESIGN, STANDARD AND RPS CONSTRUCTION OF PLANT-MIXED ASPHALT COURSES WITH PERCENT WITHIN LIMITS AND LTS TESTING (PWL-LTS)

413.1 DESCRIPTION—This work is the Standard and RPS construction of a plant-mixed, dense-graded, asphalt pavement course on a prepared surface using a volumetric asphalt mixture design developed with the Superpave Gyratory Compactor (SGC), using prescribed manufactured additives or modifiers, or plant process modifications or both. Acceptance of the work is based on testing of field samples by the LTS and statistical evaluation of sample test results by Percent Within Limits (PWL) procedures.

413.2 MATERIALS—Do not incorporate any materials into the asphalt mixture that are not specified including additives, rejuvenators, or other materials.

(a) Asphalt Material

1. Virgin Mix, Mix Containing 5% to 15% RAP, or Mix Containing 5% Recycled Asphalt Shingles (RAS). Furnish material conforming to the requirements of Standard Specifications for Performance-Graded Asphalt Binder using Multiple Stress Creep Recovery (MSCR) Test, AASHTO M 332, except as revised in Bulletin 25. Obtain material from a source listed in Bulletin 15 for the specified grade. Provide QC testing and certification as specified in Sections 106.03(b) and 702.1(b)1. Provide the Representative a copy of a signed Bill of Lading for asphalt binder on the first day of paving and when the batch number changes.

2. Mix Containing More than 15% RAP or Mix Containing Both 5% RAS and 5% or More RAP. The LTS will evaluate the asphalt binder in the RAP and, if applicable, the RAS source material. The LTS will determine the class (grade) of asphalt binder that the Contractor is required to use in the mixture.

Furnish material conforming to the requirements of Standard Specifications for Performance-Graded Asphalt Binder using Multiple Stress Creep Recovery (MSCR) Test, AASHTO M 332, except as revised in Bulletin 25. Obtain material from a source listed in Bulletin 15 for the specified grade. Provide QC testing and certification as specified in Sections 106.03(b) and 702.1(b)1. Provide the Representative a copy of a signed Bill of Lading for asphalt binder on the first day of paving and when the batch number changes.

3. WMA Technology Additives or Modifiers Blended at the Asphalt Binder Supplier's Refinery or Terminal. Provide refinery or terminal blended asphalt binder blended with a WMA Technology additive or modifier from an approved manufacturer and source listed in Bulletin 15. Include in the asphalt binder Producer QC Plan, the WMA Technology additive or modifier manufacturer name, WMA Technology name, and source, dosage rates, blending method, QC testing, corrective action points, disposition of failed material, storage, handling shipping, and bill of lading information as specified in Section 702. Include the WMA Technology additive or modifier and dosage rate on the bill of lading. Provide refinery or terminally blended asphalt binder modified with the WMA Technology additive or modifier as specified in Section 413.2(a)1 or Section 413.2(a)2 for the specified grade.

4. WMA Technology Additives or Modifiers Blended at the Asphalt Mixture Producer's Plant. Provide a blended asphalt binder consisting of an approved WMA Technology additive or modifier from an approved manufacturer and source listed in Bulletin 15 that is blended with a base asphalt binder of the specified grade conforming to the requirements of Standard Specifications for Performance-Graded Asphalt Binder using Multiple Stress Creep Recovery (MSCR) Test, AASHTO M 332, except as revised in Bulletin 25 and from an approved source listed in Bulletin 15, Section 702. Prepare a Producer QC Plan as specified in Section 106 and conforming to the Producer QC Plan requirements as specified in Section 413.2(e)1.a . Provide asphalt binder blended with the WMA Technology additive or modifier at the asphalt mixture production plant as specified Section 413.2(a)1 or Section 413.2(a)2 for the specified grade.

(b) Aggregate and RAM.

1. General Requirements. Provide aggregate from sources listed in Bulletin 14. Aggregate and RAM shall conform to the quality requirements for Superpave Asphalt Mixture Design according to Bulletin 27. For wearing courses, provide aggregate with at least the SRL designation specified. To achieve the specified SRL, the Contractor may provide a blend of two aggregates if the blend has an SRL designation equal to or better than that specified. Blends are 50% by mass (weight) of each aggregate. Blend the aggregates using an approved method. Do not use 4.75 mm asphalt mixtures in applications that require an SRL designation higher than L.

2. Fine Aggregate. Section 703.1, except Table A gradation does not apply and as follows:

Determine the uncompacted void content according to AASHTO T 304, Method A, or use the value listed in Bulletin 14, and ensure the uncompacted void content conforms to AASHTO M 323, Table 6. Determine the sand equivalent value according to AASHTO T 176 and ensure the sand equivalent value conforms to AASHTO M 323, Table 6.

3. Coarse Aggregate. Section 703.2, Type A, except Table C gradation does not apply and revise the following quality requirements of Table B:

- Abrasion, Maximum Percent according to Bulletin 27, Chapter 2A, Table 5A
- Thin and Elongated Pieces, Maximum Percent according to AASHTO M 323, Table 6, for Flat and Elongated
- Crushed Fragments, Minimum Percent, according to AASHTO M 323, Table 6, for Fractured Faces, Coarse Aggregate

(c) Recycled Asphalt Material

1. RAP. If RAP material is proposed for use in the mixture, use at least 5% RAP consisting of cold milled or crushed asphalt mixture. Include a plan to control RAP and the procedures to handle RAP of significantly different composition in the producer QC Plan. Maintain all processed material free of foreign materials and minimize segregation. Process the RAP so that the final mixture meets requirements as specified in Section 413.2(e).

2. Manufacturer Waste Recycled Asphalt Shingles (RAS). If RAS material is proposed for use in the mixture, use 5% RAS by mass (weight) of the total mixture consisting of manufacturer waste shingles that are rejected asphalt shingles or shingle tabs that are discarded in the manufacturing process of new asphalt roofing shingles. Do not use post-consumer asphalt roofing shingles that are removed from the roofs of existing structures. Due to significant composition differences, keep rejected asphalt shingles manufactured with fiberglass felt or paper or organic felt separate. Do not use both fiberglass felt, and paper or organic felt asphalt roofing shingles in the same mixture. Obtain certification, as specified in Section 106.03(b)3, from the manufacturer of the waste shingles certifying that the waste shingles were discarded during the manufacturing process of new asphalt roofing shingles and certifying the type of felt used during manufacturing of the waste shingles. Maintain and provide the Representative access to all certification records for manufacturer waste shingles.

Process RAS material by shredding, screening or other methods so that 100 percent passes the 9.5 mm (3/8 inch) sieve. RAS may be uniformly blended with fine aggregate as a method of preventing the agglomeration of RAS material. If RAS and fine aggregate are blended, blend at 50% by mass (weight) of each material.

Include a plan to stockpile and control RAS and the procedures to handle RAS of significantly different composition in the producer QC Plan. Maintain all processed material free of foreign materials and minimize segregation. Process the RAS so that the final mixture conforms to Section 413.2(e).

(d) Filler. Section 703.1(c)1. Do not use fly ash if the design traffic is greater than or equal to 3 million Equivalent Single Axle Loads (ESALs).

(e) Mixture Composition for Standard and RPS Construction.

1. Virgin Material Mixtures. Size, uniformly grade, and combine aggregate fractions, asphalt binder, and either WMA Technology additive(s) or modifier(s) in proportions to produce a JMF that conforms to the material, gradation, and volumetric Superpave Asphalt Mixture Design requirements according to Bulletin 27, Chapter 2A. Produce an asphalt mixture for the specified nominal maximum aggregate size and design ESALs except as procedurally modified by the WMA Technology Manufacturer Technical Representative (Technical Representative) to address laboratory procedures when preparing, compacting and testing asphalt mixtures to achieve a uniform blend.

Special additive(s) or modifier(s) need not be used if mixture temperature, workability, and compaction can be achieved solely through plant mechanical modification to produce foamed asphalt. Do not incorporate the WMA Technology additive, modifier or process during the volumetric asphalt mixture design process, so that the JMF volumetrics and material percentages are based on a mixture with no WMA Technology. Only use the WMA Technology additive, modifier or process to evaluate results from moisture susceptibility testing during the mix design process. Develop an asphalt mixture JMF, then incorporate the WMA Technology additive, modifier, or process into that JMF during production. Create an asphalt JMF cover sheet (Form TR-448A) for approval containing the WMA Technology used, additive dosage rate or percent water added for foaming, material code, and the TSR data from the moisture susceptibility testing.

Submit a copy of each completed JMF, signed by a certified Asphalt Level 2 plant technician, to the DME/DMM at least 3 weeks before the planned start of mixture production. Include a list of all material sources and the asphalt mixture producer in the JMF. Provide the calibration factors (C_f and 200 C_f) according to PTM No. 757 with the JMF. Do not start mixture production until after the DME/DMM reviews the JMF.

Submit a new JMF with a change in material sources or if a new JMF is necessary to produce a mixture conforming to this specification.

1.a Producer QC Plan. Each producer must prepare a QC Plan as specified in Section 106 and conforming to the additional QC requirements of this specification. Submit the QC Plan to the DME/DMM annually at least 3 weeks before the planned start of mixture production and do not start production until the DME/DMM reviews the QC Plan.

1.a.1 QC Organization Chart.

- Names of personnel responsible for QC.
- Area of responsibility of each individual.
- List outside agencies, (e.g., testing laboratories) and a description of services provided.

1.a.2 Testing Plan with Action Points.

- List of all tests to be performed.
- Frequency of testing.
- List action points to initiate corrective procedures.
- Recording method to document corrective procedures.
- Procedures for conducting JMF verification testing.

1.a.3 Materials Storage and Handling.

- Aggregate/RAP/RAM/RAS stockpiles.
- Cold-feed systems for aggregates/RAP/RAM/RAS.
- Additives or modifiers for mixture
- Modified asphalt/liquid additive storage tanks.
- Surge/storage silos for mixture. Do not store more than one JMF in a surge/storage silo at any given time.

- All measuring and conveying devices, including calibration procedures.
- Haul vehicle loading procedures.
- WMA Technology additive or modifier manufacturer name, WMA Technology name, and source as listed in Bulletin 15.
- WMA Technology additive or modifier storage and handling before blending.
- All measuring, conveying and blending devices for the WMA Technology and anti-strip additive (if required), including calibration procedures.
- WMA Technology additive or modifier and anti-strip additive (if required) method of introduction, dosage rates, blending with the asphalt binder and method of automation, recordation and print outs.
- Storage and handling of the blended asphalt binder with the WMA Technology additive or modifier.
- Asphalt production temperature range for normal paving and any specific temperature ranges for special conditions or situations.
- Asphalt laboratory compaction temperature for QC volumetric analysis. Determine the SGC compaction temperature for the production QC which yields the same target air voids as the designed JMF.

1.b Plant Technicians. During mixture production, provide a certified Asphalt Level 1 plant technician at the plant and an on-call certified Asphalt Level 2 plant technician, both meeting the requirements according to Publication 351. Instruct and train the certified technicians to perform all tests and to control plant operation. The Department may use its own certified Asphalt plant technicians to verify tests and to work in coordination with the producer's technicians. All technicians must carry a valid certification card during mixture production.

1.c Annual JMF Verification. During initial production of each JMF, verify, according to the QC Plan, that the mixture conforms to this specification. If the mixture does not conform to the single and multiple sample tolerances in Tables A and B within 2 days of production, suspend shipping the mixture to the project. Do not ship the mixture to the project until after the Representative reviews and verifies that results conform to the single and multiple sample tolerances in Tables A and B. During JMF verification, mixture acceptance is according to the approved acceptance level of Table C.

1.d Production. After JMF verification, sample and test the mixture according to the QC Plan. For daily production of each JMF greater than 50 tons, determine asphalt content, gradation, and theoretical maximum specific gravity from the same sample at least once each day. For daily production of each JMF greater than 150 tons, determine asphalt content, gradation, theoretical maximum specific gravity and perform volumetric analysis of compacted specimens from the same sample at least once each day. Perform additional sampling and testing as directed. Produce a mixture within the following production limits:

1.d.1 Apparent Moisture Content. If the water absorption of a coarse aggregate, determined according to AASHTO T 85, exceeds 2.0%, sample the mixture according to PTM No. 1 and at the frequency in the producer QC Plan. Determine the apparent moisture content in the mixture according to PTM No. 749. Produce a mixture with the apparent moisture content not to exceed 0.5%.

1.d.2 Asphalt Content. Include in the producer QC Plan a frequency of obtaining mixture samples according to PTM No. 1 and performing asphalt content tests to verify that the mixture conforms to the tolerances of Table A. Test the samples according to either PTM No. 757, PTM No. 702, or PTM No. 742. After obtaining a minimum of three test results, determine compliance with the multiple sample tolerances in Table A. After obtaining five or more test results, determine compliance with the multiple sample tolerances in Table A using the running average of the last five consecutive test results.

Printed ticket results may be used in place of laboratory test results for QC of asphalt content of the mixture if the producer is currently approved to use printed tickets according to Bulletin 27. During mixture production, maintain 90% of printed ticket results for each day of production within 0.2 percentage points of the JMF. If RAP or RAS is used in the mixture, determine asphalt content by testing samples of the completed mixture.

1.d.3 Gradation. Sample the completed mixture or sample the combined aggregate from the hot bins of a batch plant or the combined aggregate belt of a drum plant, according to PTM No. 1 and at the frequency in the producer QC Plan. If mineral filler, RAP, or RAS are used in the mixture, determine gradation by testing samples of the completed mixture.

- Test the completed mixture according to PTM No. 757 or according to PTM No. 702 and PTM No. 739.
- Test combined aggregate samples according to PTM No. 743.

Produce a mixture within the tolerances of Table A. Determine compliance with the multiple-sample tolerance after obtaining a minimum of three test results for the mixture. After obtaining five or more test results for the mixture, determine compliance with the multiple-sample tolerances using the running average of the last five consecutive test results.

1.d.4 Theoretical Maximum Specific Gravity. Sample the mixture according to PTM No. 1 at the frequency required in Bulletin 27. Condition and test the samples according to Bulletin 27.

Calculate the percentage of unfilled voids and the theoretical maximum density of the mixture using the most recently determined theoretical maximum specific gravity value or average value according to Bulletin 27. Certify the theoretical maximum specific gravity value to the Inspector daily using Form CS-4171B. If the theoretical maximum specific gravity value varies 0.030 or more from the previous test or from the JMF value, immediately notify the DME/DMM.

1.d.5 Volumetric Analysis of Compacted Specimens. Sample the completed mixture according to PTM No. 1 and at the frequency in the producer QC Plan. Prepare a minimum of two specimens from each sample according to AASHTO T 312.

Produce a mixture with volumetric properties conforming to the tolerances of Table B. Determine the bulk specific gravity of the specimens according to AASHTO T 312 and calculate air voids (V_a) and Voids in Mineral Aggregate (VMA) at N_{design} according to AASHTO R 35 and according to Bulletin 27. Determine compliance with the multiple specimen tolerances using the average of the results for all specimens prepared from the sample.

TABLE A
Job-Mix Formula
Composition Tolerance Requirements of the Completed Mix

	Single Sample (n = 1)	Multiple Samples (n $\geq$ 3)
Gradation		
Passing 12.5 mm (1/2 inch) and Larger Sieves	±8%	±6%
Passing 9.5 mm (3/8 inch) to 150 µm (No. 100) Sieves (Inclusive)	±6%	±4%
Passing 75 µm (No. 200) Sieve	±3.0%	±2.0%
Asphalt Content		
19.0 mm Asphalt mixtures and smaller	±0.7%	±0.4%
25.0 mm Asphalt mixtures and larger	±0.8%	±0.5%

Temperature of Mixture (F)				
Class of Material	**Type of Material**	**Chemical, Organic, Foaming Additives Minimum***	**Mechanical Foaming Equipment/Process Minimum***	**Maximum***
PG 58S-28	Asphalt Binder	215	230	310
PG 64S-22	Asphalt Binder	220	240	320
PG 64E-22	Asphalt Binder	240	260	330
All other Binders	Asphalt Binder	The higher of 215 or the minimum temp. specified in Bulletin 25 minus 45F	The higher of 230 or the minimum temp. specified in Bulletin 25 minus 30F	As specified in Bulletin 25
* Outline in the Producer QC Plan and follow more restrictive temperature requirements provided by the WMA technology manufacturer or Technical Representative(s) for production and placement of the mixture. Determine the SGC compaction temperature for the production QC which yields the same target air voids as the designed JMF . Include the SGC compaction temperature in the Producer QC Plan. Compact the completed mixture in the SGC for QC volumetric analysis at the SGC compaction temperature according to the guidelines provided by the Technical Representative.				

TABLE B
Job-Mix Formula
Volumetric Tolerance Requirements of the Laboratory Compacted Mix

Property	**Each Specimen**	**Multiple Specimens**
Air Voids at N_{design} (V_a)	(±2%)	(±1.5%)
Minimum VMA % for 4.75 mm	16.0	-
Minimum VMA % for 9.5 mm	15.5	-
Minimum VMA % for 12.5 mm	14.5	-
Minimum VMA % for 19.0 mm	13.5	-
Minimum VMA % for 25.0 mm	12.5	-
Minimum VMA % for 37.5 mm	11.5	-

1.e Corrective Actions. Immediately take corrective actions if one or more of the following occurs:

- QC test results on a single sample (n=1) for percent passing the 2.36 mm (No. 8) sieve, the 75 µm (No. 200) sieve, or asphalt content are not within the tolerances in Table A.
- The average of multiple samples (n≥3) for percent passing any sieve or asphalt content, as specified in Section 413.2(e)1.d, are not within the tolerances in Table A.
- QC test results on each specimen or on multiple specimens are not within the tolerances in Table B.
- Independent assurance (IA) or QA sample results tested at the producer's plant are not within the tolerances of Tables A or B.

After taking corrective actions, sample the completed mixture within 150 tons of production. After sampling, test the mixture and provide test results to the Representative within 500 tons of production. If less than three samples are tested for mixture composition, determine conformance with Table A by comparing each result to the multiple sample tolerances. If the mixture does not conform to the single and multiple sample tolerances in Table A and the single and multiple specimen tolerances in Table B, suspend production and shipping to the project and determine the cause of the problem. Provide a written explanation of the problem and a proposed solution to the Department. After the Representative reviews the proposed solution and authorizes production to continue, resume production and perform JMF verification according to the QC Plan. During corrective actions and JMF verification, mixture acceptance is according to the approved acceptance level of Table C.

2. Mixtures with RAM, 5% or More RAP, and/or 5% RAS. Section 413.2(e)1 and as follows:

2.a RAM and RAP SRL. For asphalt wearing courses, limit the total combination of RAM and RAP to a maximum of 15% of the mixture by mass (weight) unless documentation of the SRL designation of the coarse aggregate in the RAM and RAP materials is provided to the DME/DMM and the RAM and RAP meet the specified SRL or can be blended for SRL as specified in Section 413.2(b)1.

2.b RAP and/or RAS Asphalt Content and Gradation. Determine the average asphalt content and gradation of the RAP and/or RAS stockpile(s) according to Bulletin 27. Determine the proportions of RAP, RAM, RAS, and virgin materials necessary to conform to the JMF requirements. Maintain and provide the Representative access to records of all sampling, testing, and calculations.

(f) WMA Technologies (Additive(s), Modifier(s), or Processes) Produce the asphalt mixture using approved or provisionally approved WMA Technologies, including additives, modifiers or processes from manufacturers listed in Bulletin 15. If blending WMA additives or modifiers with asphalt material, provide asphalt material blended with the WMA additive or modifier as specified in Section 413.2(a)3 or Section 413.2(a)4. For WMA Technology additives or modifiers blended with the asphalt mixture at the asphalt mixture production plant, prepare a QC Plan as specified in Section 106 and also conforming to the additional Producer QC Plan requirements within this specification. Submit the QC Plan to the DME/DMM annually and at least 3 weeks before the planned start of the blending of WMA Technologies with asphalt material. Do not start blending until the DME/DMM reviews the QC Plan.

(g) Anti-Strip Additives. Use either a compatible, heat stable, amine-based liquid anti-strip or a compatible alternate anti-strip additive. If the WMA Technology includes an anti-strip additive as part of its WMA Technology, perform moisture susceptibility analysis as specified in Section 413.2(e)1 and add additional anti-strip additive or make other adjustments to the JMF if needed to meet the specified moisture susceptibility requirements.

(h) WMA Technology Manufacturer Technical Representative (Technical Representative). If the Asphalt Producer is using a provisionally or conditionally approved WMA Technology listed in Bulletin 15 or is using a fully approved WMA Technology for the very first time, identify one or more Technical Representative(s) that are knowledgeable in how the WMA Technology will affect the storage, handling, blending, mixture production, mixture QC testing, placement and compaction requirements of the mix. Have one or more Technical Representative(s) on-call and capable of being in direct, verbal contact with the Producer, Contractor, and/or Department within 2 hours after initial contact. Have one or more Technical Representative(s) review the Producer's QC Plan to ensure that all of the data as specified in Sections 413.2(e) 1.a.2 and 413.2(e) 1.a.3 are supported according to current manufacturer's recommendations. Include the Technical Representative's office and mobile telephone numbers in the Producer's QC Plan.

(i) Mixture Acceptance.

1. General. For standard construction, the Department will accept the mixture according to the appropriate level in Table C. For RPS construction, the Department will accept the mixtures by lot acceptance as specified in Section 413.3(h)2.

TABLE C
Mixture Acceptance

Acceptance Level	Acceptance Method
Certification Acceptance	Producer Certification of Mixture (Section 413.2(i)2)
Lot Acceptance	Mixture Acceptance Sample Testing (Section 413.3(h)2)

2. Certification Acceptance. Acceptance by certification is appropriate for the following mixtures, conditions, or applications:

- Scratch courses, leveling courses less than 2 inch depth and driveway adjustments.

- Mixtures used by Department maintenance forces.
- Mixtures purchased by local or municipal governments.
- Mixtures placed in quantities not exceeding 500 tons in a continuous placement operation unless otherwise directed by the Representative (See Section 101.01).
- Mixtures used for parking lots.
- All 4.75 mm NMAS asphalt mixtures.
- Other mixtures, conditions, or applications as approved by the Representative (See Section 101.01).

2.a General. Obtain certification from the mixture producer. Use all QC tests during mixture production as acceptance tests. Certify mixtures using Form CS-4171B. Include, or attach, the QC test results on the form. Provide the form to the Inspector-in-Charge within 1 working day after completing the QC tests. Certify mixtures as specified in Section 106.03(b)3 and the requirements below.

2.b Certification of Mixture. Certify each mixture daily if QC test results conform to the single sample and multiple sample JMF production tolerances of Table A. The acceptance values will be:

- Asphalt Content
- Percent Passing the 2.36 mm (No. 8) sieve (not applicable for 4.75 mm NMAS asphalt mixtures)
- Percent Passing the 75 µm (No. 200) sieve

If using printed ticket results in place of laboratory test results for asphalt content, certify that at least 90% of each day's printed ticket results for asphalt content are within 0.2 percentage points of the JMF.

If the mixture does not conform to the above requirements, do not certify the mixture. Instead, provide all QC test results to the Inspector-in-Charge. If using printed ticket results for asphalt content, provide the percentage of daily printed ticket results within 0.2 percentage points of the JMF to the Inspector-in-Charge. Payment will be determined according to Table H based on the QC test results.

If a day's production is interrupted by corrective action, material produced after the corrective action may be certified if QC test results conform to production tolerances.

2.c Maintaining Approval to Certify Mixtures. The Department may suspend a plant's approval to certify mixtures if QC is not performed according to the producer QC Plan, mixtures are not produced according to Bulletin 27, a mixture cannot be certified on 2 consecutive production days, or as described below.

The Department may take IA samples of the completed mixture at the plant. In the presence of the Department, test the IA samples for asphalt content and gradation according to the test methods indicated in the producer QC Plan. Take immediate corrective actions if the mixture does not conform to Table A.

The Department may take QA samples of the completed mixture at the plant or on the roadway directly from the uncompacted mixture placed by the paving equipment specified in Section 413.3(e). The Department will test QA samples according to PTM No. 757 or PTM No. 702, Modified Method D, if previously identified problematic aggregates are used in the mixture, for conformance to Table A. If the results of the QA samples do not comply with Table A, review the producer QC Plan and the QC test results that followed the QA samples for conformance to Table A. If QC results do not conform to Table A, perform the corrective actions necessary to provide a mixture conforming to Table A.

After completing corrective actions or the sample review, the Department will perform an on-site evaluation of the producer's plant operation and QC and then take a sample of the completed mixture at the plant. In the presence of the Representative, test the sample. If the sample does not comply with Table A, the Department will suspend certification. Immediately suspend shipping mixtures accepted by certification to the project.

After testing verifies that the produced mixture conforms to Tables A and B and with the Representative present, conduct JMF verification according to the producer QC Plan. After successfully completing JMF verification, resume both certification and shipping mixtures accepted by certification to the project.

413.3 CONSTRUCTION—

(a) Preplacement Requirements.

1. Paving Operation QC Plan. Prepare a paving operation QC Plan, as outlined on Form CS-413, for field control and evaluation of asphalt concrete paving operations that addresses all recommendations and direction from the Technical Representative(s) associated with any WMA Technology being used. Submit the QC Plan to the Representative before or at the pre-construction conference. The QC Plan shall describe the construction equipment and methods necessary to construct and test the asphalt concrete courses as specified in Section 413.3. Do not start paving until after the Representative reviews the QC Plan.

2. Preplacement Meeting. At least 2 weeks before placing asphalt paving mixtures, schedule an asphalt preplacement meeting with the Representative to review at a minimum the specification, paving operation QC Plan, sequence of paving operations, mixture acceptance, density acceptance and the care and custody of asphalt acceptance samples.

(b) Weather and Seasonal Limitations. Do not place any asphalt paving mixtures outside of the following dates, unless an extension of the paving season, as specified in Section 413.3(b)1, is granted in writing by the District Executive.

- For all PG 64E-22 wearing courses, >10 million ESALs wearing courses, 4.75 mm wearing courses, or other wearing courses placed at compacted depths less than 1.5 inches, paving may occur April 1 to October 15.
- For all other courses, paving may occur April 1 to October 31.

Do not place asphalt paving mixtures when surfaces are wet or when the air or surface temperature is 40F or lower. If work is halted because of weather conditions, the Representative may allow the Contractor to place limited quantities of mixture that are enroute to the project.

1. Paving Season Extensions. Submit requests in writing for paving outside of the dates listed in Section 413.3(b) at least 14 calendar days before performing any extended season paving operations. With the written request, submit an Extended-Season Paving Plan on Form CS-413ES that addresses quality control operations in detail. The plan must address steps at the plant and in the field to ensure that a quality product will be delivered and constructed. Do not commence paving during the extended-season until the Representative reviews the Extended-Season Paving Plan.

An extension of the paving season will be granted in writing by the District Executive with the following additional requirements:

- For all PG 64E-22 wearing and binder courses, >10 million ESALs wearing courses, 4.75 mm wearing courses, or other wearing courses placed at compacted depths less than 1.5 inches, paving may occur April 1 to November 15.
- For all other courses, paving may occur March 1 to December 15.
- Density acceptance will be by pavement cores, regardless of quantity, for mixtures placed at the minimum compacted depths in Table G. For pavements not meeting the requirements for pavement cores, density acceptance will be by optimum-rolling pattern. For non-RPS pavements, the Representative may waive the pavement core requirement at their sole discretion provided the contractor’s quality control efforts give confidence that optimum density has been achieved throughout the course.
- Utilize a Material Transfer Vehicle (MTV) as specified in Section 108.05(c)5 on any day when the paving length will exceed 1,500 linear feet, unless the Representative determines the MTV to be infeasible for the location.
- Use an approved asphalt JMF, according to the temperature restrictions specified in Section 413, Table A
- Do not ship material to the project until the Representative on the project releases the shipment.
- At least five days before extended-season paving, schedule an extended-season preplacement meeting with the Representative to review, at a minimum, the details of the Extended-Season Paving Plan.

- If the Representative determines that the Extended-Season Paving Plan is not being followed, stop paving operations, modify processes to comply with the Extended-Season Paving Plan, and communicate process modifications to the Representative. Do not resume paving operations until the Representative authorizes paving operations to continue.
- Within 24 hours of paving completion, provide Form CS-413EQC to the Representative with all documentation and measurements associated with the extended-season paving operations outlined in the Extended-Season Paving Plan. Payment will not be made until the documentation is received.
- Paving work completed during the fall portion of the Extended-Season will be subject to a spring evaluation and manual survey by the Department to be conducted by May 1. Manual surveys will be conducted according to Publication 336. The Department will evaluate the material and workmanship looking at characteristics of fatigue cracking, transverse and miscellaneous cracking, raveling/weathering, rutting, flushing, potholing, joint and edge deterioration, and loss of bond/delamination to determine acceptance or remedial action as outlined below:

Extended Season Paving Performance Requirements and Remedial Actions

Performance Criterion	Threshold Level	Remedial Action
Fatigue Cracking**	All low, medium or high severity*	Remove and replace as specified in Section 496, Table A
Transverse and Miscellaneous Cracking	All low to medium severity*	Crack seal as specified in Section 469
	All high severity*	Remove and replace as specified in Section 496, Table A
Raveling/Weathering	All medium or greater severity*	Remove and replace as specified in Section 496, Table A
Rutting	> ¼ inch	Remove and replace as specified in Section 496, Table A
Flushing	All	Remove and replace as specified in Section 496, Table A
Potholes, Loss of Bond, Delamination	All	Remove and replace as specified in Section 496, Table A for Potholes
Longitudinal Joint or Edge Joint Deterioration	All low severity*	Crack seal as specified in Section 469
	All medium or greater severity*	Remove and replace distressed layer full lane width on both sides transversely of the distressed area and a minimum of 24 inches beyond the distressed area in all longitudinal directions.

* The Threshold Level according to Publication 336.
** Fatigue cracking will only be considered in those portions of the pavement under which the contractor has performed base course placement operations

The Department will solely make the determination and notify the Contractor whether the work is accepted, or remedial action is required. The contractor may witness the manual performance survey. As specified in 413.3(o), the BOPD, CMD will review representative determinations of defective material or workmanship. Remove and replace or repair defective work as directed at no additional cost to the Department. Should the distance between repair areas be less than 100 feet, make one continuous repair. All repairs must meet the surface tolerance requirements as specified in Section 413.3(l).

- A Final Acceptance Certificate will not be issued for paving completed during the extended season until the spring evaluation and any repair work is completed.
- Any necessary changes to means, methods, or materials are at no additional cost to the Department. Complete all work by the Required Completion Date or Construction Engineering Liquidated Damages, as specified in Section 108.07(a), will apply. If repairs are required following the spring evaluation, liquidated damages will not be applied during the winter shutdown period on the project and will be applied during the repair and associated work period.

(c) Asphalt Mixing Plant. Obtain asphalt mixtures from a plant fully automated and recordated and currently listed in Bulletin 41. Make any plant modifications, if needed, to introduce the WMA Technology additives, modifiers, or processes according to specific recommendations and direction from the WMA Technology Technical Representative(s) or process manufacturer to achieve a uniform blend of the WMA Technology additive, modifier or foaming process. The necessary facilities for inspection include a plant office as specified in Section 714.5(a), except the minimum floor space is 120 square feet. For recycled mixtures, add the following requirements:

1. Batch Plant. Modify the batch plant to measure the mass (weight) of the RAP and/or RAS before adding it into the pug mill. Design the cold-feed bin(s), conveyor system(s), charging chute(s), and all special bins to prevent RAP and/or RAS from segregating and sticking. Dry the virgin aggregate and RAM and then heat the virgin aggregate and RAM to a temperature that, after adding RAP and/or RAS, produces a completed mixture within the temperatures specified in Table A for the class and type of material used. Dry the aggregate according to the specific recommendations and direction from the WMA Technology Technical Representative(s) and heat to a temperature so the resulting completed mixture temperature is within the mixture temperature recommended by the WMA Technology Technical Representative(s) or manufacturer and Table A. Ensure that the aggregate is free of unburned fuel oil and excess moisture as specified in Section 413.2(e) 1.d.1 when delivered to the pug mill.

2. Drum Mixer Plant. Modify the drum mixer plant to prevent RAP and/or RAS from directly contacting the burner flame and prevent RAP and/or RAS from overheating. Design the cold-feed bin(s), conveyor system(s), charging chute(s), and all special bins to prevent RAP and/or RAS from segregating and sticking. Produce a completed mixture that is within the mixture temperature range recommended by the WMA Technology Technical Representative(s) or manufacturer and Table A. Ensure that the aggregate and completed mixture is free of unburned fuel oil and excess moisture as specified in Section 413.2(e) 1.d.1.

(d) Hauling Equipment. Haul the mixtures in tightly sealed vehicles that do not contain petroleum oils, solvents, or other materials that adversely affect asphalt mixture. Provide covers of sufficient size and quality to protect the entire load under all conditions. Maintain the proper and uniform placement temperature as specified in Section 413.3(h)1. Provide insulation on all sides of the truck body, a double-walled truck body, or a heated truck body when the air temperature is below 50F from October 1 to April 30. Provide a 3/8 inch diameter hole near the center and approximately two-thirds the distance down from the top of the vehicular box, on both sides, to allow for asphalt mixture temperature checks.

(e) Paving Equipment

1. Asphalt Pavers. Provide self-contained, power-propelled units with activated screeds or activated strike-off assemblies and with automatic screed controls, capable of producing a finished surface of specified evenness and texture. Provide heated units capable of spreading and finishing the mixture to the widths and depths indicated. Provide units capable of being operated at forward speeds consistent with satisfactory placement of the mixture, equipped with receiving hoppers having sufficient capacity for uniform spreading, and equipped with distribution systems that place the mixture uniformly in front of the screeds.

Use hydraulic or other extension types against abutting lanes or longitudinal joints only if the unit feeds and activates the extension by the same method as the main screed. For fixed width paving operations on pavers where the screed is fed by augers, provide auger extensions to within 18 inches or less of the end gate. At the outside edge of pavement widths that cannot be uniformly placed, the Contractor may use a non-activated extension when approved by the Inspector-in-Charge.

Do not use equipment that tears, shoves, or gouges the mixture, or that causes tracks, indented areas, flushing, segregation, or other permanent blemishes. Do not use blade graders or drags.

2. Asphalt Wideners. Provide self-contained, power-propelled units with strike-off assemblies capable of producing a finished surface of specified evenness and texture. Provide units capable of spreading and finishing the mixture to the widths and depths indicated. Provide units capable of being operated at forward speeds consistent with satisfactory placement of the mixture, equipped with receiving hoppers having sufficient capacity for uniform spreading, and equipped with distribution systems that place the mixture uniformly in front of the strike-off assemblies.

Do not use equipment that tears, shoves, or gouges the mixture, or that causes tracks, indented areas, flushing, segregation, or other permanent blemishes.

(f) Rollers. Use steel-wheel, pneumatic-tire, vibratory, or oscillating rollers as specified in Section 108.05(c)3a, 3b, 3c, 3e, 3f, 3h, or 4. Operate rollers according to manufacturer's recommendations. Use vibratory and oscillating rollers with separate controls for frequency and amplitude.

(g) Preparation of Existing Surface.

1. Conditioning of Existing Surface. Before delivering asphalt mixtures, remove and dispose of loose and foreign material and excess joint sealer and crack filler from the surface of existing pavement or previously placed pavement courses. If necessary, use a broom.

Before placing a wearing course, correct irregularities in the binder course. If practical, do not allow traffic on the binder course to prevent contamination. Remove and replace binder course that cannot be cleaned to the Representative’s satisfaction.

Paint existing vertical surfaces of curbs, structures, gutters, and pavements that will be in contact with asphalt mixtures with a uniform coating of either emulsified asphalt, consisting of PennDOT Material Class TACK or NTT/CNTT and applied in two or more applications, or hot asphalt binder of the class and type designated for the asphalt course.

Before overlaying existing surfaces and previously placed courses, apply a tack coat as specified in Section 460 unless otherwise indicated.

2. Scratch and Leveling Courses. Where indicated, place a separate scratch or leveling course ahead of resurfacing operations. Use a scratch course to fill wheel ruts and other local small depressions even with the surrounding pavement. Use a leveling course to provide a relatively uniform working platform for placing binder or wearing courses.

3. Paving Notches. Mill the existing pavement surface at tie-in locations as shown on the Standard Drawings, or as otherwise indicated. Perform milling with equipment as specified in Section 491.3(a).

(h) Spreading and Finishing.

1. General Requirements.

1.a Placing. Unless otherwise allowed or indicated, deliver, place, and compact asphalt paving mixtures during daylight hours. Ensure the mixture does not contain lumps of cold material. Deliver and place mixtures at the laying temperatures specified in Table A for the type and class of material used. Do not incorporate any material delivered outside the temperature limits as specified in Table A

Utilize a Material Transfer Vehicle (MTV) as specified in Section 108.05(c)5 for RPS pavements unless otherwise approved by the Representative (See Section 101.01).

1.b Spreading and Finishing. Spread and strike off the mixture for the entire lane width or as much lane width as practical. Adjust screed assemblies to provide the required cross section and depth. After spreading, do not add mixture to the pavement mat that is segregated, below the minimum temperature, contains either a deficiency or an excess of asphalt content, or is otherwise unsuitable to add to the pavement mat.

If the course is more than 6 inches in compacted depth, construct it in two or more layers of approximately equal depth, with no layer less than 3 inches or more than 6 inches in compacted depth. For binder or leveling courses that have isolated areas exceeding 6-inch compacted depth, use a scratch or leveling course to eliminate the isolated areas before full-depth paving.

Immediately after placing the asphalt mixture, work the exposed outer edges to eliminate sharp, ragged, and open edges, to eliminate an unfinished appearance, and to reduce edge breakdown. Immediately repair edge breakdowns.

In areas where mechanical spreaders cannot be used, place and screed the mixture with suitable hand tools. Do not use rakes.

Adjacent to flush curbs, gutters, and other abutting structures, place the wearing course mixture uniformly higher so that after compaction the finished surface is slightly above the edge of the abutting structure. Remove harmful material, clean, and seal the surface of wearing courses adjacent to curbs to form an asphalt gutter. Seal the mixture surface with a hot asphalt material of the class and type listed in Table A. Evenly apply the asphalt material a minimum width of 12 inches from the curb. The Contractor may use emulsified asphalt, consisting of PennDOT

Material Class TACK or NTT/CNTT, instead of hot asphalt binder material if allowed by the Inspector-in-Charge. Control the application rate so residual asphalt completely fills surface voids and provides a watertight joint along the curb. If necessary, apply emulsified asphalt in two or more applications. After sealing, remove excess sealant material.

1.c Mixture Production, Delivery and Placing Temperatures When Placing Over Membrane Systems as Specified in Section 467 or Section 680. If a project includes an item or items of work for membrane systems, as specified in Section 467 or Section 680, produce and place asphalt mixture on top of the membrane at elevated mixture temperatures as per the membrane manufacturer's recommendation and within the Table A temperature requirements. Ensure proper adhesion between the asphalt pavement overlay and the underlying membrane.

1.d Field Technician. Provide a certified asphalt field technician, with the qualifications according to Publication 351, to control the placement of asphalt mixtures. Instruct and train the certified asphalt field technician to control the paving operation so that the completed paving work complies with the specified requirements. A certified asphalt field technician must be onsite and carry a valid certification card during placement of all asphalt mixtures.

1e. Safety Edge. Construct the Safety Edge as the standard edge treatment on the outside edge of asphalt pavements and shoulders. Use the Safety Edge for both wearing and binder courses with a depth of 1.5 inches or greater. Do not place the Safety Edge at total depths greater than 5 inches. The Safety Edge is not required where curb or sidewalk are encountered or where the face of guiderail is directly over the edge of pavements. Do not place the Safety Edge for base, leveling, or scratch courses.

Construct the Safety Edge with the same material used to construct the roadway course being placed or, if specified, the paved shoulders. Attach a device to the paver to confine material at the end gate and extrude the asphalt material in a wedge shape. Use an adjustable device that allows the operator to vary the slope extruded at the paver to account for the angle becoming steeper during compaction (roll up). Before construction, the Safety Edge device must be approved by the Representative(s) (See Section 101.01).

Compact the roadway or paved shoulder as required by the specifications. Do not delay rolling of the mat adjacent to the Safety Edge. After compaction of the mat is complete, provide a Safety Edge meeting the final shape requirements as shown on the Standard Drawings. The completed angle of the Safety Edge must be 26 to 40 degrees measured from the pavement cross slope extended. At the beginning of each days paving, measure the angle of the Safety Edge from the pavement cross slope extended. Perform measurements after final compaction is complete. If the angle of the Safety Edge does not meet the slope requirements, stop paving and provide corrective action. Do not resume production paving until final shape requirements of Safety Edge are achieved.

Allow automatic transition to intersections, driveways, guiderail sections, and obstructions.

Use the device to constrain the asphalt head, reducing the area and increasing the density of the extruded profile. A single plate strike-off method is not allowed. Do not place the Safety Edge on organic material.

2. Mixture Lot Acceptance (Standard and RPS Construction). Lot acceptance is appropriate for standard construction placed in quantities that allow consistent operation of the plant and is appropriate for RPS construction.

2.a Lots and Sublots. Material will be accepted in the field on a lot by lot basis. Lots will be established cumulatively and will be specific for each JMF. Once the sublot size for each specific JMF has been established based on the project's plan quantity, the sublot size will remain unchanged throughout project completion. A completed sublot has a mixture acceptance box sample as specified in Section 413.3(h)2.b and either a core collected according to PTM No. 1 and PTM No. 729, or other density acceptance as specified in Section 413.3(j).

For JMFs placed in quantities of 2,500 tons or greater, a normal lot size is 2,500 tons with five, 500 ton sublot s (n=5), unless operational conditions or project size dictate otherwise. If operational conditions or project size dictate, readjustment of the lot will be made as specified in Table D. Breakdowns or stoppages of short periods due to such causes as weather or equipment failure will not be considered as reasons to adjust the lot size. The original lot will be continued when work resumes after short stoppages of less than 5 calendar days. If a lot is ended due to a stoppage of 5 calendar days or more, adjust the lot size and number of sublots as specified in Table D. If the work stoppage is 5 calendar days or more, a new lot will be established.

To terminate a lot without a work stoppage of 5 calendar days or more, stop paving operations and notify the Inspector-in-Charge in writing of the lot termination and include the reason for termination. Do not begin paving again until the Inspector-in-Charge authorizes paving activities to resume. If a lot is terminated when quantities exceed a normal size lot of 2,500 tons, the work will be considered two separate lots, a normal size lot and a terminated lot.

The terminated lot will be only that portion of the work which exceeds the 2,500 ton normal sized lot up to the point the paving operations were stopped.

A terminated lot will be evaluated based on the samples obtained before the lot was terminated. For terminated lots with three or more sublots, acceptance will be determined using PWL pay factor adjustments. Terminated lots with two or fewer sublots will be evaluated as specified in Section 413.3(h) 2.a.1. For terminated lots where density acceptance is by pavement cores, if the first randomly selected coring location was not yet reached at the time the lot was terminated, the Inspector will recalculate one new sample location according to PTM No. 1, PTM No. 729, and PTM No. 746 from the pavement placed.

The payment for any terminated lot the Contractor elects to terminate will be 95% of the contract unit price or the payment value determined by evaluating the samples tested, whichever is less. Remove and replace terminated lot pavements when test results indicate defective work. The District Executive will not consider requests for reduced payment on terminated lots when test results indicate defective work.

TABLE D
Re-adjustment of Lot Size and Associated Number of Sublots

Remaining Quantity* Following Last Full Lot	Action
Less than 500 tons without a combination of one mixture acceptance sample and one core**	Quantity combined with the previous lot, (n=5)
Less than 500 tons with a combination of one mixture acceptance sample and one core**	One new sublot defined and quantity combined with the previous lot, (n=6)
500 tons to less than 1,000 tons without a combination of two mixture acceptance samples and two cores**	One new sublot defined and quantity combined with the previous lot, (n=6)
500 tons to less than 1,000 tons with a combination of two mixture acceptance samples and two cores**	Two new sublots defined and quantity combined with the previous lot, (n=7)
1,000 tons to less than 1,500 tons without a combination of three mixture acceptance samples and three cores**	Two new sublots defined and quantity combined with the previous lot, (n=7)
1,000 tons to less than 1,500 tons with a combination of three mixture acceptance samples and three cores**	New lot defined, (n=3)
1,500 tons to less than 2,000 tons without a combination of four mixture acceptance samples and four cores**	New lot defined, (n=3)
1,500 tons to less than 2,000 tons with a combination of four mixture acceptance samples and four cores**	New lot defined, (n=4)
2,000 tons to less than 2,500 tons without a combination of five mixture acceptance samples and five cores**	New lot defined, (n=4)
2,000 tons to less than 2,500 tons with a combination of five mixture acceptance samples and five cores**	New lot defined, (n=5)
*For contract items bid on an area basis, compute equivalent tons based on design depth of paving course and design density as specified in Section 110.04(b)4.b. ** If mat density is accepted using pavement cores and mixture acceptance is by lots.	

2.a.1 Partially Completed Lots (n=2 or less). When process conditions change to an extent that a partially completed lot cannot be combined with the most recently completed lot, samples will be independently evaluated on the partially completed lot. For asphalt content and percent passing the 75 μm (No. 200) sieve, mixture acceptance samples will be evaluated individually as specified in Section 413.2(e), Table A (n=1) criteria. For density, mat density acceptance samples will be evaluated individually using the criteria in Table E.

If samples tested for asphalt content and percent passing the 75 μm (No. 200) sieve meet the n=1 criteria of Table A, and samples tested for density meet the criteria in Table E, payment will be 100% of the contract unit price. If samples tested for asphalt content and percent passing the 75 μm (No. 200) sieve do not meet the n=1 criteria of Table A, the material will be considered defective work. If samples tested for density are no more than 2.0% below the minimum or no more than 2.0% above the maximum limits of Table E, payment will be 90% of the contract unit price. If samples for density are more than 2.0% below the minimum or more than 2.0% above the maximum limits of Table E, the pavement will be considered defective work.

Unless otherwise directed in writing by the District Executive, remove and replace defective work.

TABLE E
Density Limits for Partially Completed Lots

MIXTURE NMAS	DENSITY LIMITS
All RPS 9.5 mm, 12.5 mm, 19 mm, and 25 mm Wearing or Binder Courses	≥ 92.0% and ≤ 98.0%
All Standard 9.5 mm, 12.5 mm, 19 mm, and 25 mm Wearing or Binder Courses	≥ 91.0% and ≤ 98.0%
All 25 mm and 37.5 mm Base Courses	≥ 90.0% and < 100.0%

2.a.2 For JMF's placed in quantities less than 2,500 tons. For JMFs placed in quantities of greater than 500 tons and less than 2,500 tons, the tonnage will be considered a lot. The lot will be divided into five equal sublots.

For JMFs placed in quantities of 500 tons or less, mixture acceptance will not be applicable for PWL pay factor adjustments and will be accepted by certification. If density acceptance is by pavement cores, the tonnage will be considered a lot and the lot will be divided into three equal sublots. Density acceptance will be determined using PWL pay factor adjustments.

2.b Mixture Acceptance Samples. The Representative will select different sample locations in each sublot according to PTM No. 1 and PTM No. 746. In the presence of the Inspector, obtain one loose mixture sample for each sublot directly from the uncompacted mixture placed by the paving equipment specified in Section 413.3(e) and immediately package. For 19 mm and smaller NMAS mixtures, package individual samples in cardboard boxes dimensioned approximately 3 3/4 inches x 4 3/4 inches x 9 1/2 inches. For 25 mm and larger NMAS mixtures, package individual samples in cardboard boxes dimensioned approximately 5 inches x 5 1/2 inches x 9 inches. Do not package samples in cardboard boxes with any one dimension greater than 10 1/4 inches or any one dimension smaller than 3 1/2 inches.

Immediately after packaging and in the presence of the Representative, identify the samples by ECMS project number, lot and sublot number, location (station and offset), date of placement, mixture type, and as acceptance samples (Sample Class AS). Leave at least one side of the cardboard sample box free of any writing or marking for LTS use in testing the samples.

Immediately after identifying, submit the samples to the Representative.

For quality control purposes, a maximum of one loose sample per sublot may be obtained. No loose mixture or core samples may be taken by the Contractor for mixture composition testing after the mixture acceptance samples are obtained. Do not obtain any other pavement samples, except those which are directed by and surrendered to the Department, unless allowed in writing from the District Executive.

The Contractor may elect to expedite delivery of the acceptance samples to the LTS at no additional cost to the Department. If the delivery is expedited, the Inspector will secure all containers with Department issued, uniquely numbered security tape. The Inspector will record the information from the security tape onto Form TR-447 which will be packaged inside the secured container and return the secured containers to the Contractor for transport to the LTS.

The Contractor may transport the secured samples to the LTS or utilize a third-party shipping service. If the Contractor elects to utilize a third-party shipping service, the service must provide the ability to track package delivery.

Provide all expedited delivery details in the QC Plan and discuss expedited delivery details at the preconstruction and pre-paving meetings. For expedited delivery, provide all containers, cushioning material, and packaging supplies to the Inspector. The Inspector will package all samples in the provided containers and secure the samples prior to surrendering the secured containers to the Contractor.

Upon arrival at the LTS, the secured containers will be visually examined for evidence that the tape has not been compromised and the unique numbers will be compared between the security tape and the value recorded on Form TR-447 inside the container. If sample security has not been compromised, samples received under expedited delivery will be tested on a priority basis. If the containers show any signs of compromised security, the following conditions apply:

- Obtain replacement samples as directed within 12 inches longitudinally of the original samples.
- Immediately stop expedited delivery and all samples will be delivered to the Inspector for transport.
- Conduct an investigation to determine the cause of the compromised security and provide a written explanation to the Representative.

- Do not resume expedited delivery until the Representative has reviewed the written explanation and is satisfied that proper steps have been taken to address the issue. The Department reserves the right to terminate expedited delivery after the first occurrence of compromised sample security.

2.b.1 Theoretical Maximum Specific Gravity (Gmm) Verification Samples. For federally funded projects or projects on the National Highway System, when density acceptance is by pavement cores, obtain a second loose mixture sample as specified in Section 413.3(h)2.b in each sublot at the same location as the mixture acceptance sample and immediately package in cardboard boxes sized as specified in Section 413.3(h)2.b. The second loose mixture sample at each location will be used to determine the theoretical maximum specific gravity (Gmm) and corresponding theoretical maximum density (lbs/ft^3) values for each sublot.

Immediately after packaging and in the presence of the Inspector, identify the sample by ECMS project number, lot and sublot number, location (station and offset), date of placement, mixture type, and as Gmm verification samples (Sample Class FV). Leave at least one side of the cardboard sample box free of any writing or marking for LTS use in testing the samples.

2.c Mixture Acceptance and Gmm Verification Sample Testing. Utilize LTS Testing unless otherwise indicated in the proposal. These procedures apply to standard and RPS construction.

2.c.1 LTS Testing. The LTS will test the mixture acceptance samples according to PTM No. 757 or PTM No. 702, Modified Method D and PTM No. 739, if previously identified problematic aggregates are used in the mixture, to determine asphalt content and the percent passing the 75 µm (No. 200) sieve. The LTS will use the calibration factors (C_f and 200 C_f) provided with the JMF for PTM No. 757. For individual increment test results outside of the single sample (n=1) tolerances in Table A, the LTS will analyze the test results for extreme values according to PTM No. 4 at the 5% significance level. If discarding an extreme value reduces a lot to less than three remaining test results, the Department will accept the lot as specified in Section 413.3(h)2.a.1. The Department will accept lots with three or more test results as specified in Section 413.4(a)4 or Section 413.4(b).

If the asphalt content or the percent passing the 75 µm (No. 200) sieve is not within the single sample (n=1) or multiple sample (n≥3) tolerances in Table A for two consecutive lots or a total of three lots, stop all production of the JMF. Determine the cause of the problem and provide a proposed solution to the Department.

Do not resume production of the JMF until the Representative reviews the proposed solution and authorizes production to continue.

The LTS will test Gmm verification samples as specified in Section 413.3(j)4.d

3. Pattern Segregation. Pattern segregation is continuous or repeated areas of non-uniform distribution of coarse and fine aggregate particles in the finished mat. The Department will address pattern segregation as follows:

3.a Evaluating Pattern Segregation. If the Representative observes pattern segregation that may result in defective pavement, then:

- The Inspector will notify the Contractor of the observed pattern segregation.
- The Contractor may continue to work at their own risk while immediately and continually adjusting the operation to eliminate the pattern segregation from future work.
- As a minimum and in the presence of the Representative, determine the average depth of pavement surface macrotexture according to PTM No. 751 in areas with the pattern segregation and in areas with non-segregated pavement. The pattern segregation is unacceptable if the difference in average pavement texture depth between the non-segregated and segregated areas exceeds 0.024 inch. The Representative will determine if the pavement is defective as specified in Section 413.3(h)3.c.

3.b Test Section. If the macrotexture tests identify unacceptable pattern segregation, then:

- Immediately suspend placing the asphalt course. Evaluate the cause of pattern segregation according to the Paving Operation QC Plan and as directed. Provide proposed corrective actions to the Representative and do not resume placing the asphalt course until after the Representative reviews the proposed corrective actions and authorizes paving to continue.

- Determine if the pattern segregation resulted in defective pavement as specified in Section 413.3(h)3.c.

- After the Representative allows paving to resume, place a test section not to exceed 200 tons. If the corrective actions do not eliminate observed pattern segregation, the Department will suspend paving, even if it is before the Contractor places the entire test section. Propose additional corrective actions and construct another test section. Resume normal paving operations after constructing an entire test section without pattern segregation as determined by the Representative.

3.c Defective Pavement. At locations selected by the Inspector and with the Inspector present, drill a minimum of three 6-inch diameter cores from the area of pattern segregation and a minimum of three cores from the pavement representing a non-segregated area. Do not compress, bend, or distort samples during cutting and handling and immediately provide the cores to the Inspector. The Inspector will transport cores to the producer's laboratory. With the Inspector present, test the cores at the plant for density, asphalt content, and gradation. The Department may request additional tests as part of its evaluation of pattern segregation. Determine the maximum theoretical density according to Bulletin 27, the core density according to PTM No. 715, and asphalt content according to PTM No. 757 if previously identified problematic aggregates are used in the mixture, PTM No. 702 modified Method D, and PTM No. 739 or other test method identified in the producer QC Plan.

An area of pattern segregation contains defective pavement if the summation of absolute deviations from any two sieves is 20% or more from the JMF, the core density is defective, the mixture is defective in asphalt content, or the mixture is defective for percent passing the 75 µm (No. 200) sieve. Remove and replace the full width of the affected lane and a minimum of 5 feet beyond each end of the area with unacceptable pattern segregation. Construct replacement pavement conforming to the appropriate surface tolerances as specified in Section 313.3(l) or Section 413.3(l).

4. Flushing. Provide a mix that will not flush. Flushing is continuous or repeated areas of excessive asphalt on the pavement surface. The Department may recognize flushing until the Department approves the project through final inspection. The Department will address flushing as follows:

4.a Evaluating Flushing. When the Representative observes flushing, then:

- The Representative will immediately notify the Contractor of the observed flushing.

- The Contractor may continue work at their own risk while immediately and continually adjusting the operation to eliminate flushing from future work.

- In the presence of the Representative, determine the average depth of pavement surface macrotexture according to PTM No. 751 in areas of suspected flushing. If the average texture depth is less than or equal to 0.006 inches, then the pavement will be considered to be flushed and is defective.

4.b Test Section. If the macrotexture tests identify flushing, then:

- Immediately suspend placing the paving course. Evaluate the cause of flushing according to the Paving Operation QC Plan and as directed. Provide proposed corrective actions to the Representative and do not resume placing the paving course until after the Representative reviews the proposed corrective actions and authorizes paving to continue.

- Remove and replace the defective wearing course at no additional cost to the Department for the full width of the affected lane and a minimum of 5 feet beyond each end of the area of defective wearing course. Construct replacement wearing course conforming to the appropriate surface tolerances as specified in Section 413.3(l).

- After the Representative allows paving to resume, place a test section not to exceed 200 tons. If the corrective actions do not eliminate observed flushing, the Department will suspend paving even if it is before the Contractor places the entire test section. Propose additional corrective actions and construct another test section. Resume normal paving operations after constructing an entire test section without flushing as determined by the Representative.

(i) Compaction. Compact the mixture to achieve the density acceptance requirements and to eliminate all roller marks. Compact the mixture while it is in proper condition and adjust roller speed, amplitude, frequency, pattern, and roller size to eliminate displacement, shoving, cracking, and aggregate breakage. Satisfactorily correct displacement resulting from reversing roller directions and other causes.

Without using excess water, maintain wheels of steel-wheel rollers moist and clean to prevent the mixture from adhering to the wheels. Use suitable methods to clean wheels of pneumatic-tire rollers.

Use pneumatic-tire rollers for compacting scratch courses.

For areas inaccessible to rollers, compact with mechanical vibrating hand tampers.

Remove areas that are loose, broken, mixed with dirt, or show an excess or deficiency of asphalt material. Replace removed mixture with fresh hot mixture and compact the mixture even with the surrounding pavement surface.

(j) Mat Density Acceptance.

1. General. The Department will accept the mat density of standard construction according to one of the levels in Table F. Areas may be accepted by non-movement or optimum-rolling pattern based on the criteria in Sections 413.3(j)2 and 413.3(j)3. Do not place mixtures for non-movement or optimum-rolling pattern acceptance until the Department has approved the density-acceptance level.

The Department will accept the mat density of RPS construction by lots and pavement cores as specified in Section 413.3(j)4. The Department will accept mat density of all 4.75 mm NMAS asphalt mixtures by non-movement or optimum-rolling pattern.

TABLE F
Density Acceptance

Density Acceptance Level	Acceptance Criteria
Non-Movement	Table H
Optimum-Rolling Pattern	Table H
Pavement Cores	Table I

2. Non-Movement. The Inspector-in-Charge will approve density acceptance by non-movement for the following materials, conditions, or applications:

- Scratch courses or leveling courses less than 1-inch in depth or equal to or less than 110 pounds per square yard.
- Areas of paving or patching less than 4 feet in width or narrow enough to cause bridging of the area by approved compaction equipment.

The Inspector-in-Charge will accept density by non-movement for the following materials, conditions, or applications if they are determined by the Representative to be non-critical for density:

- Materials placed in small quantities not exceeding 500 tons in a continuous placement.
- Mixtures placed on unstable or non-uniform bases.
- Mixtures used for patching, road widening, shoulders, driveway adjustments, parking lots, and other miscellaneous applications determined by the Representative. Shoulders where density is critical will be accepted by pavement cores as specified in Section 413.3(j)4.a.

The Department will accept the density when the mixture does not move under the compaction equipment.

3. Optimum-Rolling Pattern. The Inspector-in-Charge may accept density using an optimum-rolling pattern for the following materials, conditions, or applications:

- Materials placed in small quantities not exceeding 500 tons in a continuous placement.

- Mixtures placed on unstable or non-uniform bases.

- Leveling courses or other courses that are greater than or equal to 1-inch in depth or greater than or equal to 110 pounds per square yard.

- Mixtures used for patching, road widening, driveway adjustments, parking lots, shoulders where density is not critical, and other miscellaneous applications determined by the Representative. Shoulders where density is critical will be accepted by pavement cores as specified in Section 413.3(j)4.a.

- Mixtures placed at less than the minimum compacted depths in Table G.

With the Representative and the Contractor's certified asphalt field technician present, determine density with an approved nuclear gauge according to PTM No. 402, or determine density with an approved electrical impedance gauge according to PTM No. 403. Nuclear gauges must be operated by a licensed nuclear gauge operator. In the presence of the Representative, establish the optimum-rolling pattern for each course according to PTM No. 402 or PTM No. 403. Document optimum-rolling patterns using the appropriate Form TR-4276B or Form TR-4276C and provide the completed forms to the Representative. Compact the course according to the optimum-rolling pattern. During paving, the Representative may require the Contractor to verify the target density established by the optimum-rolling pattern. If the target density is not achieved, establish a new optimum-rolling pattern as directed. The Representative will suspend paving when the optimum-rolling pattern is not being followed.

Use one of the following gauges or approved equal:

- Troxler Electronics, Model 3411B or Model 4640B
- Campbell Pacific Nuclear, Model MC-2
- Seaman Nuclear, Model MC-2
- TransTech Systems, Inc., PQI™, Model 300 or Model 301
- Troxler Electronic Laboratories, PaveTracker™

Submit a copy of the certificate of nuclear gauge annual calibration according to ASTM D2950 and documentation of training of the nuclear gauge operator. Recalibrate any nuclear gauge that is damaged or repaired.

4. Pavement Cores (Standard and RPS Construction).

4.a General. Pavement cores are required for accepting the density of RPS construction. Pavement cores are required for standard construction of extended-season paving, unless waived by the Representative as specified in Section 413.3(b)1. Pavement cores are appropriate for accepting the density of standard construction if all of the following materials, conditions, or applications exist:

- Materials placed at compacted depths greater than or equal to the minimum depths specified in Table G.

- Materials placed on stable and uniform bases.

TABLE G
Mixture Minimum Compacted Depths

Mixture	Minimum Depth
9.5 mm Wearing Course	1 1/2 in.
12.5 mm Wearing Course	2 in.
19 mm Binder Course	2 1/2 in.
25 mm Binder Course	3 in.

4.b Lots and Sublots. Section 413.3(h)2.a.

4.c Density Acceptance Samples. The Inspector will select different sample locations in each sublot according to PTM No. 1, PTM No. 729, and PTM No. 746. With the Inspector present, drill 6-inch diameter cores as soon as possible but no later than the day following placement. The core at each location will be used to determine the bulk specific gravity (Gmb) and density (lbs/ft^3) of the compacted mix. Do not compress, bend, or distort samples during cutting, handling, transporting, and storing. If samples are damaged, immediately obtain replacement samples, as directed by the Inspector, from within 12 inches of the original sample location. Within 24 hours after coring, backfill the hole with mixture of the same JMF or with mixture used for subsequent courses and compact and seal the mixture.

In the presence of the Inspector, identify the samples by ECMS project number, lot and sublot number, location (station and offset), date of placement, mixture type, and as acceptance samples (Sample Class AS). Provide the daily theoretical maximum specific gravity value as specified in Section 413.2(e) 1.d.4 for the density calculation of each sublot in the lot. If density samples from the lot are taken from more than 1 day's placement, the daily theoretical maximum specific gravity values from each production day will be used to calculate the percent of theoretical density for each individual density acceptance core placed on that production day upon Gmm verification as specified in Section 413.3(j)4.d.1. Immediately deliver the samples to the Inspector and provide sample containers of sufficient strength to prevent samples from being damaged during transport. The Representative will submit samples for one lot in one container.

For quality control purposes, a maximum of one pavement core per sublot may be obtained unless the Representative allows additional cores. No cores may be taken by the Contractor after the acceptance cores are obtained. Do not obtain any other pavement cores, except those which are directed by and surrendered to the Department, unless allowed in writing by the District Executive.

The Contractor may expedite delivery of the acceptance samples to the LTS at no additional cost to the Department. If the delivery is expedited, the Inspector will secure all containers with Department issued, uniquely numbered security tape. The Inspector will record the information from the security tape onto Form TR-447 which will be packaged inside the secured container and return the secured containers to the Contractor for transport to the LTS.

The Contactor may transport the secured samples to the LTS or utilize a third-party shipping service. If the Contractor elects to utilize a third-party shipping service, the service must provide the ability to track package delivery.

Provide all expedited delivery details in the Paving Operation QC Plan and discuss expedited delivery details at the preconstruction and pre-paving meetings. For expedited delivery, provide all containers, cushioning material, and packaging supplies to the Inspector. The Inspector will package all samples in the provided containers and secure the samples prior to surrendering the secured containers to the Contractor.

Upon arrival at the LTS, the secured containers will be visually examined for evidence that the security tape has not been compromised and the unique numbers will be compared between the security tape and the value recorded on Form TR-447 inside the container. If sample security has not been compromised, samples received under expedited delivery will be tested on a priority basis. If the containers show any signs of compromised security, the following conditions apply:

- Obtain replacement samples as directed within 12 inches longitudinally of the original samples.
- Immediately stop expedited delivery and all samples will be delivered to the Inspector for transport.
- Conduct an investigation to determine the cause of the compromised security and provide a written explanation to the Representative.
- Do not resume expedited delivery until the Representative has reviewed the written explanation and is satisfied that proper steps have been taken to address the issue. The Department reserves the right to terminate expedited delivery after the first occurrence of compromised sample security.

4.d Acceptance and Gmm Verification Sample Testing. These procedures apply to standard and RPS construction.

4.d.1 LTS Acceptance and Gmm Verification Testing. The LTS will test each density acceptance sample according to PTM No. 715, and if necessary PTM No. 716, to determine the bulk specific gravity (Gmb) and bulk density (lbs/ft^3) of the compacted mixture. For individual increment test results outside of the lower and upper specification limits in Table I, the LTS will analyze the bulk density test results for extreme values according to PTM No. 4 at the 5% significance level. If discarding an extreme value reduces a lot to less than three remaining test results, the Department will accept the lot as specified in Section 413.3(h)2.a.1. The Department will accept lots with three or more test results as specified in Section 413.4(a)4 or Section 413.4(b)

For lots with no required Gmm verification loose mixture samples, the Contractor's daily theoretical maximum specific gravity values from each production day will be used for acceptance.

For lots with required Gmm verification loose mixture samples, the LTS will randomly select one of the Gmm verification loose mixture samples obtained as specified in Section 413.3(h)2.b.1 from the lot according to PTM No. 1. The LTS will test the randomly selected Gmm verification loose mixture sample to determine the theoretical maximum specific gravity (Gmm) of the compacted mixture according to AASHTO T 209 as modified in Bulletin 27, with the following exception:

- The samples will be obtained as specified in Section 413.3(h) 2.b.1.

The LTS will compare the randomly selected Gmm verification sample test result with the Contractor's daily Gmm value for that same production or placement date. If the LTS and Contractor Gmm values do not differ by more than ± 0.030, the Contractor's daily Gmm values in the whole lot will be considered verified and the Contractor's daily Gmm values will be used to determine the percent of theoretical maximum density for each density acceptance sample placed on that date. If the initial randomly selected LTS Gmm verification sample test result differs from the Contractor's daily Gmm value for that same production or placement date by more than ± 0.030, the LTS Gmm test result value will be used as the acceptance Gmm value to determine the percent of theoretical maximum density for the individual density acceptance cores produced or placed on that same date. The Department reserves the right to select more than one Gmm verification sample from the lot representing the same production or placement date and to select other Gmm verification samples from the lot representing different production or placement dates to verify the Contractor's daily Gmm values. When more than one Gmm verification sample is selected from the lot representing the same production or placement date, the LTS Gmm test results will be averaged and the average will be used to verify the Contractor's daily Gmm value for that same production or placement date.

Individual sublot density values will be calculated and then rounded to the nearest tenth of a percent of theoretical maximum density according to ASTM E 29. Lot average density will subsequently be calculated from the individual sublot values and then rounded to the nearest tenth of a percent theoretical maximum density according to ASTM E 29. The Department will determine acceptance, with respect to density, as specified in Section 413.4(a)4 or Section 413.4(b).

If cores are not taken within 1 day after placing the mixture, or if the density for two consecutive lots or for a total of three lots does not meet the density payment factor percentage of ≥100, stop paving operations for the project as directed. Review and evaluate the operation and determine the cause of the problem. Do not resume paving until after the Representative reviews the proposed solution and authorizes paving to continue.

(k) Joints.

1. Longitudinal Joints.

1.a General. Offset joints in a layer from the joint in the layer immediately below by approximately 6 inches. Plan joint locations to ensure that the joint in the top layer is at the approximate pavement centerline for two-lane roadways and within 12 inches of the lane lines for roadways with more than two lanes. Avoid joint locations directly beneath planned pavement marking applications where possible.

Before placing abutting lanes, paint the entire area of the joint with a uniform coating of asphalt material, the PG-Binder used in the pavement course or PG 64S-22. Painting of the joint face is not required for scratch courses.

Place and compact the mixture at the joint according to the Paving Operation QC Plan. Ensure the surface across the joint and along the joint is within the surface tolerances specified in Section 413.3(l).

Adhere to the following additional requirements for the construction of longitudinal joints that will not be evaluated as specified in Section 405:

- Assure a true line when paving. Place and closely follow lines or markings for this purpose. When compacting loose mixture at an unsupported edge, make the first roller pass with the edge of the roller drum extending beyond and overhanging the unsupported edge by 3 to 6 inches. Do not allow pneumatic-tire rollers to cause lateral movement at any unsupported edge.
- When placing uncompacted mixture adjacent to a previously compacted lane, operate the paver so that the material overlaps the edge of the previously placed lane by 1 to 1 1/2 inches. Ensure that mixture behind the screed is tightly pushed against the free face of the existing lane. Maintain the uncompacted mixture uniformly higher than the existing lane by at least 1/4 inch per inch of material being placed to assure full compaction. When possible, use automated joint matchers when constructing joints between traveled lanes. Do not bump back or lute the overlapped material unless overlap inadvertently exceeds the specified tolerances. When compacting the loose mix at the longitudinal joint, keep the roller drum approximately 18 inches from the joint for the first pass forward, avoiding the roller edge of the drum operating directly above the bottom edge of any underlying notched wedge joint. On the backward and subsequent passes, overlap the joint 2 to 6 inches. Ensure that the joint receives at least as many roller passes as the rest of the mat.
- If traffic or other cause distorts the lane edge, restore the lane edge to its original shape, using acceptable procedures.

Seal all longitudinal joint(s) for surface courses with hot PG 64S-22 asphalt binder at no additional cost to the Department. Heat and maintain asphalt binder sealant between 265F and 320F. Do not place sealant when the air temperature is below 40F, unless permitted by the Representative. Apply the sealant only to joints in pavement surfaces that are clean, dry and free of any loose material and debris. Clean with a power broom as required. Utilize a pressure applicator with a wand or nozzle capable of applying hot asphalt sealant in a straight and consistent width band of 4 inches +/-1 inch and thickness of 1/16 inch +/- 1/32 inch. Center the sealant band within 1 inch of the joint. Remove and dispose of excess sealant at no additional cost to the Department. Reseal areas of the joint that are inconsistently or not completely covered at no additional cost to the Department. Replace pavement markings that are marred by sealing operations at no additional cost to the Department.

1.b Vertical Joints.

- The Contractor may use vertical joints for base, binder, and wearing courses.
- If traffic or other cause distorts the lane edge, carefully saw a vertical lane edge before painting.
- Place the abutting lane on the same day, and if necessary, leave only short lane sections, normally less than 25 feet in length, where the abutting lane is not placed the same day.

1.c Notched Wedge Joints.

- The Contractor may use notched wedge joints for wearing and binder courses with NMAS mixtures of 19.0 mm or smaller.
- Remove and dispose of all loose and foreign material before opening the lane to traffic.
- Construct the joint as shown on the Standard Drawing.
- If the joint is next to opposing traffic, place the abutting asphalt mixture within 1 working day after placing the mixture. If the joint is next to traffic in the same direction, place the abutting asphalt mixture within 2 working days after placing the mixture.
- If both lanes that make the joint are not placed on the same day, amend the Maintenance and Protection of Traffic Plan and install additional signing for uneven lane at no additional cost to the Department. Install "Uneven Lane" signs according to Publication 212, Publication 213, and

MUTCD and 1/2-mile before the notched wedge joint area and every 1/2-mile within the uneven pavement area.

2. Transverse Joints. Construct joints perpendicular to the pavement centerline. The Contractor may saw transverse joints. If used, install bulkheads straight and perpendicular to the surface. If a bulkhead is not used and the roller moves over the rounded edge of new mixture, locate the joint a sufficient distance from the rounded edge to provide a true surface and cross section. Paint the joint face with a thin coating of asphalt material, the PG-Binder used in the pavement course or PG 64S-22, before placing fresh mixture against the joint face. Painting of the joint face is not required for scratch courses.

3. Other Joints. Where placing a wearing course abutting to existing pavement at locations such as paving notches, lane additions, or utility openings, seal the joint with hot asphalt material of the class and type designated for the wearing course. Evenly apply the sealant a minimum of 6 inches on both sides of the joint. The Contractor may use emulsified asphalt, consisting of PennDOT Material Class TACK or NTT/CNTT, instead of hot asphalt material. Before sealing, clean and remove harmful material from the area to be sealed. Control the application rate so residual asphalt completely fills surface voids and provides a watertight joint. If necessary, use two or more applications of emulsified asphalt. Remove excess asphalt material and immediately cover the sealed area with a light application of dry sand that is acceptable to the Representative.

(l) Surface Tolerance. Test the finished surface with a 12-foot straightedge at areas the Representative determines may be deficient or irregular, and at transverse joints (including bridge decks and pavement transition) and paving notches. Hold the straightedge in contact with the surface and in successive positions parallel to the road centerline to check the entire width of the pavement. Advance along the pavement in stages of not more than one-half the length of the straightedge until the entire area is tested. The pavement is defective if irregularities are more than 3/16 inch.

(m) Tests for Depth: Binder and Wearing Courses. Construct the pavement to the depth indicated and within the specified tolerances.

For courses with density acceptance by lots, the Inspector will measure the depth of each sublot according to PTM No. 737 using the density acceptance samples.

For courses with a designed course depth and density acceptance by non-movement or optimum rolling pattern, the Inspector will calculate the mass per square meter (weight per square yard) for verification of yield. If yield results indicate insufficient course depth, drill one 6 inch diameter core for each 500 tons of material placed to determine the extent of the deficient depth. Core locations will be determined according to PTM No. 1. For courses with density acceptance by lots, the inspector will measure the depth of each sublot according to PTM No. 737 using density acceptance samples.

Pavement deficient in depth by more than 1/4 inch is defective work. Pavement deficient in depth by more than 1/8 inch in three or more adjacent core locations is defective work. The extent of the defective work is the entirety of all sublots represented by the adjacent deficient core samples. After the Inspector completes depth measurements, backfill, compact, and seal core holes with the mixture used to construct the course. Immediately start correcting courses or pavement that are deficient in depth at the core location and proceed longitudinally and transversely until the depth is within 1/4 inch of the design depth.

(n) Protection of Courses. Do not allow vehicular traffic or loads on newly compacted courses for 24 hours or until the course uniformly cools to a temperature of 140F or less. Provide alternate routes as indicated or as directed. If both lanes that form a longitudinal joint are placed on the same day and public safety is not restricted, do not allow vehicular traffic or loads on the lanes until adequate stability and adhesion is obtained and the material has uniformly cooled to 140F or less. Maintain the course, as specified in Sections 105.13, 107.15, and 901.

(o) Defective Work. As specified in Section 105.12 and as follows:

Department acceptance and QA testing shall not relieve the Contractor of responsibility for material or workmanship that the Representative determines is defective before the Department issues the acceptance certificate. Remove and replace or repair defective work as directed. The BOPD, CMD will review Representative determinations of defective material or workmanship.

Remove and replace pavement defective for pattern segregation as specified in Section 413.3(h)3, for flushing as specified in Section 413.3(h)4, surface tolerance as specified in Section 413.3(l) or Section 313.3(l) and depth as specified in Section 413.3(m), or Section 313.3(m). Remove and replace pavement defective for percent within limits or Payment Factor Percentages as specified in Tables H and I.

413.4 MEASUREMENT AND PAYMENT—

(a) Standard Asphalt Construction.

1. Asphalt Courses.

1.a Superpave Asphalt Mixture Design, Asphalt Wearing Course. Square Yard or Ton

1.b Superpave Asphalt Mixture Design, Asphalt Wearing Course (Scratch). Ton

1.c Superpave Asphalt Mixture Design, Asphalt Wearing Course (Leveling). Ton

1.d Superpave Asphalt Mixture Design, Asphalt Binder Course. Square Yard or Ton

1.e Superpave Asphalt Mixture Design, Asphalt Binder Course (Leveling). Ton

2. Asphalt Tack Coat. Section 460.4.

3. Mixture Acceptance by Certification and Density Acceptance by Non-Movement, Optimum-Rolling Pattern, or Pavement Cores. The Representative will pay at the contract unit price, adjusted according to Table H. The total payment factor percentage for pavements with density acceptance other than by pavement cores is the sum of adjustments for each test criterion subtracted from 100%. The adjustment for an individual test criterion is the payment factor percentage subtracted from 100%. The pavement will be considered defective if the payment factor for asphalt content, percent passing the 75 µm (No. 200) sieve, and percent passing the 2.36 mm (No. 8) sieve are all 85%.

For pavements with density acceptance by cores, the payment will be as specified in Section 413.4(a)4 with pay factors from Table H being applied. The pavement will be considered defective if the pavement density cores result in a percent within limits less than 50.

TABLE H
Contract Unit Price Adjustments - Mixture Acceptance by Certification

Mixture NMAS	Test Criteria	Test Value		Payment Factor Percentage
Asphalt Content				
All sizes	Printed Tickets	At least 90% of Daily Printed Tickets Within 0.2% of JMF		100
		Less than 90% of Daily Printed Tickets Within 0.2% of JMF		85
19.0 mm and smaller	QC Sample Testing**	Single Sample (n=1)	Multiple Samples (n≥2)	
		±0.7%	±0.5%	100
		±0.8% to 1.0%	±0.6%	85
		> ±1.0%	≥ ±0.7%	*
25.0 mm and larger	QC Sample Testing**	±0.8%	±0.6%	100
		±0.9% to ±1.2%	±0.7%	85
		> ±1.2%	≥ ±0.8%	*
Gradation				
		Single Sample (n=1)	Multiple Samples (n≥2)	
All sizes	QC Sample Testing for % Passing 75 µm (No. 200) Sieve**	±3.0%	±2.1%	100
		±3.1% to ±4.0%	±2.2% to ±2.7%	85
		> ±4.0%	≥ ±2.8%	*
All sizes	QC Sample Testing for % Passing 2.36 mm (No. 8) Sieve**	±6%	±4%	100
		±7% to ±8%	±5%	85
		> ±8%	≥ ±6%	*
Mat Density				
All sizes	Non-Movement	Section 413.3(j)2.		100
	Optimum-Rolling Pattern	Section 413.3(j)3.		100
Sizes from Table I	Acceptance Sample Testing of Pavement Cores	Table I		Section 413.4(a)4.a

* Defective pavement. Remove and replace or, when permitted by the District Executive in writing, leave in place and the Department will pay 70% of the contract unit price.

** For these test criteria, the daily Pay Factor will be determined by the single sample test result from the daily QC sample. If more than one QC sample test result is available for a day, the Payment Factor Percentage will be determined based on the average of the results using multiple sample tolerances. If corrective action is taken, Pay Factors will be independently determined for material placed before and after the corrective action.

4. Mixture Acceptance by Lot and Density Acceptance by Non-Movement, Optimum-Rolling Pattern, or Pavement Cores. The Department will pay on a lot-by-lot basis at the contract unit price, adjusted for Pay Factors (PF) as specified. For the PF based on Percent Within Limits (PWL), the Department will determine the individual PWL values for in-place pavement density (PWL_D), asphalt content (PWL_{AC}), percent passing the 75 µm (No. 200) sieve (PWL_{200}), and for percent passing the primary control sieve (PWL_{PCS}) as specified in Section 106.03(a)3, using the upper and lower specification limits in Table I. The Department will determine each PF for in-place pavement density, asphalt content, percent passing the 75 µm (No. 200) sieve, and for percent passing the primary control sieve as specified in Section 413.4(a)4.a. The Department will determine the Overall Lot Pay Factor (OLPF) as specified in Section 413.4(a)4.a.2.

4.a Pay Factors

4.a.1 Pay Factors for In-Place Pavement Density (PF_D), Asphalt Content (PF_{AC}), Percent Passing 75 µm (No. 200) Sieve (PF_{200}), and Percent Passing the Primary Control Sieve (PF_{PCS}). For lots with density acceptance by non-movement or optimum-rolling pattern, PF_D = 100.00.

The Department will determine PF_D, for lots with density acceptance by pavement cores and PF_{AC}, PF_{200}, and PF_{PCS} for all lots, according to the following:

4.a.1.a All PWL Parameters Greater Than or Equal to 50. When PWL_D, PWL_{AC}, PWL_{200}, and PWL_{PCS} are each greater than or equal to 50, the Department will determine the pay factor for each PWL as specified in one of the following equations as appropriate.

When PWL is ≥ 90, determine the pay factor for the specific pay parameter as specified in the following Equation:

$$PF_X = 100 + 0.4(PWL_X - 90)^*$$

Where,

PF_X = Pay Factor of the individual pay parameter (PF_D, PF_{AC}, PF_{200} or PF_{PCS})

PWL_X = Percent within Limits of the individual pay parameter (PWL_D, PWL_{AC}, PWL_{200} or PWL_{PCS})

* For 9.5 mm and 12.5 mm courses with average density < 93.0, the maximum PF_D = 100

When PWL is < 90 and ≥ 50, or when PWL_{200} is less than 50 and the average percent passing the 75 µm (No. 200) sieve is within ± 2.0% from the JMF, determine the pay factor for the specific pay parameter as specified in the following Equation:

$$PF_X = 70 + 0.75(PWL_X - 50)$$

Where,

PF_X = Pay Factor of the individual pay parameter (PF_D, PF_{AC}, PF_{200} or PF_{PCS})

PWL_X = Percent within Limits of the individual pay parameter (PWL_D, PWL_{AC}, PWL_{200} or PWL_{PCS})

4.a.1.b One PWL Parameter Less Than 50. When either one of PWL_D or PWL_{AC} is less than 50, the lot is defective. When PWL_{200} is less than 50, the lot is defective when the average percent passing the 75 µm (No. 200) sieve is greater than ± 2.0% from the JMF. When PWL_{PCS} is less than 50, the PF_{PCS} = 60.00. For defective lots, the DE will direct one of the following:

- Leave the lot in place. The DE will apply an OLPF of 70.
- Remove and replace the entire lot. The District Executive will direct removal and replacement of the entire lot at no additional cost to the Department with new lot acceptance sampling and testing.

4.a.1.c Two PWL Parameters Less Than 50. When two or more of PWL_D, PWL_{AC}, or PWL_{200}, with the average percent passing the 75 µm (No. 200) sieve greater than ± 2.0% from the JMF, are less than 50, the lot will be considered defective and the DE will direct removal and replacement of the entire lot with new acceptance sampling and testing.

4.a.2 Overall Lot Pay Factor (OLPF). The Department will determine the OLPF as specified in the following equation and then will round the resulting OLPF to the nearest whole number according to ASTM E29:

$$OLPF = (0.50 \times PF_D) + (0.30 \times PF_{AC}) + (0.10 \times PF_{200}) + (0.10 \times PF_{PCS})$$

Where,

PF_D = Pay Factor for In-Place Density

PF_{AC}= Pay Factor for Asphalt Content

PF_{200}= Pay Factor for Percent Passing the 75 µm (No. 200) Sieve

PF_{PCS}= Pay Factor for Percent Passing the Primary Control Sieve (PCS)

TABLE I
Upper and Lower Specification Limits for Calculating Percent Within Limits

	Testing Criteria	
Mixture NMAS	**Lower Specification Limit (L)**	**Upper Specification Limit (U)**
	Asphalt Content from JMF Value, %	
9.5 mm, 12.5 mm	-0.4	+0.4
19 mm	-0.5	+0.5
25 mm and 37.5 mm	-0.6	+0.6
	Percent Passing the 75 µm (No. 200) sieve from JMF Value, %	
All sizes	-1.5	+1.5
	Percent Passing the Primary Control Sieve from JMF Value, %	
9.5 mm (PCS = 2.36 mm (No. 8) sieve)	-5	+5
12.5 mm (PCS = 2.36 mm (No. 8) sieve)	-5	+5
19 mm (PCS = 4.75 mm (No. 4) sieve)	-8	+8
25 mm (PCS = 4.75 mm (No. 4) sieve)	-9	+9
37.5 mm (PCS = 4.75 mm (No. 4) sieve)	-9	+9
	Mat Density *	
All 9.5 mm, 12.5 mm	92.0	98.5
All 19 mm Courses, 25 mm Binder Courses	91.0	98.0
25 mm and 37.5 mm Base Courses	90.0	No Upper Limit
* Where Limits = Percent of Theoretical Maximum Density		

4.a.3 Lot Payment. The Representative will compute the percent of the contract unit price paid as follows:

Lot Payment = C_P (OLPF)/100

Where,

C_P = Contract unit price per lot (unit price times lot quantity)

OLPF = Overall Lot Pay Factor

4.a.4 Evaluation of Overall Lot Pay Factor and Payment of Incentive / Disincentive. Dollar.

The proposal will include a contract item and a predetermined amount of money for Evaluation of Overall Lot Pay Factor and Payment of Incentive. The contract item will have a unit of measure of DOLLAR, a unit price of $1.00, and a quantity equal to the predetermined amount.

Due to the incentive status of the payment being made, the provisions of Section 110.02(d) are not applicable to this item.

The Evaluation of Overall Lot Pay Factor and Payment of Incentive contract item will be measured and paid as follows:

- **Incentive**. When asphalt pavement evaluation indicates that an incentive adjustment is applicable, the appropriate amount will be paid under this contract item.

- **Disincentive**. When asphalt pavement evaluation indicates that a disincentive adjustment is applicable, the appropriate amount will be deducted from money due or to become due to the Contractor through the processing of a Contract Adjustment.

4.b Dispute Resolution. For mixture acceptance testing or density acceptance testing performed by the LTS, the Contractor may request, in writing, that the Department retest a lot if the initial test results indicated a defective lot (remove and replace), a lot with an OLPF < 90.00, the asphalt content pay factor for the lot is < 80.00, or the density pay factor for the lot is < 80.00, except for density when one or more density acceptance cores in the lot were coated with paraffin wax as a result of PTM No. 716 during the original density acceptance testing. Provide written retest requests to the District Executive within 3 weeks of the date the LTS test results are released. Provide in the written request the preferred test method for asphalt content determination (PTM No. 757 or PTM No. 702, Modified Method D). Retests will not be allowed if a written retest request is not received within 3 weeks of the date the LTS test results are released. Provide quality control test results and control charts, companion sample test results (if available), test data trend evaluation, and any other pertinent information to justify the retest request. The Department will evaluate the information and may allow retesting if the information submitted provides a reasonable basis to conclude that the failing test results may not represent the in-place material. The LTS will perform the retest with the Contractor present, unless otherwise agreed to in writing with the Contractor.

For retesting of materials failing for asphalt content, percent passing 75 µm (No. 200) sieve, or percent passing the PCS, the Inspector will identify the locations where the original box samples were collected. The Inspector will select retest sample locations 24 inches from the original sample locations longitudinally in the direction of traffic. If the 24 inch offset causes the retest sample location to fall outside of the sublot, the Inspector will select the retest sample location 24 inches from the original sample locations longitudinally in the opposite direction from traffic.

With the Inspector present, provide appropriate traffic control and drill 6-inch diameter cores for retesting purposes according to the procedure for drilling in PTM No. 729. Ensure drilling procedures include washing off and towel drying the core samples immediately after drilling. Within 24 hours after coring, backfill the hole with mixture of the same JMF or with mixture used for subsequent courses and compact and seal the mixture. Provide traffic control, core, and backfill the core holes at no additional cost to the Department. The test method used for asphalt determination during the original acceptance testing (PTM No. 757 or PTM No. 702, Modified Method D, and PTM No. 739) will be used for the retest, unless the DME/DMM grants written approval for a change in test method. If required to separate the applicable pavement course lift from other pavement courses, the cores will be saw cut at the course lift line(s) as determined by the LTS. The results of the retest cores will be used to calculate payment for asphalt content, percent passing the 75 µm (No. 200) sieve, and percent passing the PCS for the lot.

For retesting of density acceptance, the original density acceptance cores will be utilized. The LTS will not retest a lot for density acceptance when one or more density acceptance cores in the lot were coated with paraffin wax as a result of PTM No. 716 during the original density acceptance testing. The LTS will retest each original density acceptance core according to PTM No. 715 and PTM No. 716, as necessary, to determine the Gmb and bulk density values. The LTS will not perform Gmm testing for lots where the Contractor's Gmm value was previously considered verified as specified in Section 413.3(j) 4.d.1. After Gmb testing is completed, for lots where the Contractor's Gmm was not verified, the LTS will select one original density acceptance pavement core from each production or placement date represented by the density acceptance cores in the lot. Each core selected will be the core with the highest bulk density for that production or placement date from the retest results (e.g., if a lot was placed over 3 production days, and the lot density acceptance cores include at least one core from each production or placement day, the original density cores selected during a density retest to perform Gmm testing will be 3; one from each production or placement date). The LTS will perform Gmm testing on the selected cores according to AASHTO T 209 as modified in Bulletin 27, with the following exceptions:

- The samples will be obtained as specified in Section 413.3(j)4.c
- No conditioning, only drying, will be performed on the sample
- The minimum sample size will be waived, as necessary, to use the 6-inch diameter pavement core sample, and
- The supplemental procedure for mixtures containing porous aggregate will only be performed when either the coarse aggregate or fine aggregate in the mixture has a water absorption of ≥ 1.5% as indicated on the JMF and then only when the calculated percent of theoretical maximum density indicates any one individual failing sublot which results in a density pay factor less than 100.00.

The LTS Gmm value(s) determined will be the Gmm values used to determine the percent of theoretical maximum density for the cores represented by the applicable production or placement dates in the lot. Either the previously verified Contractor's Gmm values(s) or the newly tested LTS Gmm value(s) will be used for acceptance to determine the percent theoretical maximum density for each sublot core in the lot.

Upon completing the retesting of the original density acceptance cores, the LTS will evaluate testing repeatability for the bulk density results determined according to PTM No. 715 and PTM No. 716, if necessary, using both the bulk original density test values and the bulk density retest values according to PTM No. 5. After evaluating the testing repeatability, the density test values used to determine the final payment factor percentage for density will be as follows:

- If repeatable, the original test values will be used.
- If lack of repeatability (i.e., non-repeatable), the retest values will be used.

The Department will deduct from the payment the cost per lot associated with conducting a retest as follows in Table J:

TABLE J
Dispute Resolution Retest Cost Table

Test Method	**Mixture Acceptance Retest Cost if Retest Results Indicate ≥ 100% Pay Factor(s)***	**Mixture Acceptance Retest Cost if Retest Results Indicate <100% Pay Factor(s)**
PTM No. 702/739	$900	$3,500
PTM No. 757	$500	$2,000
	Density Acceptance Retest Cost if Retest Results Indicate a Lack of Repeatability	**Density Acceptance Retest Cost if Retest Results are Repeatable**
PTM No. 715, or PTM No. 716 only	$200	$750
PTM No. 715, or PTM No. 716, and AASHTO T 209 as specified in Section 413.3(j)4.d.1	$1,100	$4,000

* For lots where the original test results indicated a defective lot, only the pay factor(s) where original test results indicated a PWL < 50 for asphalt content, percent passing the 75 µm (No. 200) sieve, or density will be utilized to determine the retest cost. If no original test results indicated PWL < 50 for lots where OLPF < 90, then all pay factors will be utilized to determine the retest cost.

(b) Asphalt RPS Construction. Square Yard or Ton

1. Mixture Acceptance by Lot and Density Acceptance by Pavement Cores. Section 413.4(a)4, except for RPS, the Department will determine mat density by pavement cores only.

SECTION 419—STONE MATRIX ASPHALT MIXTURE DESIGN, RPS CONSTRUCTION OF PLANT-MIXED WEARING COURSES

419.1 DESCRIPTION—This work is the RPS construction of plant-mixed Stone Matrix Asphalt (SMA), on a prepared surface using a volumetric mixture design developed with the Superpave Gyratory Compactor. The SMA is to be produced as WMA using an approved WMA technology and accepted by either the Hands On Local Acceptance (HOLA) process or the LTS acceptance process.

419.2 MATERIALS— Do not incorporate material into the asphalt mixture that are not specified in Section 419.2 including additives, rejuvenators, or other materials.

(a) Asphalt Material

1. Virgin Mix. Furnish material conforming to the requirements of Standard Specifications for Performance-Graded Asphalt Binder using Multiple Stress Creep Recovery (MSCR) Test, AASHTO M 332, except as revised in Bulletin 25. Obtain material from a source listed in Bulletin 15 for the specified grade. Provide QC testing and certification as specified in Sections 106.03(b) and 702.1(b) 1. Provide the Representative a copy of a Bill of Lading for asphalt material on the first day of paving and when the batch number changes.

When producing a mixture with a WMA technology, adhere to the following requirements:

1.a WMA Technology Additives or Modifiers Blended at the Asphalt Material Supplier's Refinery or Terminal. Provide refinery or terminal blended asphalt material blended with an approved WMA Technology additive or modifier from an approved manufacturer and source listed in Bulletin 15. Include in the asphalt material Producer QC Plan, the WMA Technology additive or modifier manufacturer name, WMA Technology name, and source, dosage rates, blending method, QC testing, corrective action points, disposition of failed material, storage, handling shipping, and bill of lading information following the applicable requirements as specified in Section 702. Include the WMA Technology additive or modifier and dosage rate on the bill of lading. Provide refinery or terminally blended asphalt material, that when blended with the WMA Technology additive or modifier, the final blend meets the requirements for the specified performance grade of the asphalt binder.

1.b WMA Technology Additives or Modifiers Blended at the Asphalt Mixture Producer's Plant. Provide a blended asphalt material consisting of an approved WMA Technology additive or modifier from an approved manufacturer and source listed in Bulletin 15 that is blended with a base asphalt material of the specified performance grade conforming to the requirements of Standard Specifications for Performance-Graded Asphalt Binder using Multiple Stress Creep Recovery (MSCR) Test, AASHTO M 332, except as revised in Bulletin 25 and from an approved source listed in Bulletin 15, Section 702. Prepare a Producer QC Plan as specified in Section 106 and conforming to the Producer QC Plan requirements in Section 413.2(e)1.a and the additional Producer QC Plan requirements within this specification.

(b) Aggregate.

1. General Requirements. Provide aggregate from sources listed in Bulletin 14. Provide aggregate with at least the SRL designation specified. To achieve the specified SRL, the Contractor may provide a blend of two aggregates if the blend has an SRL designation equal to or better than that specified. Blends for SRL are 50% by weight of each aggregate. Blend the aggregates using an approved method.

2. Fine Aggregate. Section 703.1, except as follows: Determine Sand Equivalent Value according to AASHTO T 176 and meet requirements of 45% minimum sand equivalent. Do not exceed 15% sodium sulfate soundness loss in five cycles. Determine the uncompacted void content according to AASHTO T 304, Method A, or use the value listed in Bulletin 14. Provide a fine aggregate that meets 45% minimum uncompacted void content.

3. Coarse Aggregate. Type A, Section 703.2, except as follows: Meet the aggregate quality requirements of Table A.

TABLE A
Coarse Aggregate Quality Requirements

Characteristic	Test Method	Required Values
Abrasion Loss, %	AASHTO T 96	≤ 35
Flat and Elongated Particles, % 3:1 Ratio 5:1 Ratio	ASTM D4791, Method B (measured by mass, on material retained on and above the 4.75 mm (No.4) sieve)	 ≤ 20 ≤ 5
Absorption, %	AASHTO T 85	≤ 2.0
Crushed Fragments, % One Fractured Face Two or More Fractured Faces	ASTM D5821	 100 ≥ 90

(c) Mineral Filler. Furnish mineral filler consisting of finely divided mineral matter such as rock or crushed limestone dust free of organic impurities. Furnish material with a maximum plasticity index of 4 and conforming to the grading requirements of AASHTO M 17. Submit a hydrometer analysis performed according to AASHTO T 88 for mineral filler.

(d) Stabilizer. Provide mineral fiber, cellulose fiber, or crumb rubber (CR) stabilizers conforming to the requirements below and added at a rate specified in Table B. Use the dosage rate prescribed in the JMF.

1. Requirements for All Fiber Types. Fibers must prevent draindown in the mixture according to the tolerances in Table B. Use a fiber of the type and properties appropriate to the plant's metering and delivery system.

2. Cellulose Fibers. Fibers must be of sufficient quality to prevent mixture draindown.

3. Cellulose Pellets. Use cellulose fiber stabilizing additive in pellet form that disperses sufficiently at mixing temperature to blend uniformly into the asphalt mixture. Use pellets that do not exceed 0.25inch average diameter. Pellets may contain binder ingredients such as asphalt binder, wax, or polymer. Do not use pellets if the binder ingredient exceeds 20.0% of the total weight of the pellets. Use binder that produces no measurable effect on the properties of the asphalt binder. Do not use fiber pellets which soften or clump together when stored at temperatures up to 122F.

Note: If the binder material constitutes more than 3% of the pellet weight, base the dosage rate on the net fiber content.

4. Mineral Fibers. Use mineral fibers made from virgin basalt, diabase, slag, or other silicate rock. Use an approved mineral fiber meeting the following requirements for shot content, as tested according to ASTM C612.

Sieve	Percent Passing
250 µm (No. 60)	85 - 95
63µm (No. 230)	60 - 80

5. Crumb Rubber (CR). Use CR derived from the processing of recycled tires. Rubber tire buffings produced by the retreading process qualify as a source of CR. Furnish processed, free flowing CR from a manufacturer listed in Bulletin 15, certified as specified in Section 106.03(b)3.

5.a Gradation. Meet the following gradation as determined according to ASTM D5461 using 200 mm diameter sized sieves and maintaining a maximum allowable loss after sieve analysis of 7.65%. As an alternative dry sieve analysis test method, perform the sieve analysis of the CR according to Florida Test Method, FM 5-559.

CR Gradation

Sieve Size	Percent Passing
4.75 mm (No. 4)	100
2.36 mm (No. 8)	98-100
75 µm (No. 200)	0-3

5.b Contaminants. Provide CR relatively free from fabric, wire, cord, and other contaminating materials to a maximum total contaminant content of 2.5% (maximum of 1.0% iron, 1.0% fiber, and 0.5% other contaminants by weight of total CR sample components).

Remove rubber particles from the fiber balls before weighing. Determine the metal content by thoroughly passing a magnet through a 50.0 ± 0.1 g (1.76 ± 0.004 ounces) sample. Determine fiber content by weighing fiber balls, which are formed during the gradation test procedure.

(e) Mixture Composition.

1. Virgin Material Mixtures. Design and control SMA according to Bulletin 27, Chapter 2B. Size, uniformly grade, and combine aggregate fractions, asphalt material, and an approved WMA Technology in such proportions that the total aggregate and asphalt in the JMF conform to the material, gradation, and volumetric requirements for the SMA mixture according to Tables B and C. Do not use RAP in the mix.

For asphalt mixtures, the WMA Technology Manufacturer Technical Representative (Technical Representative) will address laboratory procedure modifications necessary to prepare, compact, and test ASPHALT mixtures and to achieve a uniform blend. Incorporate the WMA Technology additive, modifier, or process into that JMF during production. Do not develop a volumetric asphalt JMF based on incorporating the WMA Technology additive, modifier or process during the volumetric asphalt mixture design process. For all asphalt JMFs, perform moisture susceptibility analysis according to Bulletin 27. Ensure the WMA Technology additive, modifier, or process is not detrimental to the moisture resistance of the mixture.

TABLE B
Mix Design Requirements for SMA Mixtures

AGGREGATE GRADATION REQUIREMENTS, PERCENT PASSING		
Sieve Size	**9.5-mm Mixture**	**12.5-mm Mixture**
19.0 mm (3/4 inch)	-	100
12.5 mm (1/2 inch)	100	90 – 99
9.5 mm (3/8 inch)	75 – 95	70 – 85
4.75 mm (No. 4)	30 – 50	28 – 40
2.36 mm (No. 8)	20 – 30	18 – 30
1.18 mm (No. 16)	-	-
600 µm (No. 30)	-	-
300 µm (No. 50)	-	-
150 µm (No. 100)	-	-
75 µm (No. 200)	8 – 13	8 – 11
VOLUMETRIC DESIGN REQUIREMENTS		
Design Gyrations (N_{design})	100	
Voids in Mineral Aggregate	18.0 % Minimum	
Voids in Course Aggregate (VCA)	$VCA_{mix} < VCA_{dry\ rodded}$	
Design air voids	3.5 - 4.0 %	
Minimum asphalt binder content	Table C	
Binder grade	PG 64E-22	
Stabilizer content	Cellulose: 0.2 to 0.4 % by total mix weight Mineral: 0.3 to 0.4 % by total mix weight CR: 0.3 to 1 % by total mix weight	
Draindown	0.3 % maximum	

TABLE C
Minimum Asphalt Binder Requirements for SMA Mixtures

Combined Aggregate Bulk Specific Gravity	Minimum Asphalt Content, % by Total Mix Weight
2.400 - 2.449	7.4
2.450 - 2.499	7.2
2.500 - 2.549	7.1
2.550 - 2.599	7.0
2.600 - 2.649	6.8
2.650 - 2.699	6.7
2.700 - 2.749	6.6
2.750 - 2.799	6.5
2.800 - 2.849	6.4
2.850 - 2.899	6.3
2.900 - 2.949	6.2
2.950 - 2.999	6.1
3.000 - 3.049	6.0

Perform draindown testing according to AASHTO T 305 using a 1 hour reading. Design a mix meeting the tolerances specified in Table B.

Design each SMA mix within the job-mix tolerances according to Tables B and C. Test the materials, proportions, and the mixture at the asphalt plant laboratory.

Submit a copy of each completed JMF, signed by a certified Asphalt Level 2 plant technician, to the DME/DMM at least 3 weeks before the planned start of mixture production. Include a list of all material sources and the asphalt producer in the JMF. Provide the calibration factors (C_f and 200 C_f) according to PTM No. 757 with the JMF. Do not start mixture production until after the DME/DMM reviews the JMF.

Submit a new JMF with a change in material sources or if a new JMF is necessary to produce an SMA mixture conforming to this specification.

1.a Producer QC Plan. Section 413.2(e)1.a, except RAP/RAS/RAM is not allowed in the mixture.

1.b Plant Technicians. Section 413.2(e)1.b with the following additions: All HOLA mixture and density acceptance testing will be performed by Department Representatives certified as Asphalt Level 1 or Level 2 Plant Technicians.

1.c Annual JMF Verification. During initial production of each JMF, verify, according to the QC Plan, that the mixture conforms to this specification. If the mixture does not conform to the single and multiple sample tolerances according to Tables D and E within 2 days of production, suspend shipping the mixture to the project. Do not ship the mixture to the project until after the Representative reviews and verifies that results conform to the single and multiple sample tolerances in Tables D and E. Perform annual verification of the asphalt mixture JMF.

1.d Production. Section 413.2(e)1.d, except as follows :

Produce and test mixtures, including Superpave Gyratory Compactor (SGC) specimens for quality control , except as modified by the Producer QC Plan. Maintain records of the testing of the asphalt mixture and make available for review by the Representative when requested.

1.d.3 Gradation. Section 413.2(e)1.d.3, except RAP and RAS are not allowed. Produce the mix within the tolerances of Table D.

1.d.5 Volumetric Analysis of Compacted Specimens. Sample the completed mixture according to PTM No. 1 and at the frequency in the producer QC Plan. Prepare a minimum of two specimens from each sample according to AASHTO T 312.

Produce a mixture with volumetric properties conforming to the tolerances according to Table E. Determine the bulk specific gravity of the specimens as specified in AASHTO T 312 and calculate air voids (V_a) and Voids in Mineral Aggregate (VMA) at N_{design} according to AASHTO R 35 and as specified in

Bulletin 27. Determine compliance with the multiple specimen tolerances using the average of the results for all specimens prepared from the sample.

1.d.6 Mixture Draindown. Sample the completed mixture according to PTM No. 1 a minimum of once daily. Perform draindown testing according to AASHTO T 305 along with the first mixture samples for each day's production. Produce a mixture that meets the tolerances of Table D.

1.d.7 Degree of Particle Coating. For all asphalt mixtures, sample the mixture according to PTM No. 1 and at the frequency in the Producer QC Plan. Determine the degree of particle coating of the completed asphalt mixture according to AASHTO T 195. Produce an asphalt mixture with percent coated particles ≥ 95.0%. Increase the plant mixing time or make other plant adjustments if the required percent of coated particles is not met. Produce an asphalt mixture capable of being handled, placed, and compacted without stripping the asphalt material from the aggregate.

TABLE D
Composition Tolerance Requirements of the Completed Mix

		Single Sample (n = 1)	**Multiple Samples (n ≥ 3)**
Gradation			
Passing 9.5 mm (3/8 inch) and Larger Sieves		±5%	±4%
Passing 4.75 mm (No. 4) to 150 µm (No. 100) Sieves (Inclusive)		±4%	±3%
Passing 75 µm (No. 200) Sieve		±3.0%	±2.0%
Asphalt Content			
% Asphalt by Weight		±0.7%	±0.4%
Draindown			
% by Weight		0.3 % maximum	
Temperature of Mixture (F)			
Class of Material	**Type of Material**	**Minimum**	**Maximum**
PG 64E-22	Asphalt Binder	260	330

TABLE E
Volumetric Tolerance Requirements of the Laboratory Compacted Mix

	Single Specimen (n = 1)	**Multiple Specimens (n ≥ 2)**
Air Voids at N_{design} (V_a)	±2.0% from JMF	±1.5% from JMF
Minimum VMA	17.0	_

1.e Corrective Actions. Immediately take corrective actions if one or more of the following occurs:

- QC test results on a single sample (n=1) for percent passing the 4.75 mm (No. 4) sieve, the 2.36 mm (No. 8) sieve, the 75 µm (No. 200) sieve, or asphalt content are not within the tolerances in Table D.
- The average of multiple samples (n≥ 3) for percent passing any sieve or asphalt content, as determined according to Section 419.2(e)1.d, are not within the tolerances according to Table D.
- QC test results on a single specimen (n=1) or on multiple specimens (n≥ 2) are not within the tolerances according to Table E.
- Draindown test result(s) are not within the tolerances according to Table D.

- Independent Assurance (IA) or QA sample results from testing at the producer's plant are not within the tolerances of Tables D or E.

After taking corrective actions, sample the completed mixture within 150 tons of production. After sampling, test the mixture and provide test results to the Representative within 500 tons of production. If less than three samples are tested for mixture composition, determine conformance with Table D by comparing each result to the multiple sample tolerances. If the mixture does not conform to the single and multiple sample tolerances in Table D and the single and multiple specimen tolerances in Table E, suspend production and shipping to the project and determine the cause of the problem. Provide a written explanation of the problem and a proposed solution to the Department. After the Representative reviews the proposed solution and authorizes production to continue, resume production and perform JMF verification according to the QC Plan.

(f) Mixture Acceptance.

1. General. The Department will accept the mixtures by lot acceptance as specified in Section 419.3(i)2 by either LTS or HOLA acceptance methods as indicated.
The Department or the Contractor may for any reason stop HOLA acceptance and switch to LTS acceptance for lots with samples not yet tested. To change the acceptance method from LTS acceptance to HOLA acceptance, the Contractor and the District Executive must agree to the change in writing. The acceptance method for a lot cannot be changed after acceptance testing for that lot starts.

2. Certification. SMA mixtures will not be accepted by certification. The only exception for SMA accepted by certification is small quantities of SMA mixture used for patches and miscellaneous placements equal to or less than 150 tons as specified in Section 419.3(i)2.a.

(g) WMA Technologies (Additive(s), Modifier(s), or Processes) and WMA Manufacturers. For WMA mixtures, Section 413.2(f)

(h) Anti-Strip Additives. For asphalt mixtures, Section 413.2(g)

(i) WMA Technology Manufacturer Technical Representative (Technical Representative). For asphalt mixtures, Section 413.2(h)

419.3 CONSTRUCTION—

(a) Preplacement Requirements. Provide asphalt mixtures as indicated for the entire project.

1. Paving Operation QC Plan. Prepare a paving operation QC Plan, as outlined on Form CS-409, for field control and evaluation of asphalt concrete paving operations. Submit the QC Plan to the Representative before or at the pre-construction conference. Include in the QC Plan a description of the construction equipment and methods necessary to construct and test the asphalt concrete courses as specified in Section 419.3. For asphalt mixtures, have the Technical Representative provide all recommendations and direction specific to the WMA technology in the paving operation QC Plan. Do not start paving until after the Representative reviews the QC Plan.

2. Preplacement Meeting. At least 2 weeks before placing asphalt paving mixtures, schedule an asphalt preplacement meeting with the Representative to review at a minimum the specification, paving operation QC Plan, sequence of paving operations, mixture acceptance, density acceptance, and the care and custody of asphalt acceptance samples.

(b) Weather Limitations. Do not place SMA paving mixtures from October 1 to March 31 in Districts 1-0, 2-0 (except Juniata and Mifflin Counties), 3-0, 4-0, 5-0 (Monroe and Carbon Counties only), 9-0 (Cambria and Somerset Counties only), and 10-0; and from October 16 to March 31 in Districts 2-0 (Juniata and Mifflin Counties only), 5-0 (except Monroe and Carbon Counties), 6-0, 8-0, 9-0 (except Cambria and Somerset Counties), 11-0 and 12-0. Exceptions require the written permission of the District Executive. Do not place asphalt paving mixtures when surfaces are wet or when the air or surface temperature is 50F or lower. If work is halted because of weather conditions, the Representative may allow the Contractor to place limited quantities of mixture that are en route to the project.

(c) Asphalt Mixing Plant. Section 413.3(c), except the following requirements are for SMA mixes.

Obtain asphalt mixtures from a plant fully automated and recordated and currently listed in Bulletin 41. The necessary facilities for inspection include a plant office as specified in Section 714.5(a), except the minimum floor space is 120 square feet.

Ensure that both the aggregates and the completed mixture are free of unburned fuel oil and excess moisture as specified in Section 413.2(e)1.d.1.

For asphalt mixtures, make any plant modifications needed to introduce the WMA Technology additives, modifiers, or processes according to specific recommendations and direction from the Technical Representative or process manufacturer to achieve a uniform blend of the WMA Technology additive, modifier or foaming process and produce an asphalt mixture meeting these specifications. For batch plants, dry the aggregate according to the specific recommendations and direction from the Technical Representative.

1. Mineral Filler System. Follow the requirements listed in Chapter 1, Section 2.5 of Bulletin 27.

2. Stabilizer Supply System. Add stabilizer through specialized equipment that can accurately proportion and meter, by weight, the proper amount per batch for batch plants, or continuously and in a steady uniform manner for drum plants. Do not feed fiber, pelletized or loose, through the cold feed bins or through the RAP bins.

Provide proportioning devices that are interlocked with the plant system and controlled to ±10% of the weight of the fibers required. During the trial demonstration specified in Section 419.3(g), perform an equipment calibration to the satisfaction of the Representative to show that the fiber is being accurately metered and uniformly distributed into the mix.

Include the following on the stabilizer supply system:

- low level indicators
- no-flow indicators
- a printout of feed rate status in pounds/ minute
- a section of transparent pipe in the stabilizer supply line for observing consistency of flow or feed.

Have the Representative approve all stabilizer addition systems.

When a batch plant is used, add the stabilizer to the aggregate in the weigh hopper and increase both dry and wet mixing times. Ensure that the stabilizer is uniformly distributed before the injection of asphalt binder into the mixture. When a drum plant is used, do not allow the fibers to become removed by the exhaust system. If there is any evidence of fiber in the bag-house or wet washer fines, relocate the liquid asphalt binder line and/or the fiber line so that the fiber is captured by liquid asphalt spray and incorporated into the mix. If there is any evidence of clumps of fibers or pellets at the discharge chute, increase the mixing time and/or intensity.

Store stabilizer in a dry environment.

3. Hot-Mixture Storage. Ship material within 2 hours of plant mixing. Stored SMA material that does not consistently meet the same quality as material discharged directly into hauling vehicles will be rejected.

4. HOLA Laboratory Testing Facility. For testing of HOLA samples by the Department, identify a laboratory testing facility where the local acceptance testing is to be performed. Identify either the laboratory located at the asphalt mixture production plant, the laboratory where the plant production mixture is being tested for QC, or another agreed upon laboratory location meeting the requirements of Bulletin 27. Identify a laboratory testing facility that has demonstrated testing proficiency through an AASHTO re:source On-Site Laboratory Assessment performed within the last 2 years before the HOLA sample testing. The AASHTO re:source On-Site Laboratory Assessment must have been completed on the equipment proposed for utilization by the Department.

At the project preconstruction meeting, submit the identified laboratory testing facility location, AASHTO re:source On-Site Laboratory Assessment report, and any necessary corrective action documentation to correct any deficiencies on the Laboratory Assessment report for review by the Representative. The Representative will review the laboratory testing facility location and AASHTO re:source assessment documentation and, if acceptable, designate the laboratory testing facility for the project. Use the designated laboratory for testing all HOLA samples.

If a change in the designated laboratory testing facility is necessary, submit the new laboratory testing facility location. Include the AASHTO re:source On-Site Laboratory Assessment report for the new laboratory testing facility and corrective action documentation for deficiencies noted by the AASHTO re:source On-Site Laboratory Assessment report. The Representative will review the new laboratory testing facility and AASHTO re:source assessment documentation and, if acceptable, designate the new laboratory testing facility for the project. If an acceptable laboratory facility cannot be identified and agreed to, acceptance testing will be performed by LTS.

The Representative will specifically review the testing facility equipment to ensure it meets the required test method requirements, manufacturer installation requirements, standardization or calibration requirements and frequency, manufacturer maintenance requirements and frequency, maintenance log record requirements, and the facility QC plan includes an action plan for removing equipment from service if it fails to meet any requirements, requires standardization or calibration, becomes inoperable or requires repair/maintenance.

Provide dedicated laboratory testing equipment for Department use at the designated laboratory testing facility as required in the specified test methods and as modified in Bulletin 27 for testing mixture and density HOLA samples. The Representative may reject the proposed laboratory facility if it is determined that sufficient equipment is not available to ensure priority of the local acceptance testing. Additional equipment other than the minimum required equipment listed in Bulletin 27 may be required to properly run some of the referenced procedures.

(d) Hauling Equipment. Section 413.3(d)

(e) Asphalt Pavers. Section 413.3(e)1.

(f) Rollers. Use a minimum of three steel-wheeled rollers, each weighing a minimum of 10 tons and as specified in Section 108.05(c)3. Operate rollers according to manufacturer's recommendations. Use rollers equipped with a watering or soapy watering system that prevents material from sticking to the rollers. Do not use pneumatic wheeled rollers.

Do not use rollers in vibratory mode unless it can be demonstrated during the trial demonstration specified in Section 419.3(g) and to the satisfaction of the Representative that no breaking of aggregate or flushing of asphalt binder results from the vibration. Monitor pavement cores for aggregate breakage on every lot. Discontinue vibration if aggregate breakage or flushing of asphalt binder occurs.

(g) Demonstration. Before proceeding with the actual work, demonstrate to the Representative that the proposed SMA mix can be produced, placed, and compacted to meet the requirements of this specification. Place a minimum of 100 tons outside the project limits for each trial demonstration. Simulate the hauling time for the demonstration. Obtain and test three loose mixture samples at the plant for asphalt content, gradation, and draindown and three pavement cores from the demonstration pavement for density. Test one set of volumetric specimens for Air Voids at N_{design} (V_a) and test for one maximum specific gravity of the mixture value. If test results do not meet specification limits for both single and multiple sample tolerances for any parameter, perform another demonstration.

If vibratory rolling is proposed, demonstrate to the satisfaction of the Representative that no breaking of aggregate or flushing of asphalt binder results from the vibration.

(h) Preparation of Existing Surface. Section 413.3(g)

(i) Spreading and Finishing.

1. General Requirements.

1.a Placing. Unless otherwise allowed or indicated, deliver, place, and compact SMA paving mixtures during daylight hours. Ensure the mixture does not contain lumps of cold material. Deliver and place SMA mixtures at the temperatures specified in Table D.

Use a material transfer vehicle (MTV) as specified in Section 108.05(c)5 to apply the final surface course. Have the MTV perform additional mixing of the SMA material and then deposit the mixture into the paver at a uniform temperature and consistency.

1.b Spreading and Finishing. Section 413.3(h)1.b and as follows: Plan and schedule operations to minimize hand work of SMA. Do not allow the finished pavement surface to flush. Flushing is continuous or repeated areas of excessive asphalt on the pavement surface. Areas that are determined to be flushed will be considered defective work.

1.c Field Technician. Section 413.3(h)1. d

1.d Safety Edge. Construct the Safety Edge as the standard edge treatment on the outside edge of asphalt pavements and shoulders. Use the Safety Edge for SMA courses with a depth of 1.5 inches or greater. The Safety Edge is not required where curb or sidewalk are encountered or where the face of guiderail is directly over the edge of pavements.

Construct the Safety Edge with the same material used to construct the roadway course being placed or, if specified, the paved shoulders. Attach a device to the paver to confine material at the end gate and extrude the asphalt material in a wedge shape. Use an adjustable device that allows the operator to vary the slope extruded at the paver to account for the angle becoming steeper during compaction (roll up). Before construction, the Safety Edge device must be approved.

Compact the roadway or paved shoulder as required by the specifications. Do not delay rolling of the mat adjacent to the Safety Edge. After compaction of the mat is complete, provide a Safety Edge meeting the final shape requirements as shown on the Standard Drawings. The completed angle of the Safety Edge must be 26 to 40 degrees measured from the pavement cross slope extended. At the beginning of each days paving, measure the angle of the Safety Edge from the pavement cross slope extended. Perform measurements after final compaction is complete. If the angle of the Safety Edge does not meet the slope requirements, stop paving and provide corrective action. Do not resume production paving until final shape requirements of Safety Edge are achieved.

Allow automatic transition to intersections, driveways, guiderail sections, and obstructions.

Use the device to constrain the asphalt head, reducing the area and increasing the density of the extruded profile. A single plate strike-off method is not allowed. Do not place the Safety Edge on organic material.

2. Mixture and Density Lot Acceptance (RPS Construction). Lot acceptance is required for RPS construction.

2.a Lots and Sublots. Material will be accepted in the field on a lot by lot basis. Lots will be established cumulatively and will be specific for each JMF. Each lot consists of five equal sublots (n=5). A completed sublot has a mixture acceptance box sample as specified in Section 413.3(h)2.b and a pavement core sample collected according to PTM No. 1 and PTM No. 729 as specified in Section 413.3(j)4.c.

A normal lot size is 2,500 tons with five, 500 ton sublots (n=5), unless operational conditions or project size dictate otherwise. If operational conditions or project size dictate, readjustment of the lot will be made as specified in section 413.3(h)2 Table D. Breakdowns or stoppages of short periods due to such causes as weather or equipment failure will not be considered as reasons to adjust the lot size. The original lot will be continued when work resumes after short stoppages of less than 5 calendar days. If a lot is ended due to a stoppage of 5 calendar days or more, adjust the lot size and number of sublots as specified in Section 413.3(h)2 Table D. If the work stoppage is 5 calendar days or more, a new lot will be established.

For small quantities of SMA placements equal to or less than 150 tons, mixture acceptance will be based on certification as specified in Sections 413.2(i)2.b and 419.2(f)2 and density acceptance will be accepted on optimum rolling pattern or non-movement as specified in Section 413.3(j)

2.a.1 Partially Completed Lots (n=2 or less). When process conditions change to an extent that a partially completed lot cannot be combined with the most recently completed lot, samples will be independently evaluated on the partially completed lot. For asphalt content and percent passing the 75 µm (No. 200) sieve, mixture acceptance samples will be evaluated individually as specified in Section 419.4(a), Table I (n=1) criteria. For density, mat density acceptance samples will be evaluated individually using the criteria in Table F.

If samples tested for asphalt content and percent passing the 75 µm (No. 200) sieve meet the n=1 criteria of Table I, and samples tested for density meet the criteria in Table F, payment will be 100% of the contract unit price. If samples tested for asphalt content and percent passing the 75 µm (No. 200) sieve do not meet the n=1 criteria according to Table I, the material will be considered defective work. If samples tested for density are no more than 2.0% below the minimum or no more than 2.0% above the maximum limits according to Table F, payment will be 90% of the contract unit price. If samples for density are more than 2.0% below the minimum or more than 2.0% above the maximum limits of Table F, the pavement will be considered defective work.

Unless otherwise directed in writing by the District Executive, remove and replace defective work.

TABLE F
Density Limits for Partially Completed Lots

MIXTURE NMAS	DENSITY LIMITS

All RPS 9.5 mm, 12.5 mm Wearing Courses	≥ 93.0 and ≤ 98.0

2.a.2 For JMF's placed in quantities less than 2,500 tons. For JMFs placed in quantities of greater than 500 tons and less than 2,500 tons the tonnage will be considered a lot. The lot will be divided into five equal sublots.

For JMF's placed in quantities of 500 tons or less, the tonnage will be divided into three equal sublots and sampled as specified in Section 419.3(i)2.a.

2.b Mixture Acceptance and Theoretical Maximum Specific Gravity (Gmm) Verification Samples. The Representative will select different sample locations in each sublot according to PTM No. 1 and PTM No. 746. In the presence of the Representative, obtain two loose mixture samples (One for acceptance and one for Gmm verification) for each sublot at each sample location and immediately package. Obtain the sample from uncompacted placed mixture or from the paver screed. One loose mixture sample at each location will be used to determine the mixture acceptance and the second loose mixture sample at each location will be used to determine the theoretical maximum specific gravity (Gmm) value. Both sets of mixture samples will be submitted to the testing laboratory on separate Form TR-447 sample identification forms.

Package individual loose mixture samples using interior lined cardboard boxes dimensioned approximately 3 3/4 inches x 4 3/4 inches x 9 1/2 inches. Do not package samples in cardboard boxes with any one dimension greater than 10 1/4 inches or any one dimension smaller than 3 1/2 inches. The lining is homogenously constructed within the interior portion of the cardboard box to prevent asphalt binder absorption/adhesion of the loose mixture sample.

Immediately after packaging and in the presence of the Representative, identify the samples by ECMS project number, lot and sublot number, location (station and offset), date of placement, mixture type, and as either mixture acceptance samples (Sample Class AS) or as Gmm verification samples (Sample Class FV). Leave at least one side of the cardboard sample box free of any writing or marking for LTS use in testing the samples.

For LTS samples, immediately after identifying, submit the samples to the Representative.

For HOLA samples, provide locking containers of adequate size to accommodate at least seven loose mixture samples. Identify each sample by sublot and as either an acceptance or Independent Assurance (IA) sample. The Representative will not package samples from more than one lot in the same container. The Department will inspect the containers provided. Repair, modify or replace all containers determined to be inadequate or not secure. Provide new and sealed locks with two keys, or other acceptable device that will ensure the security of the samples, to the Representative. The containers will be secured by the Representative before being turned over to the contractor for transport to the testing location. Samples received at the testing location will only be opened by the District Materials Representative.

For QC purposes, a maximum of one loose sample per sublot may be obtained. No loose mixture or core samples may be taken by the Contractor for mixture composition testing after the mixture acceptance samples and Gmm verification samples are obtained. Do not obtain any other pavement samples, except those which are directed by and surrendered to the Department, unless allowed in writing from the District Executive.

2.b.1 IA Sampling for HOLA mixture acceptance. The Department will perform IA testing of HOLA mixture samples on the initial lot and a minimum of one lot for every 10 lots thereafter. For the IA lots selected by the Representative, obtain one additional loose mixture sample at each sublot location identified in Section 419.3(i)2b.

Immediately after packaging and in the presence of the Representative, identify each sample by ECMS project number, lot and sublot number, location (station and offset), date of placement, mixture type, and as an IA sample. Leave at least one side of the cardboard sample box free of any writing or marking for LTS use in testing the sample.

The Representative will submit the IA sample from each sublot within the lot to LTS for testing by delivering them to the shipping point within 3 days of receipt.

2.b.1.a Mixture IA Sample HOLA Test Result Analysis. LTS IA sample test results will be compared to the HOLA Acceptance Sample test results on the same lot. If the difference in the average HOLA and IA test results meet the Independent Assurance tolerances in Table G, the Department will continue with IA testing at a minimum of one out of every ten lots thereafter.

Table G
Independent Assurance Tolerances on Lot Averages

Testing Criteria	Max. Difference Between Average Test Results (n≥3)

Asphalt Content for 9.5 mm and 12.5 mm NMAS Mixtures	±0.3%
Percent Passing the No. 8 sieve for 9.5 mm and 12.5 mm NMAS mixtures	±4%
Percent Passing the No. 200 sieve for all mixtures	±1.2%

If the difference between the lot averages of IA sample test results and HOLA sample test results exceeds the maximum IA tolerances in Table G, specific calibration factors (C*f* and 200 C*f*) will be determined for each ignition furnace used for testing the IA samples and HOLA samples according to PTM No. 757 and additional IA samples will be collected as specified in Section 419.3(i)2.b.1 from the project directly behind the paving equipment for IA comparison. If the IA tolerances in Table G are still exceeded**,** the Representative will perform an investigation of the cause of the non-comparison of the test results.

Provide information to the Representative, as requested, on the integrity of samples and the testing equipment used in the sample testing. The Representative will also review personnel and test methods used in the HOLA testing. Implement corrective measures for any noted deficiencies to ensure the tests are performed according to the prescribed procedures. The Representative will record the HOLA sample test results, the IA sample test results and any applicable corrective measures. The Representative will select the next lot on the project for IA and will submit the IA samples to LTS for testing. If the difference between subsequent IA sample test results and HOLA sample test results exceeds the IA tolerances in Table G, the Department may discontinue testing of HOLA samples and begin LTS testing of the mixture acceptance samples for the remainder of the project. If the difference between subsequent IA sample test results and HOLA sample test results meets the IA tolerances in Table G, the Department may continue testing of HOLA samples with IA testing at a minimum of one out of every ten lots.

2.c Mixture and Density Acceptance Sample Testing. LTS Testing will be utilized unless otherwise indicated in the contract. The Contractor may elect to expedite delivery of the acceptance samples as specified in section 413.3(h) 2.b.

2.c.1 LTS and HOLA Acceptance Testing. Density acceptance samples will be tested according to PTM No. 715, and if necessary PTM No. 716, to determine the percent compaction. For individual increment test results outside of the individual mat density tolerances in Table I, the LTS or the District HOLA Representative will analyze the bulk density test results for extreme values according to PTM No. 4 at the 5% significance level. If discarding an extreme value reduces a lot to less than three remaining test results, the Department will accept the lot as specified in Section 419.3(i)2.a.1.

The Department will then randomly select one of the Gmm verification loose mixture samples obtained as specified in Section 419.3(i)2.b for either LTS or HOLA from the lot according to PTM No. 1. The LTS or the District HOLA Testing Representative will test the randomly selected Gmm verification loose mixture sample to determine the theoretical maximum specific gravity (Gmm) of the compacted mixture according to AASHTO T 209 as modified in Bulletin 27, with the following exception:

- The samples will be obtained as specified in Section 419.3(i)2.b.

Randomly selected Gmm verification sample test result will be compared with the Contractor's daily Gmm value for that same production or placement date. If the Department and Contractor Gmm values do not differ by more than ±0.030, the Contractor's daily Gmm values in the whole lot will be considered verified and the Contractor's daily Gmm values will be used to determine the percent of theoretical maximum density for each density acceptance sample placed on that date. If the initial randomly selected Gmm verification sample test result differs from the Contractor's daily Gmm value for that same production or placement date by more than ±0.030, the Department Gmm test result value will be used as the acceptance Gmm value to determine the percent of theoretical maximum density for the individual density acceptance cores produced or placed on that same date. The Department reserves the right to select more than one Gmm verification sample from the lot representing the same production or placement date and to select other Gmm verification samples from the lot representing different production or placement dates to verify the Contractor's daily Gmm values. When more than one Gmm verification sample is selected from the lot representing the same production or placement date, the Department Gmm test results will be averaged and then rounded to the nearest 0.001 according to the rounding method of ASTM E29 and the average value used to verify to the Contractor's daily Gmm value for that same production and placement date.

The Department will accept density lots with three or more test results as specified in Section 419.4(a)3.

The Department will test the mixture acceptance samples according to PTM No. 757 or PTM No. 702, Modified Method D, if previously identified problematic aggregates are used in the mixture, to determine asphalt content and the percent passing the 75 µm (No. 200) sieve. For PTM No. 757, the LTS will use the calibration factors (C_f and 200 C_f) provided with the JMF. For individual increment test results outside of the single sample (n=1) tolerances in Table D, the Department will analyze the test results for extreme values according to PTM No. 4 at the 5% significance level. If discarding an extreme value reduces a lot to less than three remaining test results, the Department will accept the lot as specified in Section 419.3(i)2.a.1. The Department will accept lots as specified in Section 419.4(a).

Stop all paving operations if any of the following conditions exist:

- cores are not taken within 1 day after placing the mixture
- the density for two consecutive lots or a total of three lots does not meet the density payment factor percentage of 100
- asphalt content is not within the single sample (n=1) or multiple sample (n≥3) tolerances in Table D for two consecutive lots or a total of three lots
- the percent passing the 75 µm (No. 200) sieve is not within the single sample (n=1) or multiple sample (n≥3) tolerances in Table F for two consecutive lots or a total of three lots
- the pavement exhibits flushing as outlined in 419.3(i)1.b.

Determine the cause of the problem and provide a proposed solution to the Department. Do not resume paving until the Representative reviews the proposed solution and authorizes production to continue.

(j) Compaction. Begin rolling material immediately after placement. Compact the SMA mixture to achieve the density acceptance requirements and to eliminate all roller marks while not producing flushing of the asphalt binder. Compact the mixture while it is in proper condition and adjust roller speed, pattern, and roller size (and/or amplitude and frequency if vibratory rolling is approved by the Representative) to eliminate displacement, shoving, cracking, and aggregate breakage as specified in Section 419.3(f). Satisfactorily correct displacement resulting from reversing roller directions and other causes.

Without using excess water, maintain wheels of steel-wheel rollers moist and clean to prevent the mixture from adhering to the wheels.

For areas inaccessible to rollers, compact with mechanical vibrating hand tampers.

(k) Mat Density Acceptance.

1, General Requirements. The Department will accept the mixtures by lot acceptance as specified in Section 419.3(i)2. The acceptance criteria will be as shown in Table F. The Department will determine acceptance with respect to density, as specified in Section 419.4(a)3.

1.a. Density Acceptance Samples. The Representative will select different sample locations in each sublot according to PTM No. 1 and PTM No. 729. With the Representative present, drill 6-inch diameter cores as soon as possible but no later than the day following placement. The core at each location will be used to determine the bulk specific gravity (Gmb) and density (pounds per cubic foot) of the compacted mix. Do not compress, bend, or distort samples during cutting, handling, transporting, and storing. If samples are damaged, immediately obtain replacement samples, as directed by the Representative, from within 12 inches of the original sample location. Within 24 hours after coring, backfill the hole with mixture of the same JMF or with mixture used for subsequent courses and compact and seal the mixture.

In the presence of the Representative, identify the samples by ECMS project number, lot and sublot number, location (station and offset), date of placement, mixture type, and as acceptance samples (Sample Class AS). Provide the daily theoretical maximum specific gravity value as specified in Section 419.2(e)1.d.4 for the density calculation of the lot. If density samples from the lot are taken from more than 1 day's placement, the daily theoretical maximum specific gravity values from each production day will be used to calculate the percent of theoretical density for each individual density acceptance core placed on that production day upon Gmm verification as specified in Section 419.3(i)2.c.1.

For LTS samples, immediately deliver the samples to the Representative and provide sample containers of sufficient strength to prevent samples from being damaged during transport and sufficient size to accommodate the density samples from one lot. The Representative will submit samples for one lot in one container.

For HOLA samples, provide locking containers of adequate size to accommodate seven core samples. Identify each sample by sublot and as either acceptance or IA sample. The Representative will not package samples from more than one lot in the same container. The Department will inspect the containers provided. Repair, modify or replace all containers determined to be inadequate or that are not secure. Provide new and sealed locks with two keys, or other acceptable device that will ensure the security of the samples to the Representative. The containers will be secured by the Representative before being turned over to the contractor for transport to the testing location. Samples received at the testing location will only be opened by the District Materials Representative.

For quality control purposes, a maximum of one pavement core per sublot may be obtained unless the Representative allows additional cores. No cores may be taken by the Contractor after the acceptance cores are obtained. Do not obtain any other pavement cores, except those that are directed by and surrendered to the Department, unless allowed in writing by the District Executive.

1.b. IA Density Samples. The Department will perform IA testing of HOLA density samples on the initial lot and a minimum of one out of every ten lots thereafter. The Representative will identify one HOLA sample as specified in Section 419.3(k)1.a to also serve as an IA sample. Cores coated with paraffin wax according to PTM No. 716 are omitted from IA testing.

With the Representative present, identify the samples by ECMS project number, lot and sublot number, location (station and offset), date of placement, mixture type, and as AS/IA samples. Provide the daily theoretical maximum specific gravity value as specified in Section 419.3(i)2.b for the density calculation of the lot. Immediately after identifying, submit the density samples to the Representative as specified in Section 419.3(k)1.a. Upon testing of the sample for HOLA density as specified in Section 419.3(i)2.c.1, the Representative will package the density IA samples in the containers and submit the IA samples to LTS for testing.

1.b.1. LTS Testing of IA HOLA Density Samples. The LTS will test the density samples for IA according to PTM No. 715, and if necessary PTM No. 716, to determine the percent compaction.

1.b.1.a Density IA Sample Test Result Analysis. LTS IA density sample test results will be compared to the HOLA density sample test results on the same lot. If the difference in the average test results of the HOLA and IA meet the IA tolerances in Table H, the Department will continue with IA testing at a minimum of one out of every ten lots thereafter.

Table H
Independent Assurance Tolerances on Lot Averages

Testing Criteria	Max. Difference Between Test Results (n≥3)
PTM No. 715 or PTM No. 716, Gmb	0.020
AASHTO T 209 as modified in Bulletin 27	0.030

If the difference between the lot averages of IA sample test results and HOLA sample test results exceeds the maximum IA tolerances in Table H, the Representative will perform an investigation as to the cause for the non-comparison of the test results. Provide information to the Representative, as requested, on the integrity of samples and on the equipment used in the sample testing. The Representative will also review personnel and test methods used in the HOLA testing. Implement corrective measures for any noted deficiencies to ensure the tests are performed according to the prescribed procedures. The Representative will record the HOLA Sample test results, the IA sample test results and any applicable corrective measures in the Field Inspector's Diary. The Representative will select the next lot on the project for IA and will submit the IA companion density samples to LTS for testing. If the difference between subsequent IA sample test results and HOLA sample test results exceeds the IA tolerances in Table H, the Department may discontinue testing of HOLA samples and begin LTS testing of the acceptance samples for the remainder of the project and revert to Section IV for measurement and payment. If the difference between subsequent IA sample test results and HOLA sample test results meets the IA tolerances in Table H, the Department may continue testing of HOLA samples with IA testing at a minimum of one out of every ten lots.

(l) Joints. Section 413.3(k).

(m) Surface Tolerance. Section 413.3(l)

(n) Tests for Depth. Section 413.3(m)

(o) Protection of Courses. Section 413.3(n)

(p) Defective Work. As specified in Section 105.12 and as follows:

Department acceptance and QA testing does not relieve the Contractor of responsibility for material or workmanship that the Representative determines is defective before the Department issues the acceptance certificate. Remove and replace or repair defective work as directed. The CMD will review Representative determinations of defective material or workmanship.

Unless otherwise directed in writing by the District Executive, remove and replace pavement defective for flushing as specified in Section 419.3(i)1.b, surface tolerance as specified in Section 413.3(l) and depth as specified in Section 413.3(m). Remove and replace pavement defective for percent within limits or Payment Factor Percentage according to Table I.

419.4 MEASUREMENT AND PAYMENT—

(a) SMA RPS Construction.

1. SMA Wearing Course RPS. Square Yard or Ton

2. Asphalt Tack Coat. Section 460.4.

3. Mixture and Density Acceptance by Lot using Pavement Cores. The Department will pay on a lot-by-lot basis at the contract unit price, adjusted for Payment Factor Percentages as specified in Table I. For the payment factor percentages based on percent within limits, the Department will determine the percent within limits as specified in Section 106.03(a)3, using the upper and lower specification limits in Table J.

3.a Payment.

The Representative will compute the percent of the contract unit price paid as follows:

Lot Payment = $C_P(2P_D + P_B + P_A)/400$

C_P = Contract unit price per lot (unit price times lot quantity)

P_D = Payment Factor Percentage for density

P_B = Payment Factor Percentage for asphalt content.

P_A = Payment Factor Percentage for percent passing the 75 µm (No. 200) sieve

TABLE I
Contract Price Adjustments

Test Criteria	Test Value	Payment Factor Percentage
Asphalt Content		
Acceptance Sample testing of % Asphalt	All acceptance sample test results are within ±0.7% for n=1 and ±0.4% for n≥ 3 of the JMF	100
	Percent Within Limits if all acceptance sample test results are not within ±0.7% for n=1 and ±0.4% for n≥ 3 of the JMF	Table K
Gradation		
Acceptance Sample Testing of % Passing 75 µm (No. 200) Sieve	All acceptance sample test results are within +3.0% and -3.0% for n=1, and + 2.0% and -2.0% for n≥ 3 of the JMF	100
	Percent Within Limits if all acceptance sample test results are not within +3.0% and -3.0% for n=1, and + 2.0% and - 2.0% for n≥ 3 of the JMF	Table K

Mat Density		
Acceptance Sample Testing of Pavement Cores	All individual results for the lot are ≥ 93.0 % and ≤ 98.0 % of the maximum theoretical density	100
	Percent Within Limits if any individual sublot test result for the lot is not ≥ 93.0 % and ≤ 98.0 % of the maximum theoretical density.	Table K

TABLE J
Upper and Lower Specification Limits for Calculating Percent Within Limits

Testing Criteria	
Lower Specification Limit (L)	**Upper Specification Limit (U)**
Asphalt Content from JMF Value, %	
-0.4	+0.4
Percent Passing the 75 µm (No. 200) sieve from JMF Value, %	
-2.0	+2.0
Mat Density*	
92.0	98.0
* The Percent of Theoretical Maximum Density	

TABLE K
Payment Factor Based on Percent Within Limits

Percent Within Limits	Payment Factor Percentage
99	97
98	97
97	97
96	96
95	96
94	96
93	95
92	95
91	95
90	95
89	93
88	91
87	90
86	88
85	86
84	84
83	83
82	81
81	79
80	78
79	76
78	74
77	72
76	71
75	69
74	67

73	66
72	64
71	62
70	60
69	59
68	57
67	55
66	54
65	52
64	50
Less than 64	Defective Lot**

**Remove and replace the lot. If only one lot characteristic has a percent within limits less than 64, the District Executive may allow the Contractor to leave the defective lot in place. The Department will pay for the defective lot at 50% of the contract unit price.

3.b Dispute Resolution. For mixture acceptance testing or density acceptance testing performed by the LTS, the Contractor may request in writing that the Department retest a lot if the initial test results indicated a defective lot (remove and replace) except for density when one or more density acceptance cores in the lot were coated with paraffin wax as a result of PTM No. 716 during the original density acceptance testing. For HOLA acceptance, the Contractor may only request in writing that the Department retest a mixture acceptance lot if the initial test results indicate a remove and replace defective lot. All retesting for HOLA and LTS will be performed by the LTS lab. Provide written retest requests to the District Executive within 3 weeks of the date the LTS test results are released. Retests will not be allowed if a written retest request is not received within 3 weeks of the date the LTS test results are released. Provide quality control test results and control charts, companion sample test results (if available), test data trend evaluation, and any other pertinent information to justify the retest request. The Department will evaluate the information and may allow retesting if the information submitted provides a reasonable basis to conclude that the failing test results may not represent the in-place material. The LTS will perform the retest with the Contractor present, unless otherwise agreed to in writing with the Contractor.

For retesting of materials failing for asphalt content or percent passing 75 µm (No. 200) sieve, the Representative will identify the locations where the original mixture acceptance samples were collected. The Representative will select retest sample locations 24 inches from the original sample locations longitudinally in the direction of traffic. If the 24-inch offset causes the retest sample location to fall outside of the sublot, the Representative will select the retest sample location 24 inches from the original sample locations longitudinally in the opposite direction from traffic.

With the Representative present, provide appropriate traffic control and drill 6-inch diameter cores for retesting purposes according to the procedure for drilling in PTM No. 729. Ensure drilling procedures include washing off and towel drying the core samples immediately after drilling. Within 24 hours after coring, backfill the hole with SMA or Superpave mixture of the same NMAS and PG asphalt grade as the material sampled or with mixture used for subsequent courses and compact and seal the mixture. Provide traffic control, core, and backfill the core holes at no cost to the Department. The test method used for asphalt determination during the original acceptance testing (PTM No. 757 or PTM No. 702) will be used for the retest, unless the DME/DMM grants written approval for a change in test method. The results of the retest cores will be used to calculate payment for both asphalt content and percent passing the 75 µm (No. 200) sieve for the lot.

When a request is received for retesting of density acceptance, the original density acceptance cores will be utilized. The LTS will not retest a lot for density acceptance when one or more density acceptance cores in the lot were coated with paraffin wax as a result of PTM No. 716 during the original density acceptance testing. The LTS will retest each original density acceptance core according to PTM No. 715 and PTM No. 716, as necessary, to determine the Gmb and bulk density values. The LTS will not perform Gmm testing for lots where the Contractor's Gmm value was previously considered verified as specified in Section 413.3(j)4.d.1. After Gmb testing is completed, for lots where the Contractor's Gmm value was not verified, the LTS will select one original density acceptance pavement core from each production or placement date represented by the density acceptance cores in the lot. Each core selected will be the core with the highest bulk density for that production or placement date from the retest results (e.g., if a lot was placed over three production days, and the lot density acceptance cores include at least one core from each production or placement day, the original density cores selected during a density retest to perform Gmm testing will be 3; one from each production or placement date). The LTS will perform Gmm testing on the selected cores according to AASHTO T 209 as modified in Bulletin 27, with the following exceptions:

- the samples will be obtained as specified in Section 413.3(j)4.c,
- no conditioning, only drying, will be performed on the sample,
- the minimum sample size will be waived, as necessary, to use the 6-inch diameter pavement core sample, and
- the supplemental procedure for mixtures containing porous aggregate will only be performed when either the coarse aggregate or fine aggregate in the mixture has a water absorption value ≥ 1.5% as indicated on the JMF and then only when the calculated percent of theoretical maximum density indicates any one individual failing sublot which results in a density pay factor less than 100.00.

The LTS Gmm value(s) determined will be the Gmm values used to determine the percent of theoretical maximum density for the cores represented by the applicable production or placement dates in the lot. Either the previously verified Contractor's Gmm value(s) or the newly tested LTS Gmm value(s) will be used for acceptance to determine the percent theoretical maximum density for each sublot core in the lot. Upon completing the retesting of the original density acceptance cores, the LTS will evaluate testing repeatability for the bulk density results of PTM No. 715 and PTM No. 716, if necessary, using both the original bulk density test values and the bulk density retest values according to PTM No. 5. After evaluating the testing repeatability, the density test values used to determine the final payment factor percentage for density will be as follows:

- If repeatable, the original test values will be used.
- If lack of repeatability (i.e., non-repeatable), the retest values will be used.

The Department will deduct from the payment the cost per lot associated with conducting a retest as follows in Table L:

TABLE L
Dispute Resolution Retest Cost Table

Test Method	**Mixture Acceptance Retest Cost if Retest Results Indicate** **100% Pay Factor(s)**	**Mixture Acceptance Retest Cost if Retest Results Indicate** **<100% Pay Factor(s)**
PTM No. 702/739	$900	$3,500
PTM No. 757	$500	$2,000
	Density Acceptance Retest Cost if Retest Results Indicate a Lack of Repeatability	**Density Acceptance Retest Cost if Retest Results are Repeatable**
PTM No. 715, or PTM No. 716 only	$200	$750
PTM No. 715, or PTM No. 716, and AASHTO T 209 as specified in Section 413.3(j)4.d.1	$1,100	$4,000

4. Demonstration. Section 419.3(g) PDA

SECTION 703—AGGREGATE

703.1 FINE AGGREGATE—

(a) General. Fine aggregate is natural or manufactured sand consisting of hard, durable, and uncoated inert particles reasonably free from clay, silt, vegetation, and other deleterious substances such as reactive chert, gypsum, iron sulfide, amorphous silica, and hydrated iron oxide. Substances present in amounts large enough to cause inconsistent performance in asphalt concrete or plastic or hardened portland cement concrete are considered deleterious. Spent foundry sand may be used as fine aggregate in asphalt concrete and flowable fill.

Obtain fine aggregate with physical properties according to Table A from a source listed in Bulletin 14 or approved by the LTS before use.

1. Natural Sand. Natural sand is fine aggregate resulting from glacial or water action. Fine aggregate produced simultaneously with gravel coarse aggregate may contain crushed particles.

2. Manufactured Sand. Manufactured sand is fine aggregate from the controlled mechanical breakdown of rock, air-cooled blast furnace slag, or air-cooled steel slag into sound, approximately cubical particles.

Fine aggregate manufactured from limestone may not be used in concrete wearing surfaces.

Fine aggregate manufactured from steel slag may not be used in cement concrete or mortar mixtures. Steel slag fine aggregate may only be used in asphalt wearing courses with the approval of the LTS; however, do not use steel slag fine aggregate in conjunction with steel slag coarse aggregate. Provide steel slag fine aggregate that is uniform in density and quality. If steel slag was manufactured after January 1, 2007, traceability of material must be established. If traceability cannot be established, perform chemical testing according to DEP General Permit WMGR144 and submit the test results to the LTS. Cure steel slag fine aggregate according to the following procedure:

- After gradation preparation, place steel slag fine aggregate, whether reclaimed from an old stockpile or processed directly from the steel-making process, in a controlled stockpile. Limit the stockpile size to a maximum of 30,000 tons. Completely soak the steel slag fine aggregate with water before or during stockpiling. Submit the method of constructing and controlling the stockpile to the Representative for review.

- Maintain the stockpile in a uniform moist condition for a period of not less than 6 months. After the minimum cure period, the Representative will sample and test the stockpile for expansive characteristics according to PTM No. 130. The Representative will approve the stockpile for use if the average total volumetric expansion according to PTM No. 130 is less than 0.50%.

- If the stockpile fails expansion criterion, continue curing the stockpile for a minimum of 2 additional months. The Representative will resample and retest the stockpile after the required additional cure period.

The LTS will evaluate the quality of fine aggregates by conducting petrographic analysis according to PTM No. 518 and other tests necessary to demonstrate that required construction of acceptable durability can be achieved.

(b) Production Testing.

1. Personnel and Equipment. Provide and assign to the work a PennDOT Certified Aggregate Technician who will test fine aggregate at the source according to the requirements listed in Bulletin 14.

Provide equipment for acceptance testing and for developing and maintaining a QC program to ensure compliance with specification requirements during production according to Bulletin 14.

2. Testing and Documentation. Perform tests as required by Bulletin 14. Evaluate the test results to ensure the quality requirements are met.

Document the results of tests made during production and make them available to the Department upon request.

(c) Grading and Quality Requirements.

1. Gradation. Table A lists the extreme limits for determining the suitability of supply sources.

Control the grading of Type A Fine Aggregate so the fineness modulus of at least nine out of ten consecutive test samples from a single source delivered to a project or plant varies less than ± 0.20 from the average fineness modulus of the consecutive test samples. Determine the fineness modulus according to PTM No. 501.

For asphalt mixtures:

- If directed, vary the gradations within the limits according to Table A.
- A blend of fine aggregates may be used if the proposed gradation limits for blending are approved by the District Executive in writing.
- If filler is required, provide fine aggregate conforming to the gradation according to Table A and use cement, cement dust, fly ash, or fines from the crushing of stone, gravel, or slag reasonably free of clay.

2. Material Finer than the 75 µm (No. 200) Sieve. Determine the loss by washing according to PTM No.100.

3. Minimum Strength Ratio. Determine the organic impurities in fine aggregate (Type A and Type C only) according to AASHTO T 21. If the color value result is greater than Organic Plate No. 3, determine the minimum strength ratio according to AASHTO T 71 and use fine aggregate meeting the strength ratio according to Table A.

4. Soundness Test. Determine the percentage loss after five cycles of immersion and drying using a sodium sulfate solution according to PTM No. 510.

5. Specific Gravity and Absorption. AASHTO T 84.

TABLE A
Fine Aggregate
Grading and Quality Requirements

	Cement Concrete Sand	Asphalt Concrete Sand Type B			Mortar Sand
Sieve Size	**Type A**	**#1**	**#3**	**Filler**	**Type C**
9.5 mm (3/8-inch)	100	100	100	—	—
4.75 mm (No. 4)	95-100	95-100	80-100	—	100
2.36 mm (No. 8)	70-100	70-100	65-100	—	95-100
1.18 mm (No. 16)	45-85	40-80	40-80	—	—
600 µm (No. 30)	25-65	20-65	20-65	100	—
300 µm (No. 50)	10-30	7-40	7-40	95-100	—
150 µm (No. 100)	0-10	2-20	2-20	90-100	0-25
75 µm (No. 200)	—	0-10	0-10	70-100	0-10
Material Finer Than 75 µm (No. 200) Sieve Max. Percent Passing	3	—	—	—	—
Strength Ratio Min. Percent	95	—	—	—	95
Soundness Test Max. Loss Percent	10	15	15	—	10
Fineness Modulus	2.30-3.15	—	—	—	1.6-2.5

703.2 COARSE AGGREGATE—

(a) General. Coarse aggregate consists of hard, tough, durable, and uncoated inert particles reasonably free from clay, silt, vegetation, and other deleterious substances such as reactive chert, gypsum, iron sulfide, amorphous silica, and hydrated iron oxide. Substances present in amounts large enough to cause inconsistent performance in asphalt concrete or plastic or hardened portland cement concrete are considered deleterious.

The LTS will evaluate the quality of coarse aggregates by conducting petrographic analysis according to PTM No. 518 and other tests necessary to demonstrate required construction of acceptable durability can be achieved.

Furnish coarse aggregate crushed and prepared from one of the materials described below with physical properties conforming to Tables B, C, and D. Obtain coarse aggregate from a source listed in Bulletin 14 or approved by the LTS before use.

1. Stone. Durable stone free from slate texture or cleavage planes.

2. Gravel. Durable gravel particles. For use in cement concrete, wash thoroughly during production. For use in all asphalt wearing courses, unless otherwise specified, a minimum of 85% crushed particles with at least two faces resulting from fracture is required. For use as No. Open Graded Subbase (OGS), a minimum of 75% crushed particles with at least three faces resulting from fracture is required. For all Type A use, the maximum allowable absorption determined according to AASHTO T 85 is 3.0%; however, this restriction does not apply to dredged river gravel used in portland cement concrete. For all Type B use, the maximum allowable absorption determined according to AASHTO T 85 is 3.5%.

3. Blast Furnace Slag. By-product of a pig-iron making process. Tough, hard, and durable pieces of air-cooled blast furnace slag. If blast furnace slag was manufactured after January 1, 2007, traceability of material must be established. If traceability cannot be established, perform chemical testing according to DEP General Permit WMGR144 and submit the test results to the LTS. Blast furnace slag is excluded from the abrasion requirements. The density (unit weight) of blast furnace slag cannot be less than 70 pounds per cubic foot. If there is more than 5% contamination of steel slag in a stockpile, the stockpile is considered steel slag. Limit the stockpile size to a maximum of 30,000 tons.

4. Steel Slag. By-product of a steel making process. Tough, hard, and durable pieces of steel slag reasonably uniform in density and quality. If steel slag was manufactured after January 1, 2007, traceability of material must be established. If traceability cannot be established, perform chemical testing according to DEP General Permit WMGR144 and submit the test results to the LTS. After crushing, grading, and forming a stockpile, take a sample from the stockpile and submit it to the LTS for testing of expansive characteristics. The LTS will accept the stockpile for use if the total expansion determined according to PTM No. 130 is less than 0.50%. Once a stockpile is accepted, do not add to it if it is for Department use. Limit the stockpile size to a maximum of 30,000 tons. If the stockpile fails expansion requirements, cure the aggregate stockpile as follows:

- Rework the stockpile and soak the aggregate completely with water.
- Submit the proposed method of constructing and controlling the stockpile during the cure period for review and acceptance.
- Maintain the aggregate in a uniformly moist condition in the stockpile for a period of at least 6 months. Take a sample after this curing period and submit it to the LTS for testing according to PTM No. 130.
- The Representative will accept the stockpile for use if the total expansion is less than 0.50%. If the stockpile still fails the expansion requirement, continue curing for at least 2 additional months before resampling and retesting.

Aggregate manufactured from steel slag is not acceptable for pipe or structure backfill, in cement concrete, or as subbase. Aggregate manufactured from steel slag may be used for selected granular material, shoulders, selected material surfacing, and in asphalt surface courses.

5. Granulated Slag. By-product of an iron-making process. Granulated blast furnace slag is the granular glassy material formed if molten slag from iron-making is rapidly quenched by immersion in water and contains not more than 3% total iron reported as Fe_2O_3. If granular slag was manufactured after January 1, 2007, traceability of material must be established. If traceability cannot be established, perform chemical testing according to DEP

General Permit WMGR144 and submit the test results to the LTS. Limit the stockpile size to a maximum of 30,000 tons.

Provide material containing not more than 20% by mass (weight) of substances that are not granulated slag. Use material with a dry rodded density (unit weight) determined according to AASHTO T 19 of not more than 80 pounds per cubic foot. Provide uniform material having a maximum size of 50 mm (2 inches) and not more than 20% passing the 150 µm (No. 100) sieve. Granulated slag may only be used for subbase material as specified in Section 350.

6. Lightweight Aggregate. Acceptable types of lightweight aggregate are as follows:

- Aggregate prepared by expanding, pelletizing, or sintering products such as blast-furnace slag, diatomite, fly ash, clay, shale, or slate.
- Aggregate prepared by processing natural materials such as pumice, scoria, or tuff.

Furnish lightweight aggregate conforming to AASHTO M 195, the soundness and abrasion limits for Type A aggregate according to Table B, and the following durability requirements.

• Aggregate Absorption Factor (PTM No. 526)	Max. %	2.5
• Freeze-Thaw Resistance of Concrete, Decrease of Dynamic Modulus at 300 Cycles (AASHTO T 161, Procedure B, except after 14 days of moist cure, dry the beams 3 inches by 4 inches by 16 inches at 72F ± 3F and approximately 50% relative humidity for 14 days. Then soak the beams in water for 3 days before starting the freezing and thawing test.)	Max. %	60
• Freeze-Thaw Resistance of Aggregate (PTM No. 525)	Max. %	25

TABLE B
Coarse Aggregate
Quality Requirements[7]

	Type A	Type B	Type C	Type S
Soundness, Max. %	10	12	20	16
Abrasion, Max. %	45	45	55	55
Freeze-Thaw Loss, Max %	—	—	—	7.0[6]
Thin and Elongated Pieces, Max. %	15	20	—	—
Material Finer Than 75 µm (No. 200) Sieve, Max. %	—[1]	—[1]	10	10
Crushed Fragments, Min. %	55[2]	55[2]	50	50
Compact Bulk Density (Unit Weight), lbs./cu. ft.	70	70	70	70
Deleterious Shale, Max. %	2	2	10	10
Clay Lumps, Max. %	0.25	0.25	3	3
Friable Particles, Max. % (excluding shale)	1.0	1.0	—	—
Coal or Coke, Max. %	1	1	5	5
Glassy Particles, Max. %	4 or 10[3]	4 or 10[3]	—	—
Iron, Max. %	3[5]	3[5]	3[5]	3[5]
Absorption, Max. %	3.0[4]	3.5[4]	—	2[4]
Total of Deleterious Shale, Clay Lumps, Friable Particles, Coal, or Coke Allowed, Max. %	2	2	15	15

Notes:
(1) Section 703.2(c)4.
(2) Section 703.2(c)5.
(3) Section 703.2(c)9.
(4) Gravel only for Types A and B. as specified in Section 703.2(c)2. All natural aggregates for Type S.
(5) Section 703.2(c)10..
(6) Natural coarse aggregates with an absorption less than 2% are considered freeze thaw resistant and not subject to testing according to AASHTO T 103, Procedure A. Natural aggregates with an absorption exceeding 2% shall be considered freeze thaw resistant if either their sodium sulfate soundness level is less than 16% or their AASHTO T 103 freeze thaw loss after 25 cycles (coarse fraction) does not exceed 7.0%. Type S 2A aggregate may be supplied where Type 2A aggregate for purposes other than subbase is specified at no additional cost to the Department.
(7) Test methods to determine the quality requirements of Table B as specified in Section 703.2 (c).

7. Recycled Concrete. Salvaged and crushed concrete pavements and concrete highway structures from Department, county, or municipal projects for use as 2A aggregate, shall not be used in subbase.

(b) Production Testing.

1. Personnel and Equipment. Provide and assign a PennDOT Certified Aggregate Technician to test coarse aggregate at the source according to Bulletin 14.

Provide equipment for acceptance testing and for developing and maintaining a QC program to ensure compliance with specification requirements during production according to Bulletin 14.

2. Testing and Documentation. Perform tests as required by Bulletin 14. Evaluate the test results to ensure the quality requirements are met.

Document the results of tests made during production and make them available to the Department upon request.

(c) Quality Requirements. The following notes are applicable to Table B.

1. Soundness. Determine the percentage loss after five cycles of immersion and drying using a sodium sulfate solution according to PTM No. 510. The LTS may accept aggregate failing the test if it can be demonstrated in writing the aggregate has a satisfactory service record in both pavements and structures. Acceptable aggregate produced from recycled concrete need not conform to soundness requirements since cementitious material cannot be evaluated with this test.

2. Abrasion. Determine the percentage of loss according to AASHTO T 96.

3. Thin and Elongated Particles. ASTM D4791, Method B, using the material retained on the 4.75 mm (No. 4) sieve. Measure the ratio of 5:1, comparing the length to the thickness of the aggregate particles. Calculate the percentage of flat and elongate particles by mass.

TABLE C
Size and Grading Requirements for Coarse Aggregates
(Based on Laboratory Sieve Tests, Square Openings)

AASHTO Number	Total Percent Passing														
	100 mm (4")	90 mm (3 1/2")	63 mm (2 1/2")	50 mm (2")	37.5 mm (1 1/2")	25.0 mm (1")	19.0 mm (3/4")	12.5 mm (1/2")	9.5 mm (3/8")	4.75 mm (No. 4)	2.36 mm (No. 8)	1.18 mm (No. 16)	300 µm (No. 50)	150 µm (No. 100)	75 µm (No. 200) ***
1	100	90-100	25-60		0-15		0-5								
3			100	90-100	35-70	0-15		0-5							
467				100	95-100		35-70		10-30	0-5					
5					100	90-100	20-55	0-10	0-5						
57					100	95-100		25-60		0-10	0-5				
67						100	90-100		20-55	0-10	0-5				
7							100	90-100	40-70	0-15	0-5				
8								100	85-100	10-30	0-10	0-5			
89								100	90-100	20-55	5-30	0-10	0-5		
9									100	85-100	10-40	0-10	0-5		
10									100	85-100				10-30	
2A**				100			52-100		36-70	24-50	16-38*	10-30			
OGS**				100			52-100		36-65	8-40		0-12			

* Applies only for asphalt mixtures.
** PennDOT Number – Only Type C and Type S will be listed in Bulletin 14.
*** For 75 µm (No. 200), see Table D.

Note A: A combination of No. 7 and No. 5 may be substituted for No. 57, if no more than 50% or less than 30% of the combination is No. 7 size.

Note B: Provide No. OGS material that has a minimum average coefficient of uniformity of 4.0. The average coefficient of uniformity is defined as the average of the sublots within each lot. Determine the coefficient of uniformity according to PTM No. 149 each time the gradation is determined. The required minimum coefficient of uniformity for individual samples is 3.5. If the coefficient of uniformity of any sample falls below 3.5, reject the lot. Do not use the coefficient of uniformity in the multiple deficiency formula.

4. Material Finer than the 75 µm (No. 200) Sieve. Determine the loss by washing according to PTM No. 100 and Table D.

This test is not required for aggregate processed through a mechanical dryer for use in asphalt concrete; however, the aggregate is required to be clean and free of fines that would adversely affect the coating of the aggregate with asphalt material.

This test is not required for AASHTO No. 10 aggregates.

TABLE D
Material Passing the 75 µm (No. 200) Sieve —
(Based on Laboratory Sieve Tests, Square Openings)

Section	Specification	% Maximum
350	Subbase (No. 2A)	10
350	Subbase (No. OGS)	5
470	Bit. Seal Coat	1.0
471	Bit. Seal Coat w/ Precoat. Aggr.	2.0
480	Bit. Surf. Treatment	1.0
704	Cement Concrete	1
—	All other uses	2

5. Crushed Fragments. ASTM D5821

6. Deleterious Shale. Determine the percentage of deleterious shale by four cycles of wetting and drying according to PTM No. 519. The LTS will use petrographic analysis to confirm the results.

7. Friable Particles. Percent loss according to PTM No. 620.

8. Coal or Coke. Determine the percentage of mass (weight) by visual identification and hand separation. If required, the LTS will use petrographic analysis to confirm the results.

9. Glassy Particles. Determine the percentage of mass (weight) by visual identification and hand separation. Pieces of slag containing more than 50% glass are considered to be glassy particles. Waste glass is also considered to be glassy particles. For coarse aggregate used in cement concrete, the maximum percentage of glassy particles allowed is 4%. For other uses, the maximum percentage of glassy particles allowed is 10%. Coarse aggregate containing glassy particles consisting of waste glass may not be used in cement concrete or asphalt wearing courses.

10. Metallic Iron. The LTS will use petrographic analysis to determine the content of metallic iron. Pieces of slag containing metallic iron are considered to be metallic iron. This requirement is waived if aggregate with metallic iron is used in asphalt mixtures or subbase. PTM No. 518.

11. Clay Lumps. Determine the percentage of mass (weight) by visual identification and hand separation. If required, the LTS will use petrographic analysis to confirm the results.

12. Specific Gravity and Absorption. AASHTO T 85.

13. Bulk Density (Unit Weight) and Voids. AASHTO T 19.

(d) Testing and Acceptance. Section 703.5(b)

703.3 SELECT GRANULAR MATERIAL (2RC)—

(a) General. Select granular material consists of durable bank or crushed gravel, stone, or slag mixed or blended with suitable filler materials to provide a uniform mixture. Obtain select granular material from a source listed in Bulletin 14. Stockpile, sample, and test material before it is used to ensure reasonable uniformity and acceptability. Use material free from vegetable or organic matter, lumps, or an excessive quantity of clay or other objectionable or foreign substances and not more than 10% deleterious shale by mass (weight).

(b) Gradation. Conforming to the following gradation, determined according to PTM No. 616:

- Passing 50 mm (2-inch) sieve—100%
- Passing 4.75 mm (No. 4) sieve—15% to 60%
- Passing 150 µm (No. 100) sieve—0% to 30%

703.4 ANTI-SKID MATERIAL—

(a) General. For use on ice or snow-covered pavement surfaces, furnish anti-skid material conforming to Table E from a producer or agent listed in Bulletin 14. Do not use material containing metal, glass, or substances harmful to automotive equipment and vehicles. Use material reasonably free of deleterious substances or foreign materials including, but not limited to, dirt, shale, slate, incinerated asphalt coal mine waste, and within the maximum limits of the individual deleterious and total deleterious materials according to Table B, Type C.

(b) Description.

1. Type AS1. Either natural sand, manufactured sand (except slag aggregates), or a combination of the two conforming to the following requirements:

- Bulk Density (Unit Weight). Minimum 70 pounds per cubic foot and not exceeding 110 pounds per cubic foot determined according to AASHTO T 19.
- Crushed Fragments. If natural sand is furnished, not less than 35% of the fragments retained on the 2.36 mm (No. 8) sieve are required to be crushed fragments, determined according to ASTM D5821.
- Iron. Total of individual anti-skid particles containing metallic iron may not exceed 1.0% by mass (weight) of material, determined by dividing the mass (weight) of such particles retained on the 4.75 mm (No. 4) sieve by the total dry mass (weight) of the sample.

2. Type AS2 and AS3. Crushed stone or crushed gravel conforming to the following requirements:

- Bulk Density (Unit Weight). Minimum 70 pounds per cubic foot and not exceeding 105 pounds per cubic foot determined according to AASHTO T 19.
- Los Angeles Abrasion. Abrasion loss not exceeding 55%, determined according to AASHTO T 96, Gradation D.
- Crushed Fragments. If crushed gravel is furnished, not less than 60% of the fragments retained on the 4.75 mm (No. 4) sieve are required to be crushed, one face, determined according to ASTM D5821.
- Iron. Total of individual anti-skid particles containing metallic iron may not exceed 1.0% by weight of material, determined by dividing the mass (weight) of such particles retained on the 4.75 mm (No. 4) sieve by the total dry mass (weight) of the sample.

3. Type AS4. Crushed slag conforming to the following requirements:

- Bulk Density (Unit Weight). Minimum 70 pounds per cubic foot and not exceeding 105 pounds per cubic foot determined according to AASHTO T 19.
- Los Angeles Abrasion. Abrasion loss not exceeding 55%, determined according to AASHTO T

96, Gradation D.

- Iron. Total of individual anti-skid particles containing metallic iron may not exceed 1.0% by mass (weight) of material, determined by dividing the mass (weight) of such particles retained on the 4.75 mm (No. 4) sieve by the total dry mass (weight) of the sample.

(c) Gradations. According to Table E.

TABLE E
Anti-Skid Gradation

Anti-Skid Type	Maximum Percent Passing Sieve								
	31.5 mm (1 1/4")	19.0 mm (3/4")	12.5 mm (1/2")	9.5 mm (3/8")	4.75 mm (No. 4)	2.36 mm (No. 8)	300 µm (No. 50)	150 µm (No. 100)	75 µm (No. 200)*
Type AS1				100	60-100	0-80		0-8	0-5
Type AS2				100	35-80	0-45		0-6	0-3**
Type AS3			100	90-100		0-30		0-8	
Type AS4				100		0-30		0-8	0-5

* Determined by PTM No. 100.
** If the total percent passing the 2.36 mm (No.8) sieve is less than 25%, the total percent passing the 75 µm (N0. 200) sieve is allowed to be 0-5.

(d) Testing. If shipping, test material for moisture content according to PTM No. 513. A minimum of two tests per day is required. If conditions exist that would cause a change in moisture content, conduct additional tests. A Department representative will verify the test results.

Document tests at the end of delivery quantity at the end of the day and determine the average moisture content. The Department will adjust the delivery quantity by deducting the average moisture content from the aggregate quantity shipped. Payment is based on the calculated oven dry mass (weight).

703.5 ACCEPTANCE OF CONSTRUCTION AGGREGATES—

(a) General. The following describes the certification acceptance of construction aggregates. Accept AASHTO No. 1 Coarse Aggregate as specified in Section 850.2(a)1.

(b) Testing and Acceptance. Certify each day's shipment of aggregate as specified in Section 106.03(b)3.

1. QC. Section 106.03(b)2 and as follows:

- Submit for annual review a QC Plan conforming to the minimum Department requirements for aggregate suppliers.

- Establish and positively identify aggregate stockpiles that have been tested according to the approved QC Plan and conform to Department Specifications. Material may be added to or shipped from stockpiles at the producer's discretion.

2. Source Verification Samples. Under the direction and supervision of the Representative, obtain a verification sample (n=3) from each stockpile to be tested. Obtain the sample from the stockpile according to AASHTO R 90 or from a mini-stockpile. If the mini-stockpile method is chosen, obtain the sample according to the following procedure:

- Place approximately 10 tons of aggregate into a mini-stockpile on a suitable surface. Use a loader to strike off the top of the mini-stockpile.

- Obtain sufficient material for sampling from random locations on the mini-stockpile using a square faced shovel.

If project verification samples or lot acceptance samples in Section 703.5(b)3 result in a Percent Within Limits

(PWL) < 90, the Representative will direct additional source verification sampling of the stockpile(s) from which the failing material was shipped. In such instances, do not ship additional materials from the stockpile(s) until test results from source verification samples have PWL ≥ 90.

Immediately deliver the source verification sample to the Representative for testing using the equipment provided as specified in Sections 703.1(b) and 703.2(b). The Representative will test all three increments according to Tables A, B, C, and D, as applicable. If the test results verify the material conforms to the specifications, use the material under certification, unless project verification samples require lot acceptance.

If the material does not conform to the specifications, the Representative will determine the PWL as specified in Section 106.03(a)3. If source verification results indicate a PWL < 90, the Representative will reject the stockpile.

If a stockpile is rejected, increase QC testing according to the reviewed QC Plan. Construct another stockpile of the aggregate to be tested consisting of 300 tons to 500 tons of material or the remainder of the quantity identified for Department projects, whichever is less. The Representative will accept the material under certification if test results verify the material from the new stockpile conforms to the specifications, unless project verification samples require lot acceptance.

3. Project Verification Samples. Under the direction and supervision of the Inspector, obtain verification samples (n=3) according to Table F for aggregates used for subbase applications under the roadway and shoulders as specified in Section 350. At the preconstruction conference provide the Representative estimated aggregate quantities for subbase applications under the roadway and shoulders. Other aggregate types or applications may be sampled for project verification if the Representative determines the material is visually suspect. Obtain samples at the point of placement (loose aggregate sample on grade before trimming and compaction) and not from project stockpiles unless directed:

TABLE F
Verification Samples

Aggregate Quantities	Number of Samples (n=3)
1,000 tons or more, but less than 2,000 tons	1
2,000 tons or more, but less than 10,000 tons	2
10,000 tons or more, up to 25,000 tons	3
Each additional increment of 25,000 tons	1

The Inspector will select sample locations according to PTM No. 1.

Under the direction and supervision of the Inspector, immediately deliver the sample(s) to the test site at either the producers' location or the project site. The Inspector will test the sample(s) using the equipment provided as specified in Sections 703.1(b) and 703.2(b). The Inspector will test all three increments for compliance with Tables C and D, plus the Crushed Fragments Test of Table B if applicable. The Inspector will provide the test results within 5 days from the date of sampling. The Department will continue to accept material under certification if test results verify the material conforms to the specifications.

If the material does not conform to the specifications, the Inspector will determine the average PWL of the material as specified in Section 106.03(a)3. If results indicate a PWL < 90 for the material, the Department will discontinue certification acceptance and begin project lot acceptance of the aggregate. Discontinue all operations using that size of aggregate until the Representative determines new lot sample locations according to PTM No. 1 and authorizes operations to continue. Conduct lot acceptance testing at the point of placement according to the following procedure:

- Under the direction and supervision of the Inspector, use a PennDOT Certified Aggregate Technician to obtain an acceptance sample (n=3) at the point of placement (loose aggregate sample on grade before trimming and compaction) for each 7,500 tons of material placed. The lot size of 7,500 tons will be divided into three equal sublots.

  - The Inspector will select sample locations according to PTM No. 1. The Inspector will take possession of the sample and immediately transport the sample from the sampling point to the testing site. The Inspector will test all three sample increments for compliance as specified in Section 703.2(c), Tables C and D plus the Crushed Fragments Test of Table B. Aggregates other than gravel will use 100 as the PWL for the Crushed Fragments Test according to Table

B. The Inspector will provide the test results within 5 days of sampling. Failure to provide test results within the targeted timeframe will not form a basis to dismiss the test results, and the test results will govern in all cases.

- If less than 7,500 tons remain for the project, the remaining quantity will be considered a lot. Divide the remaining approximated quantity into three equal sublots so three increments are obtained.

- If a change in aggregate sources is made before three increments are obtained for a lot, obtain additional increments from remaining materials on the project to provide one full acceptance sample (n=3) from the first source.

- The Inspector will document the placement location(s) by station of material placed to clearly delineate the location of all material within the lot.

- The Department will continue project lot acceptance testing until five consecutive lots are accepted at ≥ 90 PWL. Once five consecutive lots are accepted at ≥ 90 PWL, acceptance may again be by producer certification and verification testing will begin again at the frequency according to Table F for the remaining project quantity. The Contractor will be charged $600 for each lot of material placed, for the project lot acceptance testing performed by the Inspector.

- For all test values, the Department will determine the lot PWL as specified in Section 106.03(a)3. If results indicate a PWL ≥ 90, the lot is accepted at full payment. If results indicate a PWL <90 for the material, the Department will determine the Degree of Non-Conformance (DNC) for the lot according to the following:

  - Lot average values for all sieve sizes which do not conform to the specified limits will be used to calculate the DNC. For each sieve where the average does not conform to specifications, the difference between the average test value and the closest specified limit will be computed (upper limit for average values where the upper limit has been exceeded or lower limit for average values where the lower limit was not reached). Each difference will be multiplied by the factor according to Table G.

  - Crushed fragment average test results which do not conform to the specified limits will also be included in the DNC. The DNC will include the difference between the lower specified limit and the lot average crushed fragment test results.

  - The Department will determine the total DNC for the lot by summing of all the non-conformances for each sieve size and crushed fragments after each has been multiplied by applicable factors according to Table G and Table H. The total DNC will be used to adjust the payment represented by the non-conforming lot according to Table I.

TABLE G
Multiplication Factors for DNC

Sieve Size	Multiplication Factor
4 inch to No. 4 inclusive	1.0
No. 5 to No. 80 inclusive	1.5
No. 100	2.0
No. 200 (Table D)	Table H
Crush Count	1.0

TABLE H
No. 200 Sieve Upper Limit and Multiplication Factor

% Maximum	Upper Limit To Calculate DNC	Multiplication Factor
10	10.49	2.5
5	5.49	2.5
2	2.49	2.5
1	1.49	2.5
2.0	2.05	5
1.0	1.05	5

TABLE I
DNC Pay Reduction Percent

Total Sum of DNC	Percent of Contract Unit Price Reduction
0.5 to 3.0	2%
3.1 to 5.0	4%
5.1 to 8.0	7%
8.1 to 12.0	11%
Greater than 12.0	**
**If the sum of the DNC is greater than 12.0, the Representative will direct the material represented by the lot (n=3) be removed and replaced at no additional cost to the Department or left in place and final payment for the material will be at 70% of the contract unit price. Pending the decision by the Representative, do not place additional materials on or incorporated with the non-conforming material.	

4. QA Samples. CMD QA samples (n=3) may be taken at the source of supply or at the point of placement on the project. Submit samples to the LTS for testing. If results for any type of material indicate a PWL of less than 90, the District will immediately obtain an additional verification sample (n=3) at the appropriate site (project or source). The Department will test all three sample increments at either the producer's location or at the project site and determine the PWL for the material. If results indicate a PWL for the material of less than 90, obtain source verification samples and project verification samples as specified in Section 703.5(b)2 and Section 703.5(b)3.

(c) Weighing Responsibilities. Prepare weight slips and certifications attesting to the accuracy of the weights recorded and ensuring conformance as specified in Section 107.23(b). Designate a licensed weigh person(s) to act as the Contractor’s agent. Ensure scales are calibrated annually by an independent agency acceptable to the Department. A Department Inspector may provide random checking.

Weigh empty trucks used to haul material measured by mass (weight) daily unless otherwise directed. If the invoice mass (weight) exceeds the net mass (net weight) determined by a Department mobile weigh team by more than 3%, the Department will consider the deviation to be excessive. Take immediate corrective action upon notification of an excessive deviation. Within 30 days of notification, provide the District Executive with a written description of corrective actions and safeguards and the time they were implemented.

703.6 CERTIFICATION OF AGGREGATES AT ASPHALT AND CEMENT CONCRETE PLANTS—

(a) Certification. Certify aggregate at asphalt and cement concrete plants yearly for quality requirements as specified in Section 106.03(b)3 using Form CS-4171 or another acceptable form.

Pennsylvania Test Methods – Publication 19

This document contains the most relevant Pennsylvania Test Methods for Certified Asphalt Technicians. See PennDOT Publication 19 for a complete list of test methods. The test methods included are from **Change No. 12 of Pub 19**, with effective date of May 27, 2022.

PENNDOT PUBLICATION 19

Test Method

2013 Edition (Change 12)

Commonwealth of Pennsylvania
Department of Transportation

Publication 19

Change	Effective Date
2013 Edition	October 31, 2013
Change No. 1	March 14, 2014
Change No. 2	January 29, 2016
Change No. 3	March 25, 2016
Change No. 4	July 22, 2016
Change No. 5	January 13, 2017
Change No. 6	September 28, 2017
Change No. 7	May 31, 2018
Change No. 8	November 30, 2018
Change No. 9	March 29, 2019
Change No. 10	December 6, 2019
Change No. 11	October 23, 2020
Change No. 12	May 27, 2022

PTMs in THIS DOCUMENT

LABORATORY TESTING SECTION

Method of Test for

PROBABILITY SAMPLING

1. SCOPE

1.1 This method of test outlines the procedures for selecting sampling sites in accordance with accepted probability sampling techniques. It is intended that all Department samples, regardless of size, type or purpose shall be selected in an unbiased manner, based entirely on chance.

2. SECURING SAMPLES

2.1 Department samples shall be taken as directed by the engineer or their authorized representative.

2.2 Sample location and sampling procedure are as important as testing. It is essential that the sample location be chosen in an unbiased manner and the sample taken precisely as directed by the appropriate PTM.

3. RANDOM NUMBER TABLE

3.1 For test results or measurements to be meaningful, it is necessary that the SUBLOTS to be sampled or measured be selected at random, which means using a table of random numbers. The following table of random numbers has been devised for this purpose. To use the table in selecting sample locations, proceed as follows.

3.2 Determine the LOT size and the number of SUBLOTS Per LOT by referring to the PTM for the material being sampled.

3.3 For each LOT, use five consecutive two-digit random numbers from Table I. For example, if the PTM for a particular material specifies five sublots per LOT and the number 15 is randomly selected as the starting point from Column X (or Column Y) for the first LOT, numbers 15-19 would be the five consecutive two-digit random numbers. For the second LOT, another random starting point, number 91 for example, is selected and the numbers 91 through 95 are used for the five consecutive two-digit random numbers. The same procedure is used for additional LOTS.

3.4 For samples taken from the roadway, use the decimal values in Column X and Column Y to determine the coordinates of the sample locations as specified in the appropriate PTM.

3.5 In situations where coordinate locations do not apply (i.e., plant samples, stockpile samples, etc.), use only those decimal values from Column X or Column Y as specified in the appropriate PTM.

4. SAMPLING PROCEDURE

4.1 After the appropriate number of random locations has been determined, refer to the proper PTM for special sampling procedure instructions and examples.

5. DEFINITION OF TERMS

5.1 LOT - an isolated quantity of a specified material from a single source or a measured amount of specified construction assumed to be produced by the same process. The LOT size is specified in the PTM for the material being sampled.

5.2 SUBLOT - a portion of a LOT; the actual location from which a sample is taken. The size of the sublot and the number of sublots per LOT are specified in the PTM for the material being sampled.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
TABLE I
RANDOM POSITIONS IN DECIMAL FRACTIONS (2 PLACES)

	X		Y		X		Y		X		Y
1.	0.29	R	0.66	34.	0.61	L	0.87	67.	0.93	R	0.17
2.	0.74	R	0.49	35.	0.76	R	0.16	68.	0.40	R	0.50
3.	0.89	L	0.79	36.	0.87	L	0.10	69.	0.44	R	0.15
4.	0.60	R	0.39	37.	0.41	L	0.10	70.	0.03	L	0.60
5.	0.88	R	0.31	38.	0.28	R	0.23	71.	0.19	L	0.37
6.	0.72	L	0.54	39.	0.22	L	0.18	72.	0.92	L	0.45
7.	0.12	R	0.08	40.	0.21	L	0.94	73.	0.20	L	0.85
8.	0.09	L	0.94	41.	0.27	L	0.52	74.	0.05	R	0.56
9.	0.62	L	0.11	42.	0.39	R	0.91	75.	0.46	R	0.58
10.	0.71	R	0.59	43.	0.57	L	0.10	76.	0.43	R	0.91
11.	0.36	L	0.38	44.	0.82	L	0.12	77.	0.97	L	0.55
12.	0.57	R	0.49	45.	0.14	L	0.94	78.	0.06	R	0.51
13.	0.35	R	0.90	46.	0.50	R	0.58	79.	0.72	L	0.78
14.	0.69	L	0.63	47.	0.93	L	0.03	80.	0.95	L	0.36
15.	0.59	R	0.68	48.	0.43	L	0.29	81.	0.16	L	0.61
16.	0.06	L	0.03	49.	0.99	L	0.36	82.	0.29	R	0.47
17.	0.08	L	0.70	50.	0.61	R	0.25	83.	0.48	R	0.15
18.	0.67	L	0.68	51.	0.87	L	0.36	84.	0.73	R	0.64
19.	0.83	R	0.97	52.	0.34	L	0.19	85.	0.05	L	0.94
20.	0.54	R	0.58	53.	0.37	R	0.33	86.	0.43	L	0.05
21.	0.82	R	0.50	54.	0.97	L	0.79	87.	0.87	R	0.98
22.	0.66	R	0.73	55.	0.13	R	0.56	88.	0.37	L	0.71
23.	0.06	L	0.27	56.	0.85	R	0.64	89.	0.94	L	0.26
24.	0.03	L	0.13	57.	0.14	L	0.04	90.	0.57	L	0.63
25.	0.55	L	0.29	58.	0.99	R	0.74	91.	0.26	R	0.80
26.	0.64	L	0.77	59.	0.40	L	0.76	92.	0.01	L	0.79
27.	0.30	R	0.57	60.	0.37	L	0.09	93.	0.83	R	0.59
28.	0.51	R	0.67	61.	0.90	R	0.74	94.	0.71	L	0.21
29.	0.29	R	0.09	62.	0.09	L	0.70	95.	0.65	L	0.63
30.	0.63	R	0.82	63.	0.66	L	0.97	96.	0.65	L	0.87
31.	0.53	L	0.86	64.	0.89	L	0.55	97.	0.72	R	0.92
32.	0.99	R	0.22	65.	0.67	L	0.44	98.	0.85	L	0.78
33.	0.02	R	0.89	66.	0.02	R	0.65	99.	0.04	L	0.46
								100.	0.29	L	0.95

X = Decimal fraction of the total length measured along the road from the starting point.
Y = Decimal fraction measured across the road from either outside edge towards the centerline of the paved lane.
R = Indicates measurement from the right edge of the paved lane.
L = Indicates measurement from the left edge of the paved lane.

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PA Test Method No. 510
May 2022
12 Pages

LABORATORY TESTING SECTION

Method of Test for

SOUNDNESS OF AGGREGATE BY USE OF SODIUM SULFATE

1. SCOPE

1.1 This method of test, which is based on AASHTO T 104, covers the procedure to be followed in testing aggregates to determine their resistance to disintegration by saturated solutions of sodium sulfate. This is accomplished by repeated immersion in saturated solutions of sodium sulfate followed by oven drying to partially or completely dehydrate the salt precipitated in permeable pore spaces. The internal expansive force, derived from the re-hydration of the salt upon re-immersion, simulates the expansion of water upon freezing. This test method furnishes information helpful in judging the soundness of aggregates subject to weathering action, particularly when adequate information is not available from service records of the material exposed to actual weathering conditions.

1.2 The values stated in SI units are to be regarded as the standard.

1.3 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCED DOCUMENTS

2.1 AASHTO Standards:

2.1.1 M 231, Weighing Devices Used in the Testing of Materials

2.1.2 R 16, Regulatory Information for Chemicals Used in AASHTO Tests

2.1.3 T 104, Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate

2.2 ASTM Standards:

2.2.1 C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

2.2.2 E11, Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

2.2.3 E100, Standard Specification for ASTM Hydrometers

2.3 Pennsylvania Test Method

2.3.1 PTM No. 616, Sieve Analysis of Coarse and Fine Aggregate

3. APPARATUS

3.1 Sieves- With square openings of the following sizes conforming to ASTM E11, for sieving the samples in accordance with Sections 5, 6, and 8:

4.75 mm	(No. 4)	63 mm	(2½ in.)
4.00 mm	(No. 5)	50 mm	(2 in.)
2.36 mm	(No. 8)	37.5 mm	(1½ in.)
1.18 mm	(No. 16)	31.5 mm	(1¼ in.)
600 µm	(No. 30)	25.0 mm	(1 in.)
300 µm	(No. 50)	19.0 mm	(¾ in.)
150 µm	(No. 100)	16.0 mm	(⅝ in.)
		12.5 mm	(½ in.)
		9.5 mm	(⅜ in.)
		8.0 mm	(5/16 in.)

3.2 Mechanical Sieving Device- A mechanical sieving device shall provide the motion specified in PTM No. 616 (NOTE 1).

NOTE 1- A mechanical sieving device is required for the testing of fine aggregate by this method. Its use is not permitted in the testing of coarse aggregate larger than 9.5 mm (3/8 inch), except for making a rough separation of material prior to washing the sample.

3.3 Containers- Containers for immersing the samples of aggregate in the sodium sulfate solution.

3.3.1 For Fine Aggregates- Stainless steel pots or pans, approximately 105 mm (4⅛ inches) in diameter and not less than 76 mm (3 inches) deep are satisfactory containers for the samples.

3.3.2 For Coarse Aggregates- Stainless steel or aluminum pans, approximately 203 mm (8 inches) in diameter and not less than 76 mm (3 inches) deep are satisfactory containers for the samples.

3.4 Temperature Regulation- Suitable means for regulating the temperature of the samples during immersion in the sodium sulfate solution shall be provided.

3.5 Thermometer- A thermometer covering the recommended temperature range for solutions during the test and readable to 0.1 C (0.2F).

3.6 Balance- A balance conforming to the requirements of AASHTO M 231, Class G2.

3.7 Drying Oven- The oven shall be capable of being heated continuously at 110 °C ± 5 °C (230F ± 9F) and the rate of evaporation, at this range of temperature, shall be at least 25 g/h for 4 hours, during which period the doors of the oven shall be kept closed. This rate of evaporation shall be determined by the loss of water from 1-liter Griffin low-form beakers, each initially containing 500 g of water at a temperature of 21 °C ± 2 °C (70F ± 3F), placed at each corner and at the center of each shelf of the oven. The evaporation requirement is to apply to all test locations when the oven is empty except for the beakers of water.

3.8 Specific Gravity Measurement- Hydrometers conforming to the requirements of ASTM E100, capable of measuring the solution specific gravity within ± 0.001.

4. SPECIAL SOLUTIONS REQUIRED

4.1 Prepare the sodium sulfate solution, for immersion of the test samples, in accordance with Section 4.1.1 (NOTE 2).

NOTE 2- Some aggregates containing carbonates of calcium are attacked chemically by fresh sulfate solution, resulting in erroneously high measured losses. If this condition is encountered or is suspected, repeat the test using a filtered solution that has been used previously to test the same type of carbonate rock, provided that the solution meets the requirements of Sections 4.1.1 for specific gravity.

4.1.1 Sodium Sulfate Solution- Prepare a saturated solution of sodium sulfate by dissolving a reagent grade of anhydrous sodium sulfate salt (NA_2SO_4) in water (Note 4) at a temperature of 25 °C (77F) minimum. Add sufficient anhydrous sodium sulfate salt to ensure not only saturation but also the presence of excess crystals when the solution is ready for use in the tests (NOTE 3). Thoroughly stir the mixture during the addition of the salt and stir the solution at frequent intervals until used. To reduce evaporation and prevent contamination, keep the solution covered at all times when access is not needed. Allow the solution to cool to 20.3 °C to 21.9 °C (68.5F to 71.5F). Again stir, and allow the solution to remain at 20.3 °C to 21.9 °C (68.5F to 71.5F) for at least 48 hours before use. Prior to each use, break up the salt cake, if any, in the container, stir the solution thoroughly and determine the specific gravity of the solution. When used, the solution shall have a specific gravity of not less than 1.154 nor more than 1.171. The solution shall be reused until completion of the required 5 cycles of soaking and drying, after which it shall be discarded (NOTE 2).

NOTE 3- 215 g of anhydrous sodium sulfate salt per liter of water is sufficient for saturation of the sodium sulfate solution at 22 °C (71.6F). However, since this salt is not completely stable and since it is desirable that an excess of crystals be present, the use of not less than 225 g of the anhydrous sodium sulfate salt per liter of water is recommended.

NOTE 4- Distilled water shall be used in referee or comparison testing.

4.2 Barium Chloride Solution- A 0.2 molar solution of barium chloride is used (41.6 g of $BaCl_2$ per liter of solution) to determine the presence of sodium sulfate in the wash water.

5. SAMPLES

5.1 Fine Aggregate- Fine aggregate for the test shall be passed through a 9.5 mm (3/8-inch) sieve. The sample shall be of such a size that it will yield not less than 100 g of each of the following sizes, expressed in terms of the following sieves:

Passing Sieve	Retained on Sieve
9.5 mm (⅜ in.)	4.75 mm (No. 4)
4.75 mm (No. 4)	2.36 mm (No. 8)
2.36 mm (No. 8)	1.18 mm (No. 16)
1.18 mm (No. 16)	600 µm (No. 30)
600 µm (No. 30)	300 µm (No. 50)

5.1.1 Should the gradation of the sample contain less than 5% of any of the sizes specified in Section 5.1, that size shall not be tested.

5.2 Coarse Aggregate- Coarse aggregate for the test shall consist of material from which the sizes finer than the 4.75 mm (No. 4) sieve have been removed. The sample shall be of such a size that it will yield the amounts indicated in Table 1 (NOTE 5).

Table 1 - Coarse Aggregate Sample

Sieve Size	Mass, g
63 mm to 37.5 mm (2½ in. to 1½ in.)	5000 ± 300
Consisting of:	
50 mm to 37.5 mm (2 in. to 1½ in.) material	2000 ± 200
63 mm to 50 mm (2½ in. to 2 in.) material	3000 ± 300
37.5 mm to 19.0 mm (1½ in. to ¾ in.)	1500 ± 50
Consisting of:	
25.0 mm to 19.0 mm (1 in. to ¾ in.) material	500 ± 30
37.5 mm to 25.0 mm (1½ in. to 1 in.) material	1000 ± 50
19.0 mm to 9.5 mm (¾ in. to ⅜ in.)	1000 ± 10
Consisting of:	
12.5 mm to 9.5 mm (½ in. to ⅜ in.) material	330 ± 5
19.0 mm to 12.5 mm (¾ in. to ½ in.) material	670 ± 10

9.5 mm to 4.75 mm (⅜ in. to No. 4)	300 ± 5

NOTE 5- The sample size for AASHTO No. 8's shall be 300 g ± 5 g passing the 3/8-inch sieve retained on the No. 4 sieve only.

5.2.1 Should the gradation of the sample contain less than 5% of any of the sizes specified in Section 5.2, that size shall not be tested. When a combination of sizes is specified for the test portion and one of the sizes specified is less than 5% of the sample gradation, reduce the test portion by the applicable mass specified in Section 5.2 for the size not available.

5.2.2 When testing large rock (broken stone, ledge rock, cobbles, and boulders for use as riprap, channel lining, etc.), obtain the test portion by crushing, splitting, or sawing the larger sample pieces. Test only those pieces in the 37.5 mm to 19.0 mm (1½-inch to ¾-inch) and 63 mm to 37.5 mm (2½-inch to 1½-inch) size fractions when size reduction is by crushing or splitting.

5.2.3 When testing large rock (to evaluate a potential source) that will be subsequently crushed to produce aggregate, obtain the test portion by crushing the larger sample pieces. Test pieces only in those sizes that will be included in the produced aggregate, but ignoring any material finer than 4.75 mm (No. 4) sieve or coarser than 63 mm (2½-inch) sieve.

5.2.4 When the finished aggregate material will contain particles coarser than 63 mm (2½ inches), such as aggregate for use in mass concrete, crush the material coarser than 63 mm (2½ inches) and distribute the material among that in the range of 63 mm (2½ inches) to 4.75 mm (No. 4) sieves. Discard material finer than 4.75 mm (No. 4) sieve.

6. PREPARATION OF TEST SAMPLE

6.1 Fine Aggregate- Thoroughly wash the sample of fine aggregate on a 300 µm (No. 50) sieve, dry to constant mass at 110 °C ± 5 °C (230F ± 9F), and separate into the different sizes by sieving, as follows: Make a rough separation of the graded sample by means of a nest of the standard sieves specified in Section 5.1. From the fractions obtained in this manner, select samples of sufficient size to yield 100 g after sieving to refusal (In general, a 110 g sample will be sufficient). Sieve the selected samples to refusal according to PTM No. 616. Do not use fine aggregate sticking in the meshes of the sieves in preparing the samples. Weigh samples consisting of 100 ± 0.1 g out of each of the separated fractions after final sieving, record the masses of the test samples, and place in separate containers for the test.

6.2 Coarse Aggregate- Thoroughly wash and dry the sample of coarse aggregate to constant mass at 110 °C ± 5 °C (230F ± 9F) and separate it into the different sizes shown in Section 5.2 by sieving to refusal according to PTM No. 616. Weigh out quantities of the different sizes within the tolerances of Section 5.2 and combine them to the designated total mass (NOTE 6). Record the masses of the test samples and their fractional components. In the case of sizes larger than 19.0 mm (3/4 inch), count and record the number of particles in the test samples.

NOTE 6- The fractional components of each sample may be placed in separate containers if so desired, but it is not required. If separate containers are used, the two sizes must be combined for the calculations under Section 8.1.2 (Table 2).

Table 2 - Suggested Form for Recording Test Data (with Illustrative Test Values)

Sieve Size			Grading of Original Sample, Percent Retained	Mass of Test Fractions Before Test, g	Percentage Passing Designated Sieve After Test	Weighted Percentage Loss
Soundness Test of Fine Aggregate						
Minus 150 µm			5			
300 µm to 150 µm			12			
600 µm to 300 µm			26	100	4.20	1.09
1.18 mm to 600 µm			25	100	4.80	1.20
2.36 mm to 1.18 mm			17	100	8.00	1.36
4.75 mm to 2.36 mm			11	100	11.20	1.23
9.5 mm to 4.75 mm			4		11.20[a]	0.45
Totals			100			5.33
Soundness Test of Coarse Aggregate						
63 mm to 50 mm 50 mm to 37.5 mm	2825 g 1958 g	63 to 37.5 mm	20	4783	4.80	0.96
37.5 mm to 25.0 mm 25.0 mm to 19.0 mm	1012 g 513 g	37.5 to 19.0 mm	45	1525	8.00	3.60
19.0 mm to 12.5 mm 12.5 mm to 9.5 mm	675 g 333 g	19.0 to 9.5 mm	23	1008	9.60	2.21
9.5 mm to 4.75 mm	298 g		12	298	11.20	1.34
Totals			100			8.11

[a] The percentage loss (11.20%) of the next smaller size is used as the percentage loss for this size, since this size contains less than 5% of the original sample as received. Section 10.1.3.2.

NOTE 7- Calculate the percentage loss and weighted percentage loss for each size fraction and the weighted average percentage loss to the nearest 0.01%. Record the soundness loss for the appropriate gradation to the nearest 0.01%.

6.3 For PennDOT No. 2A and No. OGS and AASHTO Nos. 57 and 67, the standard grading is as follows:

Table 3 – No. 2A, No. OGS, No. 57, and No. 67 Gradation

Sieve Size		Standard Grading %
Passing	Retained On	
37.5 mm (1½ in.)	19.0 mm (¾ in.)	36.8
19.0 mm (¾ in.)	9.5 mm (⅜ in.)	36.9
9.5 mm (⅜ in.)	4.75 mm (No. 4)	26.3

7. PROCEDURE

7.1 Storage of Samples in Solution- Pour the prepared solution of sodium sulfate into the sample containers in such a manner that the solution covers them to a depth of at least 12.5 mm (1/2 inch), for not less than 16 nor more than 18 hours. Cover the containers to reduce evaporation and prevent the accidental addition of extraneous substances. Maintain the samples immersed in the solution at a temperature of 20.3 °C to 21.9 °C (68.5F to 71.5F) for the immersion period.

7.2 Drying Samples After Immersion- After the immersion period, carefully drain the solution from the sample container and return the solution to a common container for reuse. Then place the sample containers in a drying oven maintained at a temperature of 110 °C ± 5 °C (230F ± 9F). Dry the samples at the specified temperature until constant mass has been achieved. Establish the time required to attain constant mass as follows: with the oven containing the maximum sample load expected, check the mass losses of test samples by removing and weighing them without cooling, at intervals of 2 to 4 hours. Check to establish the required drying time for the least favorable oven location (Section 3.7) and sample condition (NOTE 8). Constant mass will be achieved when the mass loss is less than 0.1% of sample mass in 4 hours of drying. After constant mass has been achieved, allow the samples to cool to 20 °C to 25 °C (68F to 77F) (NOTE 9), when they shall again be placed in the prepared solution and tested as described in Section 7.1. Cooling may be aided by the use of an air conditioner or fan. The temperature of the material shall be checked by thermometer or other acceptable means before placing the material in the soaking solution.

NOTE 8- Drying time required to reach constant mass may vary considerably for several reasons. Efficiency of drying will be reduced as cycles accumulate because of salt adhering to particles and in some cases, because of increase in the surface area due to breakdown. The different size fractions of aggregate will have differing drying rates. The smaller sizes will tend to dry more slowly because of their larger surface area and restricted interparticle voids, but this tendency may be altered by the effects of container size and shape.

NOTE 9- Experience has shown that sample temperatures significantly different than the solution temperature of 20.3 °C to 21.9 °C (68.5F to 71.5F) may change the temperature of the solution temporarily, thereby causing a change in salt saturation even though the solution returns to 20.3 °C to 21.9 °C (68.5F to 71.5F) for most of the soaking period. This may cause erroneous results.

7.3 Number of Cycles- Repeat the process of alternate immersion and drying until five cycles are completed.

8. QUANTITATIVE EXAMINATION

8.1 Make the quantitative examination as follows:

8.1.1 After completion of the final cycle and after the sample has cooled, wash the sample free from the sodium sulfate. Wash by circulating water at 43 °C ± 6 °C (110F ± 10F) through the samples in their containers by introducing hot water near the bottom and allowing the water to pass through the samples and overflow out of the container. The thoroughness of washing shall be checked by obtaining a sample of rinse water after it has passed through the samples and checking the water sample with 0.2 molar barium chloride. Further washing is required if the sample becomes cloudy upon addition of the barium chloride solution. In areas where the water gives a reaction with barium chloride other analytical means shall be used to assure thoroughness of washing. In the washing operation, the samples shall not be subjected to impact or abrasion that may tend to break up particles.

8.1.2 After the sodium sulfate has been removed by washing, dry each fraction of the sample to constant mass at 110 °C ± 5 °C (230F ± 9F). Sieve the fine aggregate over the same sieve on which it was retained before the test, and sieve the coarse aggregate over the sieve shown below for the appropriate size of particle. For fine aggregate, the method and duration of sieving shall be the same as were used in preparing the test samples. For coarse aggregate, sieving shall be by hand, with agitation sufficient only to assure that all undersize material passes the designated sieve. No extra manipulation shall be employed to break up particles or cause them to pass the sieves. Determine the mass of the material retained on each sieve and record each amount. The difference between each of these amounts and the initial mass of the fraction of the sample tested is the loss in the test and is to be expressed as a percentage of the initial mass for use in Table 2.

Size of Aggregate	Sieve Used to Determine Loss
63 mm to 37.5 mm (2½ to 1½ in.)	31.5 mm (1¼ in.)
37.5 mm to 19.0 mm (1½ to ¾ in.)	16.0 mm (⅝ in.)
19.0 mm to 9.5 mm (¾ to ⅜ in.)	8.0 mm (5/16 in.)
9.5 mm to 4.75 mm (⅜ in. to No. 4)	4.0 mm (No. 5)

9. QUALITATIVE EXAMINATION

9.1 Make a qualitative examination of test samples coarser than 19.0 mm (3/4 inch) as follows (Note 10):

9.1.1 Separate the particles of each test sample into groups according to the action produced by the test (NOTE 10).

9.1.2 Count and record the number of particles showing each type of distress.

NOTE 10- Many types of action may be expected. In general, they may be classified as disintegration, splitting, crumbling, cracking, flaking, etc. While only particles larger than 19.0 mm (3/4 inch) in size are required to be examined qualitatively, it is recommended that examination of the smaller sizes be made in order to determine whether there is any evidence of excessive splitting.

10. REPORT

10.1 The report shall include the following data (Note 11):

10.1.1 Mass of each fraction of each sample before the test.

10.1.2 Material from each fraction of the sample finer than the sieve designated in Section 8.1.2 for sieving after the test, expressed as a percentage of the original mass of the fraction.

10.1.3 Weighted average calculated from the percentage of loss for each fraction, based on the grading of the sample as received for examination determined by using PTM No. 616 or, preferably, on the average grading of the material from that portion of the supply of which the sample is representative except that:

10.1.3.1 For fine and coarse aggregate sizes finer than the 300 µm (No. 50) sieve they shall be assumed to have 0% loss.

10.1.3.2 For the purpose of calculating the weighted average, consider any size in Section 5.1 or 5.2 that contain less than 5% of the sample to have the same loss as the average of the next smaller and the next larger size, or if one of these sizes is absent, to have the same loss as the next larger or next smaller size, whichever is present.

10.1.3.3 For large rock tested according to Section 5.2.2 the weighted average (if more than one size fraction is tested) shall be the arithmetic mean of the loss on the fractions tested.

10.1.3.4 For large rock tested according to Sections 5.2.3 or 5.2.4, the weighted average shall be based on a sample grading conforming to the middle of the specification to which the aggregate will be produced, or the actual grading as produced. If the specification grading includes fractions larger than the 63 mm (2½-inch) sieve, assume such sizes to have the same percentage loss as the 63 mm to 37.5 mm (2½-inch to 1½-inch) fraction.

10.1.4 Report the weighted percentage loss to the nearest 0.01%.

10.1.5 In the case of particles coarser than the 19.0 mm (3/4-inch) sieve, report the number of particles counted and recorded in Section 6.2 and Section 9.1.2 as shown in Table 4.

Table 4 - Suggested Form for Qualitative Examination (with Illustrative Test Values)

Qualitative Examination of Coarse Sizes									
	Particles Exhibiting Distress								Total No. of Particles Before Test
	Splitting		Crumbling		Cracking		Flaking		
Sieve Size	No.	Percent	No.	Percent	No.	Percent	No.	Percent	
63 mm to 37.5 mm (2½ to 1½ in.)	2	7			2	7			29
37.5 mm to 19.0 mm (1½ to ¾ in.)	5	-	-	2	-	-	-	-	50

10.1.6 Type of solution (sodium sulfate)

10.1.7 Method of producing particles for test, when reduced from large pieces as described in Sections 5.2.2, 5.2.3, or 5.2.4

NOTE 11- Table 2, shown with test values inserted for purpose of illustration, is a suggested form for recording test data.

11. PRECISION

11.1 For coarse aggregate with weighted average sulfate soundness losses in the range of 6% to 16% for sodium sulfate, the precision indexes are as indicated, in Table 5 (NOTE 12).

Table 5 - Precision Indexes

	Coefficient of Variation (1S%), Percent[a]	Difference Between Two Tests (D2S%), Percent of Average[a]
Multilaboratory:		
Sodium sulfate	41	116
Single-Operator:		
Sodium sulfate	24	68

[a] These numbers represent, respectively, the (1S%) and (D2S%) limits as described in ASTM C670.

NOTE 12- The values in the precision statement are based on testing according to AASHTO T 104 prior to the AASHTO T 104 revisions in 1991. The AASHTO T 104 revisions in 1991 are believed to improve the precision of AASTHO T 104.

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Commonwealth of Pennsylvania
Department of Transportation

PA Test Method No. 616
October 2013
3 Pages

LABORATORY TESTING SECTION

Method of Test for

SIEVE ANALYSIS OF COARSE AND FINE AGGREGATE

This PTM is a modification of AASHTO T-27. The full standard is available from American Association of State Highway and Transportation Officials, 444 N. Capitol Street, N.W., Suite 249, Washington, D.C. 20001 (www.transportation.org).

The modifications to AASHTO T-27 are as follows:

6. APPARATUS

6.4 Oven- An oven of appropriate size capable of maintaining a uniform temperature of 110 ± 5°C (230 ± 9°F). Hot plates either electric or gas may be used when test results must be obtained quickly. Confirmation samples shall be tested using ovens as described in this section.

7. SAMPLING

7.1 Sample the aggregate in accordance with PTM 607.

7.3 Fine Aggregate - The size of the test sample of aggregate, after drying shall have an approximate mass of 500 grams.

7.4 Coarse Aggregate- The mass of the test sample of coarse aggregate shall conform with the following:

AASHTO / PA Number	Minimum Mass of Sample	
	Kg	lb.
# 1	Usual inspection per section 850.2 (a) 1 & 2, Pub. 408	
# 3	20	44
# 5	10	22
# 57	10	22
# 67	10	22
# 7	10	22
# 8	5	11
# 10	1	2
2A	15	33
OGS	15	33

7.7.1 Delete this section
7.7.2 Delete this section
7.7.3 Delete this section

8. PROCEDURE

8.4 (For Fine Aggregates) - Sieve for a sufficient period and in such a manner that, after completion, not more than 0.5 percent by mass of the total sample passes any sieve during 1 minute of continuous hand sieving performed as follows: Hold the individual sieve, provided with a snug fitting pan and cover, in a slightly inclined position in one hand. Strike the side of the sieve sharply with an upward motion while holding the sieve in the other hand, at the rate of about 150 times per minute. Turn the sieve about one-sixth of a revolution at intervals of about 25 strokes.

(For Coarse Aggregates) - Sieve for a sufficient period and in such a manner that, after completion, not more than 0.5 percent by mass of the total sample passes any sieve during 1 minute of continuous mechanical shaking as follows: Weigh the material retained on each individual sieve after the initial shaking period. Individually place each sieve with the material retained on the sieve back into the mechanical shaking device and sieve for an additional minute. In determining the sufficiency of sieving for sizes larger than 4.75 mm (No. 4) sieve, limit the material on the sieve to a single layer of particles.

Note- The Sufficiency of Sieving procedure is documented in PTM 608.

8.7 Determine the mass of each size increment by weighing on a scale or balance conforming to the requirements specified in Section 6.1 to the nearest 0.1 percent of the total original dry sample mass. The total mass of the material after sieving shall check closely with the original mass of sample placed on the sieves. If the amounts differ by more than 0.8 percent, based on the original dry sample mass, the results shall not be used for acceptance purposes.

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Commonwealth of Pennsylvania
Department of Transportation

PA Test Method No. 702
October 2013
24 Pages

LABORATORY TESTING SECTION

Method of Test for

QUANTITATIVE EXTRACTION OF BITUMEN FROM BITUMINOUS PAVING MIXTURES

l. SCOPE

1.1 This method covers procedures for the quantitative determination of bitumen in hot-mixed paving mixtures, mixtures containing liquid bituminous materials, and pavement samples. This method is a modification of AASHTO T-164. Contact the Innovation and Support Services Division, Laboratory Testing Section for copies of the AASHTO or ASTM test methods referred to in this PTM.

1.2 The extracted aggregate may be used for sieve analysis according to PTM No. 739.

NOTE 1- Although bitumen, by definition, is material soluble in carbon disulfide, 1,1,1-Trichloroethane is used in this method for safety reasons. Toluene or Trichloroethylene may also be used.

NOTE 2 - Terpene type solvents may be substituted for 1,1,1-Trichloroethane in Method A providing the following steps have been taken:

1. Follow all steps in Sections 8.2.1 and 8.3.1 modified for Terpene use.

2. A trial extraction of a sample with a known asphalt content has been performed using the modified procedures yielding satisfactory results (± 0.1 percent).

1.3 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. SUMMARY OF METHOD

2.1 The paving mixture is extracted with 1, 1, 1-Trichloroethane using the extraction equipment applicable to the particular method. The bitumen content is calculated by taking the difference between the mass of the original sample, and the combined mass of the extracted aggregate, moisture content, and ash from an aliquot part of the extract. A bitumenometer may be used to determine the bitumen content.

3. APPARATUS

3.1 Oven- Capable of maintaining the temperature at 163 ± 5ºC (325 ± 9 ºF).

3.2 Pan- Flat pan, 300 mm (12 in.) long, 200 mm (8 in.) wide, and 25 mm (1 in.) deep.

3.3 Balance- A balance conforming to the requirements of AASHTO M-231, Class G2.

3.4 Hot Plate- Electric, with an adjustable heating rate.

3.6 Graduated Cylinder- 1000 or 2000 mL capacity

3.7 Ignition Dish- 125 mL capacity

3.8 Desiccator

3.9 Analytical Balance- An analytical balance conforming to the requirements of AASHTO M-231, Class B.

3.10 Muffle furnace or gas burner capable of maintaining temperatures between 500 and 660 C (932 and 1220 F).

4. REAGENTS

4.1 Ammonium Carbonate- Saturated solution of reagent grade ammonium carbonate $(NH_4)_2CO_3$.

4.2 1,1,1-Trichloroethane- Conforming to Federal Specification O-T-620 a (Int. Amd. 3); Refer to Sec. 17.1 (Method D) for an additional requirement when the bitumenometer is used for bitumen content.

NOTE 3- The solvents shall be used only under a hood in a well-ventilated area, since they are all toxic to some degree. The maximum acceptable concentration for an eight hour exposure for 1,1,1-Trichloroethane is 500 ppm.

CAUTION: 1,1,1-Trichloroethane in the presence of heat and moisture may form acids that are extremely corrosive to certain metals, particularly, when subjected to contact over lengthy periods of time. Proper precautions shall be taken to not allow the solvents to remain, even in small quantities in the effluent tanks of aluminum vacuum extractors.

5. WATER DETERMINATION

5.1 Determine the water content of a representative portion of the mixture according to AASHTO T-110, Test for Moisture or Volatile Distillates in Hot-Mix Asphalt.

5.2 Calculate the mass of water in the sample (W_2) by multiplying the moisture content by the mass of the sample.

NOTE 4- The Water Determination Test is conducted only when water is known to be present or if its presence is suspected.

6. PREPARATION OF SAMPLE

6.1 If the mixture is not sufficiently soft to separate with a spatula or trowel, place the mixture in a large flat pan and warm until it can be handled at the following temperature 163 ± 5 ^{o}C (325 ± 9 ^{o} F). Separate the particles of the mixture as uniformly as possible using care not to fracture the mineral particles. Care shall be taken to avoid overheating the sample or leaving the sample in the oven for too long a period. Thoroughly mix the sample and form into a flat pile. Quarter the sample to the required size of sample for the extraction test.

6.2 Recommended approximate sizes of the sample are given in the test methods.

NOTE 5- In no case shall the selection of a predetermined mass be attempted.

NOTE 6- When the required minimum mass of the sample is greater than the allowable maximum mass for the method used, divide the sample into equal portions for testing. The masses for calculations will be the sum of like masses of the test portions.

6.3 Weighing of the extraction test apparatus and/or samples shall be done on a balance meeting the requirements of Section 3.3.

6.4 Mixtures containing liquid bituminous materials (such as cutbacks and emulsified asphalt) shall be cured before testing.

6.4.1 All bituminous mixtures containing emulsified asphalt and cutback asphalt (except stockpile patch mixes containing emulsified asphalt) shall be spread on a tray of sufficient size to hold the total sample, one layer deep. Place the sample in an oven maintained at 163 ± 5 ^{o}C (325 ± 9 ^{o}F) for one-half hour, remove and weigh. Place the sample back in the oven and remove at half-hour intervals until the sample has reached a constant mass. Approximately one to two hours are required. Proceed with the extraction.

6.4.2 Stockpiled patch mixes containing emulsified asphalt shall be cured for 15 minutes at 163 ± 1.5 ^{o}C (325 ±9 ^{o}F), either in an oven or on a hot plate, mixing occasionally.

6.4.3 Stockpiled patch mixes containing polypropylene fibers shall be cured in an oven, overnight at 88 ± 5.5 ^{o}C (190 ± 10^{o}F). Also, the extracted aggregate shall be dried to a constant mass at 88 ± 5.5 ^{o}C (190 ± 10º F).

6.5 Mixtures containing tar (FB-1, FB-2, and some stockpile patch mixes) do not require curing. The sample is extracted by an approved method and the resulting bitumen content corrected for insoluble tar as determined in the remaining part of this section.

6.5.1 Apparatus

6.5.1.1 125 mL Erlenmeyer flask

6.5.1.2 Air cooled condenser, 7 mm glass tube approximately 500 mm (20 in.) long.

6.5.2 Procedure- Prepare a Gooch crucible according to AASHTO T-44 (Section 7) and follow the procedure in AASHTO T- 44 Sections 9 and 10 with the following change:

6.5.2.1 Transfer approximately 2 grams of the tar used to make the mix into a tared 125 mL Erlenmeyer Flask. Weigh accurately to the nearest 0.001 g. Add 100 mL of 1, 1, l-Trichloroethane and place the air condenser into the top of the flask. Place the flask on a hot plate and reflux for 30 minutes. Determine the percent soluble as stated in AASHTO T-44, Section 10.

6.5.2.2 Calculations- Divide the percent bitumen, as determined by extraction, by the percent soluble to find the correct bitumen (tar) content.

6.5.3 In lieu of this procedure, the percent soluble may be obtained from the Laboratory Testing Section, Harrisburg.

METHOD A (CENTRIFUGE METHOD)

7. APPARATUS

7.1 In addition to the apparatus listed in Section 3, the following apparatus is required for Method A.

7.1.1 Extraction apparatus- Consisting of a bowl approximating that shown in Figure 1, which may be revolved at controlled variable speeds up to 3600 rpm. The apparatus shall be provided with a container for catching the solvent thrown from the bowl and a drain for removing the solvent. The apparatus shall be provided with explosion proof features and installed in a hood to provide ventilation.

NOTE 7 - Similar apparatus of a larger size may be used.

7.1.2 Filter ring- A heavy, weighty, smooth, white medium fast filter paper (Eaton-Dikeman Grade 627 has been found satisfactory for this purpose) of a diameter at least equal to the bowl seating surfaces outside diameter and to internally exceed the bowl sealing surfaces width by at least 25.4 mm (1 in).

7.1.3 2000 mL Florence flask

7.1.4 Bitumenometer, 750 or 1500 mL

8. PROCEDURE

8.1 Weigh an approximate 500 to 2500 gram sample into the bowl to the nearest 0.1 gram. In no case shall the wearing course and binder samples be less than 500 and 1000 grams, respectively.

NOTE 8- In the case of Heavy Duty Bituminous Concrete Base Course and Heavy Duty ID-2 Binder, the mass of the sample shall not be less than 1400 grams.

8.2 Cover the sample in the bowl with 1,1,1-Trichloroethane and allow sufficient time for the solvent to disintegrate the sample (not over 1 hour). Place the bowl containing the sample and the solvent in the extraction apparatus. Dry and weigh the filter ring and place it around the edge of the bowl. Clamp the cover on the bowl tightly and place a 2000 mL Florence flask under the drain to collect the extract:

OR

8.2.1 Cover the sample in the bowl with Terpene solvent and let the sample digest for a minimum of 30 minutes. During this period, probe the sample with a metal rod at ten minute intervals. Place the bowl containing the sample and solvent in the extraction apparatus. Dry the bowl. Clamp the cover on the bowl tightly and place the 2000 mL Florence flask under the drain to collect the extract.

8.3 If using the procedure in Section 8.2: Start the centrifuge revolving slowly and gradually increase the speed to a maximum of 3600 rpm or until solvent ceases to flow from the drain. Allow the machine to stop, add 200 mL of solvent and repeat the procedure. Use sufficient 200 mL solvent additions (not less than three) so that the extract is clear and not darker than a light straw color. Collect the extract and the washings in a 2000 mL Florence flask.

8.3.1 If using the procedure in Section 8.2.1: Start the centrifuge revolving and gradually increase the speed to a maximum of 3600 rpm or until solvent ceases to flow from the drain. Allow the machine to stop, add 300 mL of solvent and repeat the procedure. Use three (3) 300 mL solvent additions. Remove the 2000 mL Florence flask with the extract for use in Section 8.5. Place a container under the drain, charge the bowl with 500 mL of tepid water and extract. Repeat using five (5) 300 mL tepid water washings.

NOTE 9- The number of water washings may be decreased if the extraction of samples of known asphalt content indicate satisfactory results (± 0.1 percent).

8.4 Remove the filter ring from the bowl and dry in air. Remove as much of the mineral matter adhering to the filter ring is as possible and add the mineral matter to the aggregate in the bowl. Dry the ring to constant mass in an oven at 163 ± 5 ^oC (325 ± 9 ^oF). Dry the contents of the bowl to a constant mass in an oven at 163 ± 5 ^oC (325 ± 9 ^oF).

NOTE 10- The sample shall be dried until further drying at 163 ± 5 ^oC (325 ± 9 ^oF) does not alter the mass 0.1 percent, the precision of weighing.

8.5 Agitate the extract in the Florence flask thoroughly by swirling to insure uniform dispersion and immediately measure 100 mL into a previously weighed ignition dish. Pour the remaining extract liquid into the graduate, and record the volume (V). Evaporate the extract liquid in the ignition dish to dryness on a hot plate. Burn the residue at a dull red heat (500 to 600 ^oC), cool, and add 5 mL of saturated ammonium carbonate solution $(NH_4)_2CO_3$ per gram of ash. Digest at room temperature for one hour. Dry the ash in an oven at 110 ± 5 ^oC (230 ± 9 ^oF) to a constant mass, cool in a desiccator, and weigh to 0.001 gram on an analytical balance.

8.6 An alternate procedure is to use a bitumenometer, following the procedure in Sections 19.5 and 20.

9. CALCULATIONS

9.1 Calculate the mass of mineral matter in the total volume of extract as follows:

$$\text{grams total ash} = G \text{ x } \frac{V + 100}{100}$$

Where:

G = Mineral matter in grams

V = Volume of the extract after removing the aliquot in milliliters

9.2 Calculate the percentage of bitumen in the sample as follows:

$$\text{\% Bitumen content of a dry sample} = [(W_1 - W_2) - (W_3 + W_4 + W_5)] \text{ x } \frac{100}{(W_1 - W_2)}$$

Where:

W_1 = mass of the sample

W_2 = mass of water in the sample

W_3 = mass of the extracted mineral matter

W_4 = mass of mineral matter in the extract

W_5 = mass of mineral matter on the filter ring

NOTE 11 - Add the increase in the mass of the filter ring to the masses of the recovered aggregate and the ash in the recovered bitumen.

METHOD C (MARYLAND METHOD)

10. APPARATUS

10.1 In addition to the apparatus listed in Section 3, the following apparatus is required for Method C.

10.1.1 Extraction apparatus- Consisting of metal containers, condenser lid and stand similar to that shown in Figure 2.

10.1.2 A basket for the sample as shown in Figure 2. A 4.75 mm (No. 4) or heavier screen shall be placed in the basket to support the sample.

10.1.3 Filter Cloth- (A 16 xx Swiss stencil cloth available from the Atlas Silk Screen Supply Co., 1733 Milwaukee Ave., Chicago, IL 60647 is suitable for this purpose) with approximately 85 µm openings (No.185 mesh), shaped to cover completely the inside of the basket.

10.1.4 Thermometer-, Accurate to 0.1 ^{o}C (0.2° F), covering a temperature range of 19 to 27 ^{o}C (66 to 80 ^{o}F), conforming to the requirements for a 17C (17F) thermometer as prescribed in ASTM Specification E-1.

10.1.5 Scraper- To loosen asphalt and fine bituminous mixture on the bottom of the extractor.

10.1.6 Rubber Gloves, Gas Mask, Trowel, Rubber Tubing, etc.

11. REAGENT

11.1 1,1,1-Trichloroethane.

12. PREPARATION OF SAMPLE

12.1 Samples do not have to be heated prior to extracting but shall be thoroughly dry. The sample size shall be between 3,500 and 11,000 grams. Weigh the basket assembly, place the sample in the basket, and obtain the total mass to the nearest gram.

13. PROCEDURE

13.1 Place the basket with the sample in the extractor. Pour 1150 to 1250 mL of Trichloroethane over the sample. Put the extractor lid tightly in place and allow water to circulate freely through the condenser on the top. Apply heat from a gas ring burner.

13.2 Reflux the samples for 1.5 to 3 hours until all the bitumen is extracted from the aggregate. Shut down the extractor after 1.5 hours and inspect the sample. Mix the sample with a trowel and continue extraction to completion.

NOTE 12- The sample is completely extracted when upon inspection, no discoloration is found either on the aggregate or on the surface of the trowel which has thoroughly mixed the sample.

13.3 Drain the extract from the extraction and wash clean the extractor apparatus with fresh solvent. Recover the extract in a 2000 mL Florence flask. Agitate the extract liquid in the 2000 mL graduate and record the volume. Remove the sample basket and dry in air. The basket shall be dried on a hot plate or oven at 163 ± 5 ^{o}C (325 ± 9 ^{o}F) to a constant mass. Determine the ash recovered bitumen as described in Section 8.5.

13.4 When using the bitumenometer method of bitumen determination use the procedure as stated in Section 19.5.

14. CALCULATIONS

14.1 Calculate the percentage bitumen in the sample as described in Section 9, if the ash method is used, or as in Section 20 when using the bitumenometer.

METHOD D (IMMERSION-REFLUX METHOD)

15. SCOPE

15.1 This method of test is intended for the determination of the percentage of bitumen in a paving mixture in which the aggregate size does not exceed 63 mm (2.5 inches) (NOTE 13). The sample is first immersed in hot solvent, for rapid disintegration of the mixture and extraction of the bitumen, and is then thoroughly washed by refluxing to complete the extraction. The percentage of bitumen is determined by calculation from the specific gravities and the volume of the materials in the extract, using a pycnometer. The mineral matter recovered from either test can be used for the sieve analysis.

NOTE 13 - These methods are adaptable to paving mixtures in which aggregate size is up to 90 mm (3.5 inches) by employing an extractor four times larger than that described herein and a larger pycnometer (bitumenometer) of 1500 mL capacity. The larger apparatus accommodates samples of up to 7000 grams of sample with a larger size aggregate.

16. APPARATUS

16.1 In addition to the apparatus listed in Section 3, the following apparatus is required for Method D.

16.1.1 Extraction apparatus- (Figure 3) Consisting of an extraction kettle of stainless steel or borosilicate glass, with a perforated basket and condenser. The underside of condenser shall be covered with numerous rounded knobs to distribute condensed solvent uniformly onto the surface of the sample. The suspension of the basket shall be arranged to support the basket 12.5 mm (0.5 inches) above the bottom of kettle for immersion of the sample in solvent, a minimum of 75 mm (3 inches) above the bottom of the kettle for refluxing. The apparatus preferably shall be used under a hood to provide ventilation.

16.2 Cloth Filter Sacks for lining the basket

16.3 Bitumenometer (Pycnometer)- Approximately 750 mL capacity, as shown in Figure 3, calibrated to the nearest 0.1 mL. A 1500 mL capacity pycnometer is required for the larger sized extractor.

16.4 Thermometer- Accurate to 0.1 ^{o}C (0.2º F), covering a temperature range of 19 to 27 ^{o}C (66 to 80 ^{o}F), conforming to the requirements for a 17C (17F) thermometer as prescribed in ASTM Specification E-1.

16.5 Cold Water Bath, Metal Funnel, Washing Bottle, Brush, Spatula, etc.

17. SOLVENT

17.1 1,1,1-Trichloroethane- For the bitumenometer method of extract analysis, the specific gravity of solvent must be known within 0.001, and must remain constant through the extraction process. This is considered very important. If the solvent has proper inhibitor(s), the specific gravity should not change. This can be verified by extracting mixtures of known bitumen contents or by subjecting the solvent to the extraction process (without a sample) and measuring the specific gravity before and after the process.

18. PREPARATION OF SAMPLE

18.1 If the mixture is not sufficiently soft to separate with a spatula or trowel, place 2000 to 5000 grams in an oven at 163 ^{o}C (325 ^{o}F) for a maximum of two hours, or on a hot plate over low heat, until it can be handled. Use care not to fracture the mineral particles. Thoroughly mix, form into a flat pile, and quarter to the required size of sample. Insert a filter sack in the extractor basket and weigh the filter and basket with the tared pan to determine the total tared mass. Weigh into the filter sack a representative sample of mix not less than 500 grams if the maximum aggregate size is less than 12.7 mm (0.5 inches). If the maximum aggregate size is 12.7 to 63.5 mm (0.5 to 2.5 inches), the mass of the sample shall not be less than 1000 grams. While transferring the mix onto the filter sack, any fine mix sticking to the inside of the spatula shall be scrapped and included with the sample for extraction. All weighing shall be to nearest 0.1 gram. Larger samples up to 7000 grams may be tested by using a larger apparatus. In no case, however, shall the selection of a sample of a predetermined mass be attempted.

NOTE 14 - In the case of Heavy Duty Bituminous Concrete Base Course and Heavy Duty ID-2 Binder, the mass of the sample shall not be less than 1500 grams.

19. PROCEDURE

19.1 Attach the suspension rod to the loaded basket and set the assembly into the extraction kettle. Pour carefully approximately 600 mL of solvent over sample. The extractor can be filled with the solvent prior to suspending the loaded basket in the extraction kettle. Set the condenser cover in place on the kettle. Provide a flow of cold water through the condenser cover.

19.2 Raise the basket to the immersion level, i.e. 12.5 mm (0.5 inch) above the bottom of the kettle, by inserting the support pin through the upper hole of the suspension rod. Place the extractor on the hot plate or over a burner and adjust the heating rate so that solvent is maintained at a gentle boil. Avoid vigorous boiling which might wash fines over the sides of the basket. Continue heating the sample during the immersion position for 15 to 30 minutes, depending upon composition, size, and age of sample.

19.3 Raise the basket to the refluxing level, a minimum of 75 mm (3 inches) above the bottom of the kettle, by inserting the pin through the lower hole of the suspension rod. Increase the heat and maintain active boiling for 15 to 30 minutes, or until solvent dripping from the basket appears colorless. If a stainless steel kettle is used, solvent can be examined by lifting the basket out of the condenser assembly.

19.4 Remove the extractor from the heat source and allow the extractor to cool for several minutes. Lift the basket out of the condenser assembly. Remove the filter sack, distribute its contents onto the tared pan in which the sample was originally weighed, dry on hot plate over low heat, or in an oven at 163 ± 5 ^{o}C (325 ± 9 ^{o}F) to a constant mass, with the filter sack on top of the aggregate. Use care not to char the sack. Place the extractor basket onto the pan, and weigh the assembly of aggregate, filter sack, extractor, and tared pan. Subtract the total tared mass from the mass of this assembly and record this weight as the mass of extracted aggregate.

19.5 While the aggregate is being dried, set the covered kettle in a cold water bath 50 to 120 mm (2 to 4 inches) deep to hasten cooling to approximately 27 ^{o}C (80 ^{o}F). Transfer the extract to the bitumenometer, using a funnel. Wash down the inside of the kettle with solvent, adding enough additional solvent to fill the bitumenometer to the base of the neck. Air bubbles must be eliminated. Adjust the temperature of the bitumenometer contents to 25 ^{o}C (77.0 ^{o}F) (NOTE 15). Insert the volume adjustment stopper, fill the stopper capillary and apply the overflow cap. Dry the outside of the bitumenometer and weigh to the nearest 0.1 of a gram (NOTE 16). Subtract the mass of the bitumenometer from this mass and record as the mass of the extract. Record the actual temperature of the extract to the nearest 0.1 ^{o}C (0.2 ^{o}F) at the time of weighing.

NOTE 15 – A correction can be applied for extract temperatures differing from 25 ^{o}C (77.0 ^{o}F), between 23 and 27 ^{o}C (74 and 80 ^{o}F). Corrections for solvents can be computed from their specific gravity and coefficient of expansion. If a 750 mL bitumenometer is used, the following corrections have been determined to be adequate: add 1.23 grams to the mass of the extract for each degree ^{o}C above 25 ^{o}C (0.7 g per degree above 77 ^{o}F), and subtract 1.23 grams from the weight for each degree below 25 ^{o}C (0.7 g per degree below 77 ^{o}F).

NOTE 16 - The mass of the bitumenometer filled with the extract liquid shall be taken very carefully. Variations of ± 0.5 gram in mass can affect the asphalt content determination by ± 0.1 percent.

20. CALCULATIONS

20.1 Calculate the percentage bitumen in the sample using one of the following procedures:

PROCEDURE 1

$$\% \text{ bitumen} = [G_2/(W_1(G_3-G_2))] \times [G_3(V_l-((W_2+W_3-W_l)/G_l))+W_3-W_l] \times 100$$

Where:

G_1 = Specific gravity of the solvent at 25 ^{o}C (77.0 ºF) (within 0.001)

G_2 = Specific gravity of the bitumen at 25 ^{o}C (77.0 ºF) (within 0.01)

G_3 = Specific gravity of the aggregate fines at 25 ^{o}C (77.0º F) (within 0.1)

V_l = Volume of the bitumenometer at 25 ^{o}C (77.0º F)

W_1 = Mass of the original dry sample

W_2 = Mass of the extract

W_3 = Mass of the extracted aggregate

NOTE 17- The formula above corrects for the amount of fines contained in the extract.

NOTE 18- It is very important that the specific gravity values of solvent and bitumen are very accurate. The bitumen content will vary by approximately ± 0.1 percent for the following variations in the measurements of specific gravities:

specific gravity of the solvent ± 0.001
specific gravity of the bitumen ± 0.01

NOTE 19 - If the specific gravity values of aggregate fines are not known, the following values may be used:

stone	2.70
gravel	2.60
slag	2.95

20.2 Calculate the mass of fines in the extract as follows:

$W_4 = (G_3/(G_3-G_2))$ X $[W_l-W_3-G_2(V_1-((W_2-W_l+W_3)/G_l))]$

Where:

W_4 = Mass of the fines in the extract

PROCEDURE 2

Percent Bitumen Calculation

Specific Gravity of Bitumen (± 0.01) at 25 C (77.0 F)	G_2 =
Specific Gravity of Aggregate Fines (± 0.1) at 25 C (77.0 F)	G_3 =
Specific Gravity of Solvent (± 0.001) at 25 C (77.0 F)	G_1 =
Volume of Bitumenometer at 25 C (77.0 F)	V_1 =
Weight of Original Sample	W_1 =
- Weight of Extracted Sample	W_3 =
Weight of Extraction Loss or weight of bitumen and fines:	$W_c = W_1-W_3$
Weight of Bitumenometer and Extracted liquid	W_a =

- Weight of Bitumenometer	W_b =
Weight of Extracted Liquid	$W_2 = W_a - W_b$
Weight of Extracted Liquid	W_2 =
- Weight of Extraction loss or weight of bitumen and fines	W_c =
Weight of Solvent	$W_d = W_2 - W_c$

$$\frac{\text{Weight of Solvent } (W_d)\ (\quad)}{\text{Sp. Gr. Of Solvent } (G_1)\ (\quad)} = \text{Volume of Solvent } (V_a) \text{ in the Bitumenometer}$$

Volume of Bitumenometer	V_1 =
- Volume of Solvent	V_a =
Volume of Extraction Loss or Volume of Bitumen & Fines:	$V_b = V_1 - Va$
Volume of Extraction Loss	V_b =
x Sp. Gr. Of Aggregate Fines	G_3 =
Algebraic Term (Weight of Extraction Loss)	$a_1 = V_b x G_3$ =
Algebraic Term (Weight of Extraction Loss)	a_1 =
- Weight of Extraction Loss	W_c =
Algebraic Term (Weight of Bitumen)	$a_2 = a_1 - W_c$ =
Specific Gravity of Aggregate Fines	G_3 =
- Specific Gravity of Bitumen	G_2 =
Algebraic Term (Weight of Bitumen)	$a_3 = G_3 - G_2$ =

$$\frac{\text{Algebraic Term (Weight of Bitumen) } (a_2)\ (\quad)}{\text{Algebraic Term (Sp. Gr. Of Bitumen) } (a_3)(\quad)} = \text{Volume of Bitumen in Sample } (V_c)$$

Volume of Bitumen in Sample	V_c =
x Specific Gravity of Bitumen	G_2 =
Weight of Bitumen in Sample	$W_e = V_c x G_2$ =

$$\frac{\text{Weight of Bitumen in Sample } (W_e)\ (\quad)}{\text{Weight of Original Sample } (W_1)\ (\quad)} \times 100 = \_\_\% \text{ of Bitumen in Sample}$$

Weight of Original Sample	W_1 =
- Weight of Bitumen	W_e =
Weight of Total Aggregate in Sample	$W_f = W_1 - W_e$ =

Weight of Extraction loss (bitumen and fines)	W_c =
- Weight of Bitumen	W_e =
Weight of Fines in Sample	$W_4 = W_c - W_e$ =

PROCEDURE 3

Percent Bitumen Calculation

20.3 If the ash method is used, calculate the percent bitumen in the sample as described in Section 9.

MODIFIED METHOD D (IMMERSION-REFLUX-CENTRIFUGE)

21 SCOPE

21.1 This method of test is intended for the determination of asphalt content of bituminous mixtures in which the aggregate size does not exceed 63mm (2.5 inches). The sample is first immersed in hot solvent, for rapid disintegration of the mixture and extraction of the bitumen. The sample is thoroughly washed by refluxing, the extract liquid is run through a centrifuge to trap the fines.

22. APPARATUS

22.1 In addition to the apparatus listed in Section 3, the following apparatus is required for Modified Method D.

22.1.1 Extraction apparatus (Figure 3)- Consisting of an extraction kettle of stainless steel or borosilicate glass, with a perforated basket and condenser. The underside of the condenser shall be covered with numerous rounded knobs to distribute condensed solvent uniformly onto the surface of the sample. The suspension of the basket shall be arranged to support the basket 12.5 mm (0.5 inches) above the bottom of the kettle for immersion of the sample in solvent, a minimum of 75 mm (3 inches) above the bottom of the kettle for refluxing. The apparatus preferably shall be used under a hood to provide ventilation.

22.1.2 Cloth Filter Sacks for lining the basket

22.1.3 Centrifuge- High-speed (3000 rev./min or higher). A continuous flow type with a metal thimble to catch the fines.

23. SOLVENT

23.1 normal-Propyl Bromide (*n*PB), conforming to ASTM D6368

24. PREPARATION OF SAMPLE

24.1 If the collected mixture sample is not sufficiently soft to separate with a spatula, scoop, or trowel, place the collected mixture sample in an oven at 163 ± 5°C (325 ± 9°F) for a maximum of 2 hours, or on a hot plate over low heat, until it is sufficiently soft to separate. Thoroughly mix, form into a flat pile, and quarter the mixture sample. Use care not to fracture the mineral particles. The minimum mass of the test sample shall be the result of quartering from a larger mixture sample and shall conform to the minimum mass requirements in Table 1.

Table 1

Superpave or SMA Mixture Nominal Maximum Aggregate Size (NMAS), mm	**Other Asphalt Mixtures or Material Classes**	**Minimum Mass of Test Sample, g**
12.5 or smaller	FJ-1, FJ-1C, FJ-4, FB-1W, FB-2W, FB-3 Modified, Micro-Surfacing, Ultra-Thin Friction Course, Cold Path	500
19	ATPBC, FB-1B, FB-2B, FB-Modified	1000
25 or greater		1500

25. PROCEDURE

25.1 Insert a filter sack in the extractor basket and determine the total tare mass of the filter, basket, suspension rod, and pan to the nearest 0.1 g.

25.2 Prepare the test sample according to Section 24. Using a scoop, add the minimum mass of test sample according to Table 1 into the filter sack. Scrape any fine mixture particles that stick to the inside of the scoop with a spatula and include the fine particles in the filter sack with the mixture test sample for extraction.

25.3 Attach the suspension rod to the basket and set the assembly into the extraction kettle. Carefully pour 700 ± 50 ml of solvent over the sample. The extractor can be filled with solvent prior to suspending the loaded basket. Set the condenser cover in place on the kettle. Provide a flow of cold water through the condenser cover.

25.4 Raise the basket to the immersion level, 12mm (0.5 inches) above the bottom of the kettle by inserting the support pin through the upper hole of the suspension rod. Place the extractor on the hot plate and adjust the heat rate so that the solvent is maintained at a gentle boil. Avoid vigorous boiling which might wash fines over the sides of the basket. Continue heating with the sample in the immersion position for a minimum of 30 minutes.

25.5 Raise the basket to the reflux level, a minimum of 75mm (3 inches) above the bottom of the kettle by inserting the pin through the lower hole of the suspension rod. Increase the heat and maintain active boiling for a minimum of 30 minutes, or until solvent dripping from the basket appears colorless. If a stainless steel kettle is used, the solvent can be examined by lifting the basket out of the condenser assembly.

25.6 Remove the extractor from the hot plate and lift the basket out of the condenser assembly. Remove the suspension rod and basket from the condenser assembly. Remove the filter sack, distribute its contents into the pan and dry on a hot plate over low heat, or in an oven at 163°C ± 5°C (325°F ± 9°F) to a constant mass, with the filter sack on top of the aggregate. Use care not to char the filter sack.

25.7 When the aggregate is dry, place the extractor basket and the suspension rod assembly into the pan. Weigh and record the mass of the aggregate, filter sack, suspension rod assembly and pan to the nearest 0.1 g.

25.8 While the aggregate is being dried, allow the kettle to cool to approximately 27°C (80°F). To hasten cooling set the kettle in a cold water bath 50 mm to 120 mm (2 to 4 inches) deep.

25.9 Place a pre-weighed thimble in the centrifuge. Run the extract liquid through the centrifuge 3 times. Wash the material in the thimble using a final wash of approximately 200 ml of clean solvent or enough wash solvent until the wash runs clear.

25.10 Dry the thimble and material in an oven at 163 C ± 5°C (325 F ± 9°F). Record the weight of the thimble and material.

26. CALCULATIONS

Calculate the percentage bitumen in the sample using the following procedure:

1. Wt. of pan + basket + filter + sample ____________________

2. Wt. of pan + basket+ filter ____________________

A. 1-2 = Wt. of original sample ____________________

3. Wt. of pan + basket + filter + aggregate ____________________

4. Wt. of pan + basket + filter ____________________

B. 3-4 = Wt. of aggregate in the pan ____________________

5. Wt of aggregate in the thimble ____________________

6. Wt. of the thimble ____________________

C. 5-6 = Wt. of aggregate in the thimble ____________________

Calculation for Percent Bitumen:

$$\frac{A-(B+C)}{A} \times 100 = \%\ AC$$

27. PRECISION

The following data shall be used for judging the acceptability of the results (95 percent probability).

27.1 Duplicate results by the same operator should be considered suspect if they differ by more than the following amounts:

	repeatability
standard deviation, percent	0.12
bitumen content, percent	0.34

27.2 The result submitted by one laboratory should not be considered suspect unless the result differs from that of another laboratory by more than the following amounts:

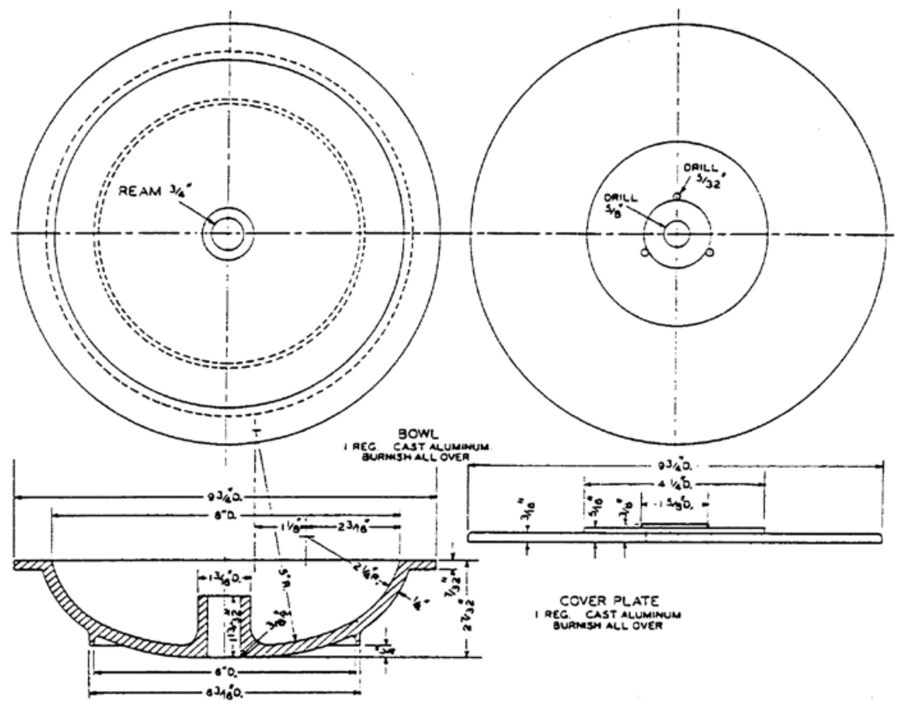
	reproducibility
standard deviation, percent	0.20
bitumen content, percent	0.56

NOTE 20- The precision statement is derived from 10 laboratories testing 4 samples with 3 replicates per test.

28. REFERENCE

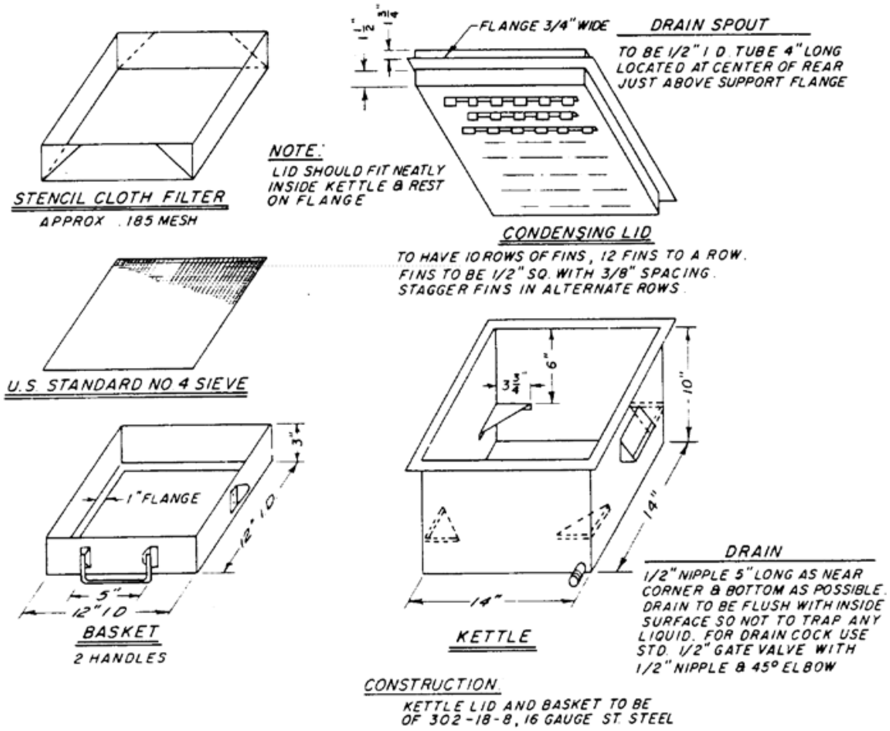
AASHTO Method T-164 ASTM Method D 2172

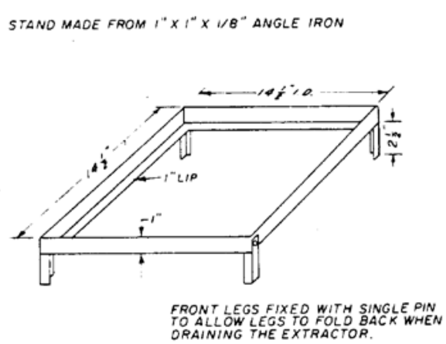
Attachments: Figures 1 thru 4; Table 1.



NOTE—See Table 1 for metric equivalents.

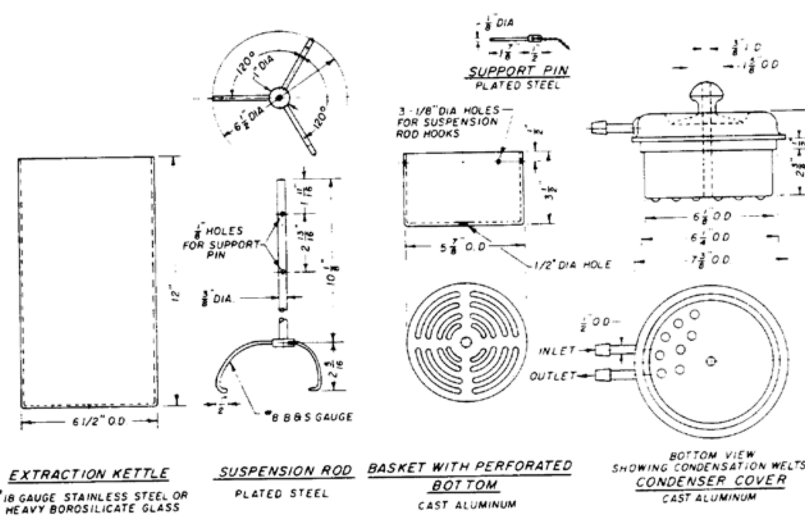
Figure 1 - Extraction Unit Bowl





See Table 1 for metric equivalents.

FIG. 2



NOTE—See Table 1 for metric equivalents.

FIG. 3

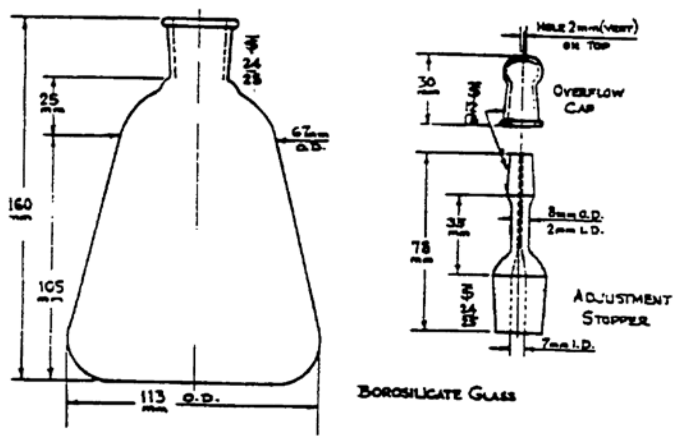


Figure 4 - Bitumenometer, 750ml Capacity

TABLE 1 Metric Equivalents for Figures

Inch-Pound Units, in.	SI Equivalent,mm	Inch-Pound Units, in.	SI Equivalent,mm	Inch-Pound Units, in.	SI Equivalent,mm
1/8	3.2	1 11/16	43	5 7/8	149
3/16	4.8	1 3/4	44	6	152
7/32	5.6	2 3/16	55	6 1/8	155
1/4	6.3	2 7/32	56	6 3/16	157
5/16	7.9	2 5/16	59	6 1/4	159
3/8	9.5	2 1/2	64	6 1/2	165
1/2	12.7	2 5/8	69	7 3/8	187
5/8	15.9	2 13/16	72	8	207
3/4	19.0	3	76	9 3/4	247
1	25.0	3 3/4	96	10	254
1 1/8	28.6	4	102	10 1/8	257
1 3/16	30.2	4 1/4	108	12	305
1 13/32	35.7	5	127	14	355
1 1/2	38.0	5 7/16	138	14 1/2	370
1 5/8	41.0				

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Commonwealth of Pennsylvania
Department of Transportation

PA Test Method No. 703
October 2013
3 Pages

LABORATORY TESTING SECTION

Method of Calibration for

VOLUMETER

1. SCOPE

This method is intended to determine the volume of the volumeter.

2. APPARATUS

2.1 Volumeter- Of an appropriate capacity

2.2 Thermometer- ASTM 17 C (17 F) having a range of 19 to 27 ^{o}C (66 to 80 ºF), graduated in 0.1 ^{o}C (0.2 º F) subdivisions

2.3 Water Bath- Thermostatically controlled so as to maintain the bath temperature at 25 ± 0.5 ^{o}C (77 F ± 0.9º F)

2.4 Balance- A balance conforming to the requirements of AASHTO M-231, Class G2.

2.5 Distilled Water- Freshly-boiled distilled water

3. SIGNIFICANCE

3.1 It is essential that all equipment is calibrated accurately. Exercise care in calibrating the equipment. All subsequent tests are dependent on the calibrated equipment. It is also important to calibrate all equipment and material at the same temperature as will be used in conducting the test. All air bubbles shall be eliminated prior to weighing. All weights shall be made to the nearest tenth (0.1) of a gram. The maximum permissible variation in temperature shall not exceed ± 0.1 ^{o}C (± 0.2º F) from the specified temperature.

4. PROCEDURE

4.1 Weigh the clean, dry volumeter (metal pycnometer). Fill the volumeter with freshly-boiled distilled water, cover, and immerse the volumeter for one hour in a distilled water bath maintained at 25 ^{o}C (77º F). Remove the cover, and eliminate any air bubbles that are present. If necessary add distilled water to fill the volumeter. Cover and make certain that the capillary tube is filled with water, wipe the volumeter dry, and weigh.

5. CALCULATIONS

5.1 Calculate the volume of the volumeter as follows:

$$(WV_o + W_a) - WV_o = Vv_o$$

Where:

$W\ V_o$ = mass of the volumeter in grams

W_a = mass of the water in grams

$V\ V_o$ = volume of the volumeter in mL's

NOTE 1- The mass of the volumeter in grams plus the mass of the water in the volumeter in grams, minus the mass of the volumeter in grams, equals the volume of the volumeter in mL's.

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LABORATORY TESTING SECTION

Method of Test for

EFFECTIVE ASPHALT CONTENT OF BITUMINOUS PAVING MIXTURES

1. SCOPE

1.1 This method computes the effective asphalt content in a bituminous paving mixture. The effective asphalt content (P_{be}) of a paving mixture is the total asphalt content (P_b) minus the quantity of asphalt lost by absorption into the aggregate particles. It is the portion of the total asphalt content that remains as a coating on the outside of the aggregate particles in which the service performance of a paving mixture depends.

1.2 The effective asphalt content (not the total asphalt content) is to be used to compute the VMA (voids in mineral aggregate) and the VFA (voids filled with asphalt) in Marshall specimens (PTM No. 705) and pavement cores.

2. REFERENCED DOCUMENTS

2.1 AASHTO Standards:

2.1.1 R 76, Reducing Samples of Aggregate to Testing Size

2.1.2 T 84, Specific Gravity and Absorption of Fine Aggregate

2.1.3 T 85, Specific Gravity and Absorption of Coarse Aggregate

2.1.4 T 133, Density of Hydraulic Cement

2.1.5 T 209, Theoretical Maximum Specific Gravity (Gmm) and Density of Hot Mix Asphalt (HMA)

2.1.6 T 228, Specific Gravity of Semi-Solid Asphalt Materials

2.2 Pennsylvania Test Methods:

2.2.1 PTM No. 705, Marshall Criteria for Compacted Bituminous Specimens

3. MATERIALS AND TESTS

3.1 Coarse Aggregate(s)

3.1.1 A representative sample of the coarse aggregate(s) shall be obtained in accordance with AASHTO R 76.

Nominal Maximum Size (inches)	Minimum Mass of Sample (kg)
12.5 mm (1/2 inch) or less, (1B) aggregate	2.5
25.0 mm (1 inch), (2B) aggregate	4.5

3.1.2 The bulk specific gravity (dry) of the coarse aggregate(s) shall be determined in accordance with AASHTO T 85 using the following formula (the value shall be reported to three decimal places):

$$\text{Bulk Sp. Gr.} = \frac{A}{B - C}$$

3.2 Fine Aggregate(s)

3.2.1 A representative sample of the fine aggregate(s) weighing at least 1.0 kg shall be obtained in accordance with AASHTO R 76.

3.2.2 The bulk specific gravity (dry) of the fine aggregate(s) shall be determined in accordance with AASHTO T 84 using the following formula (the test value shall be reported to three decimal places):

$$\text{Bulk Sp. Gr.} = \frac{A}{B + S - C}$$

3.3 Mineral Filler

3.3.1 If a mineral filler is added separately to the paving mixture, a representative sample weighing at least 200 g shall be obtained in a plastic lined bag.

3.3.2 The specific gravity of the mineral filler shall be determined in accordance with AASHTO T 133 using kerosene as a wetting agent. The test value shall be reported to three decimal places.

3.4 Asphalt Cement

3.4.1 The specific gravity of the asphalt cement (G_b) shall be determined at 25 °C (77F) in accordance with AASHTO T 228 and shall be reported to three decimal places. The value furnished by the asphalt supplier may be used.

3.5 Bituminous Paving Mixture

3.5.1 The maximum specific gravity (G_{mm}) of the loose bituminous paving mixture containing a known asphalt content (P_b), by total mass of the mixture, shall be determined by AASHTO T 209.

3.5.2 The effective specific gravity (G_{se}) of the combined aggregates in the same mixture shall be calculated as follows (Note 1):

$$G_{se} = \frac{G_{mm}\,(100 - P_b)}{100 - \dfrac{G_{mm}\,\text{FUNCx}\,P_b}{G_b}}$$

Where:

G_{se} = effective specific gravity of the aggregates

G_{mm} = maximum specific gravity of the loose paving mixture

P_b = asphalt content, percent by total weight of the mixture

G_b = specific gravity of the asphalt

NOTE 1- A worksheet to calculate the effective specific gravity(G_{se}) by the above formula is appended to this PTM.

4. CALCULATIONS

4.1 Bulk specific gravity of the total aggregate (G_{sb})- When the total aggregate consists of separate fractions of coarse aggregate(s), fine aggregate(s), and mineral filler (if added separately), all having different specific gravities, the combined bulk specific gravity for the total aggregate is calculated as follows (assuming there are three aggregates):

$$G_{sb} = \frac{P_1 + P_2 + P_3}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \frac{P_3}{G_3}}$$

Where:

G_{sb} = bulk specific gravity of the total aggregate

P_1, P_2, P_3 = percentages by weight of aggregates l, 2 and 3 in the paving mixture

G_1, G_2, G_3 = bulk specific gravities of aggregates l, 2, and 3 (Sections 3.1, 3.2, and 3.3 of this PTM)

NOTE 2- A worksheet to calculate G_{sb} by the above formula is appended to this PTM.

4.2 Percent asphalt absorbed by the aggregate (P_{ba})- Absorption is expressed as a percentage by weight of aggregate rather than as a percentage by total weight of the mixture. It shall be calculated as follows:

$$P_{ba} = \frac{G_{se} - G_{sb}}{G_{se} \times G_{sb}} \times G_b \times 100$$

Where:

P_{ba} = absorbed asphalt, percent by weight of aggregate

G_{se} = effective specific gravity of the aggregate

G_{sb} = bulk specific gravity of the aggregate

G_b = specific gravity of the asphalt

NOTE 3 - A worksheet to calculate P_{ba} by the above formula is appended to this PTM.

4.3 Effective asphalt content of the paving mixture- The effective asphalt content (P_{be}) of a paving mixture is the total asphalt content minus the quantity of asphalt lost by absorption into the aggregate particles.

Effective asphalt content (P_{be}) shall be calculated as follows:

$$P_{be} = P_b - \frac{P_{ba}}{100}(100 - P_b)$$

Where:

P_{be} = effective asphalt content, percent by total weight of the mixture

P_b = asphalt content, percent by total weight of the mixture

P_{ba} = absorbed asphalt, percent by weight of the aggregate

NOTE 4 - A worksheet to calculate P_{be} by the above formula is appended to this PTM.

5. REPORT

5.1 Effective asphalt content (P_{be}) shall be reported to the nearest 0.1 percent.

5.2 Effective asphalt content (P_{be})is intended to be used to compute the VMA (voids in mineral aggregate) and the VFA (voids filled with asphalt) using the Marshall specimen worksheet (PTM No. 705).

6. REFERENCES

6.1 Asphalt Institute MS-2, Asphalt Mix Design Methods

APPENDIX TO PTM No. 709

EXAMPLE 1 (Using Formula)

Given:

Constituent Material	Value	Bulk Sp. Gr Test Method	Percent by Weight Total Mix
Coarse aggregate	2.604 (G_1)	AASHTO T 85	51.4 (P_1)
Fine aggregate #1	2.827 (G_2)	AASHTO T 84	18.7 (P_2)
Fine aggregate #2	2.619 (G_3)	AASHTO T 84	22.9 (P_3)
Asphalt cement	1.010 (G_b)	AASHTO T 228	7.0 (P_b)
		TOTAL:	100.0

Maximum Sp. Gr. of Mix (AASHTO T 209) = 2.439 (G_{mm})

Calculate the Effective Asphalt Content in the above mixture as follows:

(a) Bulk Sp. Gr. of the Total Aggregate (G_{sb})

$$G_{sb} = \frac{P_1 + P_2 + P_3}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \frac{P_3}{G_3}}$$

$$= \frac{51.4 + 18.7 + 22.9}{\frac{51.4}{2.604} + \frac{18.7}{2.827} + \frac{22.9}{2.619}}$$

$$= \frac{93.0}{19.739 + 6.615 + 8.744}$$

$$= \frac{93.0}{35.098} = 2.650$$

(b) Effective Sp. Gr. of the Total Aggregate (G_{se}):

$$G_{se} = \frac{G_{mm}\,(100 - P_b)}{100 - \dfrac{G_{mm} \text{ x } P_b}{G_b}}$$

$$= \frac{2.439\,(100 - 7.0)}{100 - \dfrac{2.439 \text{ x } 7.0}{1.010}}$$

$$= \frac{226.827}{100 - 16.904}$$

$$= \frac{226.827}{83.096} = 2.730$$

(c) Percent Asphalt Absorbed by the Aggregate (P_{ba}):

$$P_{ba} = \frac{G_{se} - G_{sb}}{G_{se} \text{ x } G_{sb}} \text{ x } G_b \text{ x } 100$$

$$= \frac{2.730 - 2.650}{2.730 \text{ x } 2.650} \text{ x } 1.010 \text{ x } 100$$

$$= \frac{0.080}{7.234} \text{ x } 101.0 = 1.117$$

(d) Effective Asphalt Content (P_{be}) in the Mixture:

$$P_{be} = P_b - \frac{P_{ba}}{100}(100 - P_b)$$

$$= 7.0 - \frac{1.117}{100}(100 - 7.0)$$

$$= 7.0 - 1.039$$

$$= 5.961 = 6.0 \text{ (rounded to one-tenth percent)}$$

WORK SHEET
DETERMINATION OF EFFECTIVE ASPHALT CONTENT

A. BULK SP. GR. OF TOTAL AGGREGATE (G_{sb})

Aggregate	Type (Coarse or Fine)	Percentage in Mix (P)	Bulk Sp. Gr. (G)	$\frac{P}{G}$
Aggregate #1	Coarse (1B)	51.4	2.604	19.739
Aggregate #2	Fine (Nat. Sand)	18.7	2.827	6.615
Aggregate #3	Fine (Screenings)	22.9	2.619	8.744
Aggregate #4	—	—	—	—
Mineral Filler	—	—	—	—
TOTALS	—	93.0	—	35.098

$$G_{sb} = \frac{\text{Summation of P}}{\text{Summation of P/G}} = \frac{93.0}{35.098} = 2.650$$

B. EFFECTIVE SP. GR. OF TOTAL AGGREGATE (G_{se})

Line		1	2	3
1	Max. Sp. Gr. Of Mix (G_{mm})	2.439		
2	% Total AC in Mix (P_b)	7.0		
3	Sp. Gr. Of AC (G_b)	1.010		
4	Line 2 ÷ Line 3 (cc of AC)	6.931		
5	100 - Line 2	93.0		
6	Line 1 x Line 5	226.827		
7	Line 1 x Line 4	16.905		
8	100 - Line 7	83.095		
9	Line 6 ÷ Line 8 (Effective Sp. Gr. Of Total Aggregate, (G_{se})	2.730		

Average Value of G_{se} =

C. PERCENT ASPHALT ABSORBED BY AGGREGATE (P_{ba})

Line

1	Effective Sp. Gr. Of Total Aggregate (G_{se})	2.730
2	Bulk. Sp. Gr. Of Total Aggregate (G_{sb})	2.650
3	Sp. Gr. Of Asphalt Cement (G_b)	1.010
4	Line 1 - Line 2	0.080
5	Line 1 x Line 2	7.2345
6	Line 4 ÷ Line 5	0.01106
7	Line 6 x Line 3	0.01117
8	Line 7 x 100 (Percent AC Absorbed by Aggregate, P_{ba})	1.117

D. EFFECTIVE ASPHALT CONTENT IN MIX (P_{be})

Line

1	% Total AC in Mix (P_b)	7.0
2	% AC Absorbed by Aggregate (P_{ba})	1.117
3	Line 2 - 100	0.01117
4	100 - Line 1	93.0
5	Line 3 x Line 4	1.0388
6	Line 1 - Line 5 (Effective Asphalt Content in Mix, P_{be})	5.9612 6.0 (rounded)

TR-4265 (9-77)
M (1/96)

Example

MARSHALL SPECIMEN WORK SHEET

SAMPLE NO.	1					
SPECIFICATION	ID-2W					
AGGREGATE	Gravel					
% ASPHALT (Total) P_b	7.0					
MASS SAMPLE + H_2O	1826.9					
– MASS S.S.D. SAMP.	1229.3					
= VOL WATER	597.6					
VOL VOLUMETER	1122.8					
– VOL WATER	597.6					
= VOL SAMPLE	525.2					
MASS SAMPLE	1228.8					
÷ VOL SAMPLE	2.439					
= SP GR SAMPLE	503.8					
MASS SAMPLE	1228.8					
÷ THEOR. SP GR (Gmm)	2.439					
= THEOR. VOL.	503.8					
VOL. SAMPLE	525.2					
– THEOR. VOL.	503.8					
= VOL. VOIDS	21.4					
÷ VOL. SAMPLE	525.2					
= % VOIDS	4.1					
MASS SAMPLE	1228.8					
x % ASPHALT (Effective) P_{be}	6.0					
= MASS ASPHALT	73.7					
÷ SP GR A.C.	1.010					
= VOL. A.C.	73.0					
+ VOL. VOIDS	21.4					
= VOL. V.M.A.	94.4					
÷ VOL. SAMPLE	525.2					
= % V.M.A.	18.0					
VOL. ASPHALT	73.0					
÷ VOL. V.M.A.	94.4					
= % V.F.A.	77.3					
MASS S.S.D. SAMP.						
– DRY MASS						
= MASS ABSORB.						
÷ VOL. SAMPLE						
= % ABSORB (VOL.)						
STABILITY						
FLOW						
AVG. SP. GR.						
AVG. % VOIDS						
AVG. % VMA						
AVG. % VFA						
AVG. STABILITY						
AVG. FLOW						

TR-4265 (9-77)
M (1/96)

MARSHALL SPECIMEN WORK SHEET

SAMPLE NO.						
SPECIFICATION						
AGGREGATE						
% ASPHALT						
MASS SAMPLE + H_2O						
– MASS S.S.D. SAMP.						
= VOL WATER						
VOL VOLUMETER						
– VOL WATER						
= VOL SAMPLE						
MASS SAMPLE						
÷ VOL SAMPLE						
= SP GR SAMPLE						
MASS SAMPLE						
÷ THEOR. SP GR						
= THEOR. VOL.						
VOL. SAMPLE						
– THEOR. VOL.						
= VOL. VOIDS						
÷ VOL. SAMPLE						
= % VOIDS						
MASS SAMPLE						
x % ASPHALT *(Effective)*						
= MASS ASPHALT						
÷ SP GR A.C.						
= VOL. A.C.						
+ VOL. VOIDS						
= VOL. V.M.A.						
÷ VOL. SAMPLE						
= % V.M.A.						
VOL. ASPHALT						
÷ VOL. V.M.A.						
= % V.F.A.						
MASS S.S.D. SAMP.						
– DRY MASS						
= MASS ABSORB.						
÷ VOL. SAMPLE						
= % ABSORB (VOL.)						
STABILITY						
FLOW						
AVG. SP. GR.						
AVG. % VOIDS						
AVG. % VMA						
AVG. % VFA						
AVG. STABILITY						
AVG. FLOW						

WORK SHEET FOR DETERMINATION OF
EFFECTIVE ASPHALT CONTENT

A. BULK SP. GR. OF THE TOTAL AGGREGATE (G_{sb})

Aggregate	Type (Coarse or Fine)	Percentage in Mix (P)	Bulk Sp. Gr. (G)	$\frac{P}{G}$
Aggregate #1				
Aggregate #2				
Aggregate #3				
Aggregate #4				
Mineral Filler				
TOTALS				

$$G_{sb} = \frac{\text{Summation of P}}{\text{Summation of P/G}} =$$

B. EFFECTIVE SP. GR. OF THE TOTAL AGGREGATE (G_{se})

		1	2	3
1	Max. Sp. Gr. of the Mix (G_{mm})			
2	% Total AC in the Mix (P_b)			
3	Sp. Gr. of the AC (G_b)			
4	Line 2 ÷ Line 3 (cc of AC)			
5	100 - Line 2			
6	Line 1 x Line 5			
7	Line 1 x Line 4			
8	100 - Line 7			
9	Line 6 ÷ Line 8 (Effective Sp. Gr. of the total aggregate, (G_{se})			

Average Value of G_{se} =

C. PERCENT ASPHALT ABSORBED BY AGGREGATE (P_{ba})

Line		
1	Effective Sp. Gr. of the total aggregate (G_{se})	
2	Bulk. Sp. Gr. of the total aggregate (G_{sb})	
3	Sp. Gr. of the Asphalt Cement (G_b)	
4	Line 1 - Line 2	
5	Line 1 x Line 2	
6	Line 4 ÷ Line 5	
7	Line 6 x Line 3	
8	Line 7 x 100 (Percent AC Absorbed by the aggregate, P_{ba})	

D. EFFECTIVE ASPHALT CONTENT IN MIX (P_{be})

Line		
1	% Total AC in the Mix (P_b)	
2	% AC Absorbed by the aggregate (P_{ba})	
3	Line 2 - 100	
4	100 - Line 1	
5	Line 3 x Line 4	
6	Line 1 - Line 5 (Effective Asphalt Content in the Mix, P_{be})	

PA Test Method No. 715
October 2013
5 Pages

LABORATORY TESTING SECTION

Method of Test for

DETERMINATION OF BULK SPECIFIC GRAVITY OF COMPACTED BITUMINOUS MIXTURES

1. SCOPE

1.1 This method of test is intended for determining the bulk specific gravity of laboratory compacted bituminous mixtures or bituminous roadway samples, such as cores, small sawed slabs, density ring samples, etc. This method shall not be used if the samples contain open or interconnecting voids and/or absorb more than 3.0 percent water. For such samples, PTM No. 716 shall be used.

2. TEST SPECIMEN

2.1 Compacted specimens in accordance with PENNDOT Methods or obtained in accordance with PENNDOT methods of sampling a compacted roadway.

2.2 Size of specimens- It is recommended, (1) that the diameter of cylindrically molded or cored specimens, or the length of the sides of the sawed specimens, be at least equal to four times the nominal maximum size of the aggregate; and (2) that the thickness of the specimens be at least 1.5 times the nominal maximum size of the aggregate.

2.3 Specimens shall be free of foreign materials such as seal coat, tack coat, foundation material, soil, paper, or foil.

2.4 If desired, specimens may be separated from the other pavement layers by sawing or other suitable means. Care shall be exercised to ensure sawing does not damage the specimens.

METHOD A (VOLUMETER)

3. APPARATUS

3.1 Weighing Device-A weighing device conforming to the requirements of AASHTO M-231, Class G2

3.2 Water Bath- Thermostatically controlled so as to maintain the bath temperature at 25 ± 0.5ºC (77 ± 0.9ºF)

3.3 Thermometer- ASTM 17C (17F), having a range of 19 to 27ºC (66 to 80ºF), graduated in 0.1ºC (0.2ºF) subdivisions

3.4 Volumeter[1] - Calibrated, 1.2 L or an appropriate capacity depending upon the size of the test sample

4. PROCEDURE

4.1 Immerse the specimen in the water bath and let saturate for at least 10 minutes. At the end of the 10 minute period, fill a calibrated volumeter with distilled water at 25 ± 1ºC (77 ± 1.8ºF). Place the saturated specimen into the volumeter. Bring the temperature of the water in the volumeter to 25 ± 1ºC (77 ± 1.8ºF), and cover the volumeter making certain that some water escapes through the capillary bore of the tapered lid. Wipe the volumeter dry with a dry absorbent cloth and weigh the volumeter and contents to the nearest 0.1 of a gram.

4.2 Remove the immersed and saturated specimen from the volumeter, quickly damp dry the saturated specimen with a damp towel, and as quickly as possible weigh the specimen. Any water that seeps from the specimen during the weighing operation is considered as a part of the saturated specimen. Dry the specimen to constant mass (NOTE 1). Weigh the dried specimen to the nearest 0.1 of a gram.

> NOTE 1- Constant mass shall be defined as the mass at which further drying at 52 ± 3ºC (125 ± 5ºF) does not alter the mass by more than 0.05 percent. Samples saturated with water shall initially be dried overnight at 52 ± 3ºC (125 ± 5ºF), flipped top to bottom, then dried until a Minimum Standard Drying Time of 20 hours has elapsed. This Minimum Standard Drying Time shall be reestablished using the procedure in NOTE 1A if there are substantial changes in ovens, paving materials, or mix design methods from 2002 conditions. Laboratory compacted specimens and density ring samples need not be dried.

[1]Aluminum Volumeters of different sizes available from Pine Instrument Co., 101 Industrial Drive, Grove City, PA. 16127 and Rainhart Co., 604 Williams St., Austin, TX, 78765 have been found suitable.

NOTE 1A- PROCEDURE FOR DETERMINING A MINIMUM STANDARD DRYING TIME: Assemble a random sample of cores representing the compacted asphalt mixtures typically tested. Saturate the cores with water, and place the saturated cores in the 52 ± 3ºC (125 ± 5ºF) oven overnight. At the start of the following workday flip the cores top to bottom. Continue to dry and weigh the cores at two-hour intervals until constant mass is attained. Document and use the time it took for all cores to reach constant weight as the Minimum Standard Drying Time.

NOTE 2- If desired, the sequence of testing operations can be changed to expedite the test results. For example, first the dry mass of the specimen can be determined. Then the volumeter containing the saturated specimen and water can be weighed. The mass of the saturated specimen can be obtained last.

5. CALCULATIONS

5.1 Calculate the bulk specific gravity (dry basis) of the samples as follows (report the value to three decimal places):

$$GSm = \frac{WSm}{(0.997 \text{ g/mL}) \times [VVo - (1.003 \text{ mL/g}) \times (WT - WSa - WVo)]}$$

Where:

GSm = bulk specific gravity of the specimen at 25.0ºC (77ºF)

WSm = mass in grams of the dry specimen

VVo = volume in mL of the volumeter at 25.0ºC (77ºF) to the nearest tenth of a milliliter

WT = total mass in grams of the volumeter, saturated specimen, and water in the volumeter at 25.0ºC (77ºF)

WSa = mass in grams of the saturated specimen

WVo = mass in grams of the volumeter

5.2 Calculate the percent water absorbed by the specimen as follows (report the value to one decimal place):

$$\text{Percent Water Absorbed} = \frac{WSa - WSm}{(0.997\ g/mL) \times [VVo - (1.003\ mL/g) \times (WT - WSa - WVo)]} \times 100$$

If the percent water absorbed is more than 3.0 percent, use PTM No. 716.

METHOD B (SUSPENSION IN WATER)

AASHTO T-166, Method A, except as follows:

NOTE 1- replace with the following: Constant mass shall be defined as the mass at which further drying at 52 ± 3ºC (125 ± 5ºF) does not alter the mass by more than 0.05 percent. Samples saturated with water shall initially be dried overnight at 52 ± 3ºC (125 ± 5ºF), flipped top to bottom, then dried until a Minimum Standard Drying Time of 20 hours has elapsed. This Minimum Standard Drying Time shall be reestablished using the procedure in NOTE 1A if there are substantial changes in ovens, paving materials, or mix design methods from 2002 conditions. Laboratory compacted specimens and density ring samples need not be dried.

Add: NOTE 4 – Referee Method- In case of discrepancies between the test results obtained by Method A and Method B, the referee test shall be Method A.

METHOD C (RAPID TEST)

AASHTO T-166, Method C

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Commonwealth of Pennsylvania
Department of Transportation

PA Test Method No. 716
October 2013
6 Pages

LABORATORY TESTING SECTION

Method of Test for

DETERMINATION OF BULK SPECIFIC GRAVITY OF COMPACTED BITUMINOUS MIXTURES THAT ABSORB MORE THAN 3.0 PERCENT WATER BY VOLUME

1. SCOPE

1.1 This method of test is intended for determining the bulk specific gravity of laboratory compacted bituminous mixtures or bituminous roadway samples that contain open or interconnecting voids and/or absorb more than 3.0 percent of water by volume.

2. TEST SPECIMEN

2.1 Compacted specimens in accordance with PENNDOT Methods or obtained in accordance with PENNDOT Methods of sampling a compacted roadway.

METHOD A (VOLUMETER)

3. APPARATUS

3.1 Balance- A balance conforming to the requirements of AASHTO M-231, Class G2

3.2 Water Bath- A thermostatically controlled bath, capable of maintaining the bath temperature at 25 ± 0.5ºC (77 ± 0.9ºF)

3.3 Thermometer- An ASTM 17 C (17 F), having a range of 19 to 27ºC (66 to 80ºF), graduated in 0.1ºC (0.2ºF) subdivisions

3.4 Volumeter[1] – Calibrated, 1.2 L or an appropriate capacity depending on the size of the test sample

[1]Aluminum Volumeters of different sizes available from Pine Instrument Co., 101 Industrial Drive, Grove City, PA. 16127 and Rainhart Co., 604 Williams St., Austin. TX 78765 have been found suitable.

4. PROCEDURE

4.1 Dry the specimen to constant mass (NOTE 1) and weigh the specimen to the nearest tenth (0.1) of a gram.

NOTE 1- Constant mass shall be defined as the mass at which further drying at 52 ± 3ºC (125 ± 5ºF) does not alter the mass by more than 0.05 percent of the test load.

4.2 Coat the specimen with melted paraffin sufficiently thick to seal all surface voids. Allow the specimen to cool in air at room temperature for 30 minutes, and then weigh to the nearest tenth (0.1) of a gram.

NOTE 2- Application of the paraffin may be accomplished by chilling the specimen in a refrigerating unit to a temperature of approximately 4.5ºC (40ºF) for 30 min. and then dipping the specimen in warm paraffin at 5.5ºC (10º F) above the melting point. It may be necessary to brush the surface of the specimen with added hot paraffin in order to fill any pinpoint holes.

4.3 Fill a calibrated volumeter with distilled water at 25ºC (77ºF). Place the coated specimen into the volumeter and cover the volumeter making certain that some water escapes through the capillary bore in the tapered lid. Wipe the volumeter dry with a dry absorbent cloth and weigh the volumeter and its contents to the nearest tenth (0.1) of a gram.

4.4 Determine the specific gravity of the paraffin at 25 ± 1ºC (77 F ± 2ºF), if unknown, using the bitumenometer method, as is used for determining the specific gravity of bitumen (AASHTO T-228).

5. CALCULATIONS

5.1 Calculate as follows:

$$GSm = \frac{WSm}{VVo - [(PWSm + WWa) - PWSm + \frac{(PWSm - WSm)}{GP}}$$

Where:

GSm = Specific gravity of the specimen at 25.0ºC (77ºF)

WSm= Mass in grams of the uncoated specimen in air at 25.0ºC (77ºF)

VVO = Volume in cc of the volumeter at 25.0 ºC (77ºF)

PWSm = Mass in grams of the paraffin coated specimen in air at 25.0 ºC (77ºF)

(PWSm + WWa) = Mass in grams of the paraffin coated specimen and water in the volumeter at 25.0ºC (77ºF)

GP = Specific gravity of the paraffin at 25.0ºC (77ºF)

5.2 Report the bulk specific gravity value to three decimal places.

NOTE 3- The mass of the specimen and water in the above formula does not include the mass of the volumeter. The use of a tare weight for the volumeter is recommended.

NOTE 4- If the bulk specific gravity value of the sample is to be converted to kg/m^3 (pounds per cubic foot), it shall be multiplied by 1000 (62.4) and the value rounded to the nearest tenth.

METHOD B (SUSPENSION IN WATER)

6. APPARATUS

6.1 Balance-Conforming to the requirements of AASHTO M- 231, Class G2. The balance shall be equipped with a suitable suspension apparatus and holder to permit weighing the specimen while suspended from the center of the scale pan of the balance (NOTE 5).

NOTE 5- The holder should be immersed to a depth sufficient to cover it and the sample during weighing. Wire suspending the holder should be the smallest practical size to minimize any possible effects of a variable immersed length.

6.2 Water Bath- For immersing the specimen in water while suspended under the balance, equipped with an overflow outlet for maintaining a constant water level. The water bath temperature shall be maintained at 25 ± 1ºC (77 ± 2ºF).

7. PROCEDURE

7.1 Weigh the uncoated specimen after it has been dried to constant mass (NOTE 1). Designate this as mass A.

7.2 Coat the test specimen on all surfaces with melted paraffin sufficiently thick to seal all voids. Allow the specimen to cool in air at room temperature for 30 minutes, then weigh the specimen. Designate this as mass D (NOTE 2).

7.3 Weigh the coated specimen in the water bath at 25 ± 1ºC (77 ± 2ºF). Designate this as mass E.

7.4 Determine the specific gravity of the paraffin at 25ºC (77ºF), if unknown, and designate this as mass F.

8. CALCULATION

8.1 Calculate the bulk specific gravity of the specimen as follows (report to three decimal places):

$$\text{Bulk Specific Gravity} = \frac{A}{D - E - \frac{(D - A)}{F}}$$

Where:

A = mass of the dry specimen in air

D = mass of the dry specimen plus paraffin in air

E = mass of the coated specimen in water

F = specific gravity of the paraffin at 25ºC (77ºF)

9. REFEREE METHOD

9.1 In case of discrepancies between the test results obtained by Methods A and B. The referee test shall be Method A.

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LABORATORY TESTING SECTION

Method of Test for

SIEVE ANALYSIS OF EXTRACTED AGGREGATE

1. SCOPE

1.1 This method of test covers a procedure for the determination of the particle size distribution of aggregates extracted from bituminous mixtures using sieves with square openings. This method was developed for use with PTM 702, Method D.

2. APPARATUS

2.1 Balance- Conforming to the requirements of AASHTO M-231, Class G2.

2.2 Sieves- Square openings and conforming to the requirements AASHTO M-92. All sizes shall be available as required by bituminous concrete specification.

2.3 Timer- An electric timer accurate and variable in one-minute increments with a minimum range of 15 minutes.

2.4 Mechanical Shaker- Capable of performing the sieving action as specified in Section 4.3.

3. SAMPLE

3.1 The sample shall consist of the entire aggregate sample from PTM 702.

NOTE 1- When the extracted sample is too large in quantity to be sieved over one set of 203.2 mm (8") sieves, the sample may be split and sieved over more than one set of 203.2 mm (8") sieves. The weights on each sieve size are combined for calculation of the final percent passing. For sieves with openings of 4.75 mm (No.4) and larger, the mass retained in grams at the completion of the sieving operation shall not exceed the product of 2,500 x (sieve opening in mm) x (sieving surface area in m^2). For the 2.36 mm (No.8) sieve, the mass retained shall not exceed 9 kg/m^2 (6g/$in.^2$), or 300 g for the usual 8-inch diameter sieve. For sieves with openings smaller than 2.36 mm (No.8), the mass retained shall not exceed 6 kg/m^2 (4g/$in.^2$), or 200 g for the usual 8-inch diameter sieves.

3.2 If the sample has remained at room temperature for more than one hour it shall be dried to constant mass.

4. PROCEDURE

4.1 Record the mass of the extracted aggregate from PTM No. 702.

4.2 The sample shall be sieved over sieves of various sizes as required by the bituminous concrete specifications. The mass of material passing each sieve and retained on the next shall be recorded, starting with the pan mass (material passing the 75 μm (No. 200) mesh) and continuing up to and including the maximum sieve size.

4.3 The sieving operation shall be conducted by means of a circular motion of the sieve accompanied by a jarring action to keep the sample moving continuously over the surface of the sieve. In no case shall fragments in the sample be turned or manipulated through the sieve by hand. Mechanical sieving shall be controlled by a timer and shall continue for the pre-determined time. The pre-determined time is established when not more than one percent by mass of the residue passes the sieve during one minute of hand sieving. Hand sieving shall be used to evaluate the thoroughness of mechanical sieving.

NOTE 2- When mechanical shakers and 8 inch sieves are used, 8 minutes has generally shown to be a suitable shaking time.

4.4 The mass of each size aggregate shall be obtained by weighing the pan material and accumulating the mass of each increasing sieve size (Column A, Table 1). All sieve masses shall be accurate to within 0.1 percent of the total sample mass.

4.5 Add the mass of fine aggregate in the extract liquid (Column B, Table 1) as determined in PTM 702, to the mass of aggregate passing each sieve used in the gradation, (Column A, Table 1), to obtain the total mass passing each sieve (Column C, Table 1).

NOTE 3- The mass of fine aggregate in the extract liquid may be obtained with suitable accuracy by subtracting the total mass obtained on the maximum sieve size from the total mass of aggregate in the sample. The total mass of aggregate in the sample is obtained by subtracting the mass of the bitumen in the sample from the total mass of the sample. This calculation assumes that all mass loss on grading is passing the 75 μm (No. 200) mesh sieve. The mass loss on grading shall be limited to 0.4 percent of the total sample. All weights for the wash test are recorded to the nearest 0.1 g (0.004 ounce). All weights for the gradation testing are recorded to the nearest 1 g (0.04 ounce).

5. CALCULATIONS

5.1 Divide the total mass of the extracted aggregate into the total mass passing each sieve (Column C, Table 1), and record in Column D, Table 1, as the percent of raw aggregate passing each sieve.

6. REPORT

6.1 Percentages shall be reported to the nearest whole number except for the percentage passing the 75 μm (No. 200) sieve which shall be reported to the nearest 0.1 percent.

GRADATION WORK SHEET
Table 1

(All masses in grams)

Mass of Original Sample = 2173.8
Mass of Extracted Sample = 2073.2
Mass of Aggregate in Extract = 19.0
Mass of Total Extracted Aggregate= 2092.2

Mass of Bitumen = 81.6
% Aggregate = 96.2
% Bitumen = 3.8

Passing Sieve Size	Mass Passing each Sieve		Fines in Ext. Liq.		Total Mass Passing each Sieve	Raw Aggreg. % Passing
	A	+	B	=	C	D
37.5 mm (1½)	2073		19		2092	100
25 mm (1)	2018		19		2037	97
12.5 mm (1/2)	1035		19		1054	50
4.75 mm (No.4)	593		19		612	29
2.36 mm (No. 8)	435		19		454	22
1.18 mm (No. 16)	363		19		382	18
600 mm (No. 30)	156		19		175	8
300 mm (No. 50)	89		19		108	5
150 mm (No. 100)	56		19		75	4
75 mm (No. 200)	35		19		54	2.6

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LABORATORY TESTING SECTION

Method of Test for

DETERMINATION OF ASPHALT CONTENT AND GRADATION OF BITUMINOUS MIXTURES BY THE IGNITION METHOD

1. SCOPE

1.1 This test method covers the determination of asphalt content of bituminous mixtures by the ignition of the asphalt binder at 538 °C ± 5 °C (1000F ± 9F) in a furnace, and is a modification of AASHTO T 308. The aggregate remaining after burning can be used for the sieve analysis using AASHTO T 30 as modified herein.

1.2 The values in metric units are to be regarded as the standard.

1.3 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCED DOCUMENTS

2.1 AASHTO Standards

2.1.1 M 231, Weighing Devices Used in the Testing of Materials

2.1.2 R 76, Reducing Samples of Aggregate to Testing Size

2.1.3 R 90, Sampling Aggregate Products

2.1.4 T 30, Mechanical Analysis of Extracted Aggregate

2.1.5 T 40, Sampling Bituminous Materials

2.1.6 T 308, Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method

2.2 Pennsylvania Test Methods

2.2.1 PTM No. 729, Sampling Roadway Bituminous Concrete

2.2.2 PTM No. 746, Sampling Bituminous Paving Mixtures

2.3 Furnace manufacturer’s instruction manual.

3. SUMMARY OF TEST METHODS

3.1 The asphalt binder in the bituminous mixture is ignited using the furnace equipment applicable to the particular method. The asphalt content is calculated as the difference between the initial mass of the bituminous mixture and the mass of the residual aggregate, any calibration factor(s) and moisture content. The asphalt content is expressed as a mass percent of the moisture-free mixture.

4. SIGNIFICANCE AND USE

4.1 This method can be used for quantitative determinations of asphalt binder content and gradation in bituminous paving and patching mixtures and pavement samples for quality control, specification acceptance, and mixture evaluation studies. This method does not require the use of solvents. Aggregate obtained by this test method may be used for gradation analysis according to AASHTO T 30 as modified herein.

5. SAMPLING

5.1 Obtain samples of aggregate in accordance with AASHTO R 90.

5.1.1 The test specimen shall be the end result of quartering a larger sample taken in accordance with AASHTO R 76.

5.2 Obtain samples of asphalt binder in accordance with AASHTO T 40.

5.3 Obtain samples of freshly produced bituminous mixture in accordance with PTM No. 746, or samples of compacted roadway in accordance with PTM No. 729, or prepared mixture samples composed of the design aggregate structure and design asphalt content as directed in Section 6.2 for mix calibration.

5.3.1 The size of the test sample shall be the result of quartering from a larger sample, according to PTM No. 746 and shall conform to the mass requirement in Table 1. Specimen size shall not be more than 200 grams greater than the minimum recommended specimen size.

Table 1

Bituminous Mixture	**Minimum Mass of Specimen, g**
SP9.5, SP12.5, FJ’s, ID2W, ID2WHD, FB1W, FB2W, FB3Mod, Micro-Surfacing, Ultra-Thin Friction Course, Cold Patch	1200
SP19, ID3W, ID2B, ATPBC, FB1B, FB2B, FBMod, SMA	1500
SP25, SP37.5, BCBC, ID2BHD	2000

6. CALIBRATION

6.1 Apparatus Calibration and Certification

6.1.1 Items requiring periodic verification by calibration include ignition furnaces and balances. Calibration is performed annually using standards traceable to nationally or internationally recognized standards. Calibration services may be performed by the original manufacturer or by other outside certified agencies.

6.1.2 Ignition Furnaces and their internal balances shall be calibrated using the manufacturer's procedure and tolerances for temperature and mass determination. Each furnace or balance is given a calibration status, which indicates the most recent calibration date.

6.1.3 Balances used to weigh pans, baskets, or graded aggregate shall be calibrated to conform to the tolerances outlined in the most recent edition of AASHTO M 231 for the type and class of balance being used.

6.2 Mix Calibration

6.2.1 This method may be affected by the type of aggregate in the mixture. The results may also be affected by the presence of additives and modifiers. Accordingly, to optimize accuracy, a Calibration factor (Cf) shall be established by testing a set of calibration samples for each mix type. This procedure must be performed before any acceptance testing is completed.

6.2.2 The calibration shall be repeated each time if there is a change in the mix ingredients or design.

6.2.3 According to the requirements of Section 5, prepare two calibration samples at the design asphalt content and aggregate structure, which shall also include additives and modifiers, if any. Prior to mixing, prepare a butter mix at the design asphalt content. The purpose of the butter mix is to condition the mixing bowl to provide a coating of asphalt and fines in the bowl. Mix and discard the butter mix prior to mixing any of the calibration specimens to ensure accurate asphalt content. Aggregate used for the calibration specimens shall be sampled from stockpiled material produced in the current production season and designated for use on the candidate project. Any method may be used to combine the aggregates, however, an additional "blank" specimen shall be batched and tested for the aggregate gradation according to AASHTO T 30. The washed gradation shall fall within the mix design tolerances.

6.2.4 The freshly mixed specimens may be placed directly in the sample baskets except for mixtures containing cutbacks or emulsions as directed in Section 8.2. If allowed to cool, the samples must be preheated in a 163 °C ± 5 °C (325F ± 9F) oven for 25 minutes. Do not preheat the sample baskets.

6.2.5 Test the specimens in accordance with Sections 9 and 10 (Test Method A) or Sections 11 and 12 (Test Method B).

6.2.6 Once all of the calibration specimens have been burned, determine the measured asphalt content for each sample by calculation or from the furnace printout.

6.2.7 If the difference between the measured asphalt contents of the two samples exceeds 0.15 percent, repeat the two tests, and from the four tests, discard the high and low result. Determine the Cf from the two remaining results. Calculate the difference between the measured and actual asphalt content for each sample. The Cf is the average of the differences expressed in percent by weight of the asphalt mixture, (measured-actual). Sign convention (+/-) is important and must be maintained.

6.2.8 It will be necessary to determine a separate Cf for the material passing the 75μm (No. 200) sieve. Perform a gradation analysis on the residual aggregate as indicated in Section 13. Compare this gradation, to the gradation of the unburned, "blank" specimen in Section 6.2.3, to evaluate the amount of aggregate breakdown. The No. 200 sieve Cf shall be the average percent passing the 75 μm (No. 200) sieve of the burnt samples minus the percent passing the 75 μm (No. 200) sieve of the blank sample.

6.3 RAP Calibration Factor Determination

6.3.1 Test a minimum of four 100% RAP samples. The sample size shall conform to Table 1. Test each sample according to Method A or Method B (60-minute burn time) to determine the AC content of each.

6.3.2 Determine the average total loss of the four samples. Subtract 0.5% from the average total percent loss (NOTE 1). This is the corrected percent of AC of the RAP (Pbr).

NOTE 1- Since it is difficult and time consuming to determine the actual Cf for 100% RAP without a blank (virgin) aggregate specimen, 0.5% will be the standard Cf for 100% RAP. Only if prior testing experience with a specific RAP source indicates inadequate accuracy when compared to alternate methods, such as solvent extraction, should this standard factor (0.5%) not be used.

6.3.3 The value determined in Section 6.3.2 will be considered the corrected percent of asphalt in the RAP (Pbr).

6.3.4 Perform a sieve analysis (Washed) on three of the incinerated RAP samples as per Section 13. The average of the three samples will be considered the gradation for the 100% RAP. The fourth incinerated (unwashed) sample will be used to make the blank sample in Section 6.3.5.

6.3.5 Batch and test two calibration samples (plus a butter mix) according to Section 6.2.3, and according to the proportions of RAP and virgin materials established in the JMF. Also, batch a blank sample (aggregate only) meeting the JMF of the RAP/virgin aggregate combination, using material from the unwashed RAP sample of Section 6.3.4. The actual asphalt content used to calculate the Cf shall be a combination of the Pbr and the virgin asphalt added. The No.200 sieve Cf shall be the average percent passing the 75 µm (No. 200) sieve of the burnt samples minus the percent passing the 75 µm (No. 200) sieve of the blank sample.

6.3.6 Calculations for Cf for mixtures with RAP:

Actual asphalt % = [(%RAP/100) x Pbr] + % Virgin Asphalt Added

Pbr = Corrected Percent Asphalt in 100% RAP

% Virgin Asphalt Added = % of new asphalt by total mix weight

EXAMPLE: If THE JMF INDICATES 20% RAP Material:

6.2% Avg. Total Loss

Pbr = 6.2% - 0.5% = 5.7%

4.3% new asphalt added

THEN: Actual Asphalt % = [(20/100) x 5.7] + 4.3%
Actual Asphalt % = 1.14% + 4.3% = 5.44%

$$Cf = \frac{[(D1 - P1) + (D2 - P2)]}{2}$$

Where: D1, D2 = Total sample loss in percent for Calibration samples 1 and 2.
P1, P2 = Actual asphalt % for Calibration samples 1 and 2.

IF: D1 = 5.52%
D2 = 5.61%
P1 and P2 = 5.44%

THEN: Cf = 0.13%

7. MOISTURE CONTENT

7.1 Determine the moisture content of a representative portion of the mixture according to PTM No. 749 Apparent Moisture In Bituminous Paving Mixtures.

NOTE 2- The Moisture Content Test is conducted only when water is known or suspected to be present.

8. SAMPLE PREPARATION

8.1 If the mixture is not sufficiently soft to separate with a spatula, scoop, or trowel, place 2000 to 5000 grams in an oven at 163 °C ± 5 °C (325F ± 9F) for a maximum of two hours or on a hot plate over low heat, until the mixture can be handled. Use care not to fracture the mineral particles. Thoroughly mix and form into a flat pile and quarter to the required size.

8.2 Mixtures containing liquid bituminous materials such as cutbacks and emulsified asphalt shall be cured before testing.

8.2.1 All bituminous mixtures containing emulsified asphalt and cutback asphalt shall be spread uniformly on a tray of sufficient size to hold the total sample. Place the sample in an oven maintained at 163 °C ± 5 °C (325F ± 9F) for approximately 15 minutes, remove and weigh. Place the sample back in the oven and remove at approximately 15 minute intervals, mixing occasionally, until the sample has reached constant mass.

NOTE 3- Constant mass will be defined as the mass at which further drying at 163 °C ± 5 °C (325F ± 9F) does not alter the mass by more than 0.6 grams.

TEST METHOD A

9. APPARATUS

9.1 Ignition furnace- A forced air ignition furnace, capable of maintaining the temperature at 578 °C ± 5 °C (1072F ± 9F), with an internal balance thermally isolated from the furnace chamber accurate to 0.1 g. The balance shall be capable of weighing a 3500 gram sample in addition to the sample baskets. A data collection system shall be included so that the weight can be automatically determined and displayed during the test. The furnace shall have a built-in computer program to calculate the change in mass of the sample and provide for the input of a correction factor for determining the aggregate loss. The furnace shall produce a printed ticket with the initial specimen mass, specimen mass loss, temperature compensation, correction factor, corrected asphalt content (%), test time, and test temperature. The furnace chamber dimensions shall be adequate to accommodate a sample size of 3500 grams. The furnace shall provide an audible alarm and indicator light when the sample mass loss does not exceed 0.01 percent of the total sample mass for three consecutive minutes. The furnace door shall be equipped so that the door cannot be opened during the ignition test. A method of reducing furnace emissions shall be provided. The furnace shall be vented into a hood or to the outside. When set up properly the furnace shall have no noticeable odors escaping into the laboratory. The furnace shall have a fan with the capability of pulling air through the furnace to expedite the test, and to reduce the escape of smoke into the laboratory.

9.2 Sample basket(s)- Of an appropriate size that allows the samples to be thinly spread, and allows airflow through and around the sample particles. Sets with two or more baskets shall be nested. The sample shall be completely enclosed with screen mesh or a perforated stainless steel plate, or other suitable material.

NOTE 4- Screen mesh or other suitable materials with maximum and minimum openings of 2.36 mm (No. 8) and 600 μm (No. 30), respectively, have been found to perform well.

9.3 Catch Pan- Of sufficient size to hold the sample basket(s) so that aggregate particles and melted asphalt binder falling through the screen mesh are caught.

9.4 Oven- Capable of maintaining 163 °C ± 5 °C (325F ± 9F)

9.5 Balance- External balance used to weigh pans, baskets, bituminous samples, or graded aggregate, conforming to AASHTO M 231 Class G2.

9.6 Safety Equipment - Safety glasses or a face shield, high temperature gloves, long sleeve jacket, a heat resistant surface capable of withstanding 650 °C (1202ºF), and a protective cage capable of surrounding the sample and baskets during the cooling period

9.7 Miscellaneous Equipment - A pan larger than the sample basket(s) for transferring the sample after ignition, spatulas, scoops, bowls, and wire brushes

10. TEST PROCEDURES

10.1 Preheat the ignition furnace to 538 °C ± 5 °C (1000F ± 9F). Manually record the furnace temperature (set point) prior to the initiation of the test if the furnace does not record it automatically.

10.2 The Cf value shall be entered into the ignition furnace for the specific mix to be tested as determined in Section 6.2 or 6.3.

10.3 Weigh and record the mass of the sample basket(s) and catch pan (with guards in place).

10.4 Prepare the sample as described in Section 8. Evenly distribute the required amount of sample in the sample basket(s) that have been placed in the catch pan, taking care to keep the material away from the edges of the basket. While transferring the mix into the baskets, any fine mix sticking to the inside of the spatula shall be scraped and included in the sample. Use a spatula or trowel to level the specimen. The required sample sizes are listed in Section 5, Table 1.

10.5 Weigh and record the total mass of the sample, basket(s), catch pan, and basket guards. Calculate and record the initial mass of the specimen (total mass - the mass of the specimen basket assembly).

10.6 Input the initial mass of the specimen, in whole grams, into the ignition furnace controller. Press the enter key. Verify that the correct mass has been entered.

10.7 Open the chamber door and place the sample baskets in the furnace. Close the chamber door and verify that the sample mass (including the basket(s)) displayed on the furnace scale equals the total mass recorded in Section 10.5 within ± 5 g. Differences greater than 5 g or failure of the furnace scale to stabilize may indicate that the sample basket(s) are contacting the furnace wall. Initiate the test by pressing the start/stop button. This will lock the sample chamber and start the combustion blower.

> NOTE 5- The furnace temperature will drop below the set point when the door is opened, but will recover with the door closed and when ignition occurs. Sample ignition typically increases the temperature well above the set point, depending on sample size and asphalt content.

10.8 Allow the test to continue until the stable light and audible stable indicator indicate the test is complete (the change in mass does not exceed 0.01 percent for three consecutive minutes). Press the start/stop button. This will unlock the sample chamber and cause the printer to print out the test results.

10.9 Open the chamber door, remove the sample basket(s) and allow the baskets to cool to room temperature (approximately 30 minutes).

10.10 Use the corrected asphalt content (%) from the furnace printout. If a moisture content has been determined, subtract the moisture content from the printed ticket corrected asphalt content and report the difference as the corrected asphalt content.

> NOTE 6- In the event of a suspect result, it is recommended that the burnt aggregate be weighed after the aggregate has cooled (Never weigh the baskets hot, see Section 10.9) and calculate the asphalt content manually (see the formula in Section 12.15).

TEST METHOD B

11. APPARATUS

11.1 Ignition Furnace- A forced air furnace, capable of maintaining the temperature at 578 °C ± 5 °C (1072F ± 9F). The furnace chamber dimensions shall be adequate to accommodate a sample size of 3500 grams. The furnace door shall be equipped so that the door cannot be opened during the ignition test. A method of reducing furnace emissions shall be provided. The furnace shall be vented into a hood or to the outside. When set up properly the furnace shall have no noticeable odors escaping into the laboratory. The furnace shall have a fan with the capability of pulling air through the furnace to expedite the test, and to reduce the escape of smoke into the laboratory.

11.2 Sample basket(s)- Of an appropriate size that allows the samples to be thinly spread out and allows airflow through and around the sample particles. Sets with two or more baskets shall be nested. The sample shall be completely enclosed with screen mesh or a perforated stainless steel plate or other suitable material.

NOTE 7- Screen mesh or other suitable materials with maximum and minimum openings of 2.36 mm (No. 8) and 600 μm (No. 30), respectively, have been found to perform well.

11.3 Catch Pan- Of sufficient size to hold the sample basket(s) so that aggregate particles and melted asphalt binder falling through the screen mesh are caught.

11.4 Oven- capable of maintaining 163 °C ± 5 °C (325F ± 9F)

11.5 Balance- Of sufficient capacity and conforming to the requirements of AASHTO M 231, Class G2 for weighing the specimen and basket(s).

11.6 Safety Equipment- Safety glasses or a face shield, high temperature gloves, long sleeve jacket, a heat resistant surface capable of withstanding 650 °C (1202F), and a protective cage capable of surrounding the sample and baskets during the cooling period

11.7 Miscellaneous Equipment- A pan larger than the sample basket(s) for transferring the sample after ignition, spatulas, scoops, bowls, and wire brushes

12. TEST PROCEDURES

12.1 Preheat the ignition furnace to 538 °C ± 5 °C (1000F ± 9F).

12.2 Enter the Cf value into the ignition furnace for the specific mix to be tested as determined in Section 6.2 or 6.3.

12.3 Weigh and record the mass of the sample basket(s) and each pan (with guards in place).

12.4 Prepare the sample as described in Section 8. Place the sample baskets in the catch pan. Evenly distribute the sample in the basket(s) taking care to keep the material away from the edge.

12.5 Weigh and record the total mass of the sample, basket(s), catch pan, and basket guards. Calculate and record the initial mass of the specimen (total mass - the mass of the specimen basket assembly).

12.6 Burn the sample in the furnace for at least 45 minutes.

NOTE 8- The appropriate time for the initial burn of a sample is dependent on the sample size. For large samples, the time could be significantly longer than 45 minutes. See the manufacturer's manual for guidelines.

12.7 Remove the sample from the furnace after ignition and allow the sample to cool to approximately room temperature (at least 30 minutes).

12.8 Weigh and record the mass (W_a) of the sample after ignition to the nearest 0.1 gram.

12.9 Return the sample to the furnace.

12.10 After the furnace reaches the set temperature, burn the sample for at least 15 minutes.

12.11 Remove the sample from the furnace and allow it to cool to approximately room temperature (at least 30 minutes).

12.12 Weigh and record the mass (W_a) of the sample after ignition.

12.13 Repeat these steps until the change in measured mass (W_a) of the sample after ignition does not exceed 0.01 percent of the initial sample mass (W_s).

12.14 Record the last value obtained for (W_a) as the mass (W_a) of the sample after ignition.

NOTE 9- Steps 12.9 through 12.14 may not be necessary if it can be demonstrated from the mix calibration data that constant mass can be achieved by heating the sample for the same time as the calibration samples. The type and mass of the sample being tested shall be reasonably close (within 200 grams) to those of the calibration sample.

12.15 Calculate the asphalt content of the sample as follows:

$$AC\% = \frac{W_s - W_a}{W_s} \times 100 - Cf$$

Where:

AC% = the measured (corrected) asphalt content percent by weight of the sample
W_a = the total weight of the aggregate remaining after ignition
W_s = the total weight of the sample prior to ignition
Cf = calibration factor, percent by weight of the sample

13. GRADATION, METHODS A & B

13.1 Allow the specimen to cool to approximately room temperature in the sample baskets.

13.2 Empty the contents of the baskets into a flat pan. Use a small wire sieve brush to ensure that any residual fines are removed from the baskets.

13.3 Perform the gradation analysis according to AASHTO T 30 with the exception of NOTES 10 and 11.

NOTE 10- All gradations are to be washed. To expedite drying samples to a constant weight after washing, samples may be dried at 191 °C ± 5 °C (375F ± 9F).

NOTE 11- The permissible limit for mass retained on the 2.36 mm (No. 8) sieve shall be 9 kg/m^2 (6 g/square inch), or 300 g for the usual 8-inch diameter sieve.

13.4 A gradation worksheet example is attached.

14. REPORT, METHODS A & B

14.1 Always report the test method (A or B), corrected asphalt content, Cf for asphalt content, Cf for the percent passing the 75μm (No. 200) sieve, temperature compensation factor (if applicable), total percent loss, sample mass, moisture content (if determined), and test temperature. For units with internal balances attach a copy of the furnace printout to the report.

Worksheet EXAMPLE

A	**Mass of Aggregate before wash**	**=**	**1143.0**
B	**Mass of Aggregate after wash**	**=**	**1085.4**
C	**Mass Loss on wash**	**=**	**57.6**
D	**No. 200 Calibration factor (200Cf)**	**=**	**0.5**

Passing Sieve Size	**Mass Passing each sieve E**		**Mass loss on wash F**		**Total Mass Passing each sieve G=(E+F)**	**Raw Agg. % passing H=(G/A)**	**Corrected No. 200 I=(H-D)**
12.5 mm (1/2 in.)	1085	+	57.6	=	1142.6	100	
9.5 mm (3/8 in.)	1048	+	57.6	=	1105.6	97	
4.75 mm (No. 4)	674	+	57.6	=	731.6	64	
2.36 mm (No. 8)	478	+	57.6	=	535.6	47	
1.18 mm (No. 16)	233	+	57.6	=	290.6	25	
600µm (No. 30)	126	+	57.6	=	183.6	16	
300µm (No. 50)	61	+	57.6	=	118.6	10	
150µm (No. 100)	23	+	57.6	=	80.6	7	
75µm (No. 200)	**1.3**	**+**	**57.6**	**=**	**58.9**	**5.2**	**- 0.5 = 4.7**

IMPORTANT NOTE REGARDING BULLETIN 27

This section covers only parts of PennDOT Bulletin 27 that are referred to as part of Plant Certification Course. This section does NOT include all chapters and appendices included in PennDOT Bulletin 27. The user must refer to PennDOT publications to access complete version of Bulletin 27. The user is also cautioned regarding changes in Bulletin 27 and is encouraged to check with PennDOT regarding the most recent changes or upcoming changes that are not reflected in the sections provided here.

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OS-299 (7-08) pennsylvania DEPARTMENT OF TRANSPORTATION	TRANSMITTAL LETTER	**PUBLICATION:** Publication 27 January 2003 Edition Change 5
		DATE: January 19, 2011

SUBJECT:

Revisions to Publication 27 - BULLETIN 27
Bituminous Concrete Mixtures, Design Procedures, and Specifications for Special Bituminous Mixtures
January 2003 Edition, Change 5

INFORMATION AND SPECIAL INSTRUCTIONS:

Change 5 includes revisions to Publication 27 related to the addition of a new Appendix J - Annual Asphalt Concrete Mix Design Submittal Procedure, revisions from ASTM Test Methods to more routinely performed AASHTO Test Methods for Full Depth Reclamation (FDR), and several editorial revisions in Chapter 2.

Specifically, Change 5 includes revisions to the Index and Introduction, Chapters 2, 2A, and 2B and adds the new Appendix J as is detailed in the Summary of Change 5 below.

Summary of Change 5:

A. Index and Introduction Sections:
1. Added new Appendix J to Index (Page i) and to Introduction (Page ii).

B. Chapter 2:
1. Section 2.1 - Added reference to new Appendix J in the first paragraph (Page 2-3).
2. Section 7.1 - Editorial revision to the first paragraph (Page 2-24).
3. Section 7.2 - Revision from ASTM Test Methods to the more routinely performed AASHTO Test Methods for Plasticity Index and Sand Equivalent Test and editorial revisions to the second and third bullets and the last paragraph (Page 2-25).

C. Chapter 2A:
1. Revised the Department modifications to the AASHTO Standard Practice for Superpave Volumetric Design for Hot Mix Asphalt including the following:
-- AASHTO R 35, Section 4.5, Review of Job-Mix Formula (JMF) - Added reference to new Appendix J in the first paragraph (Page 2A-4).

D. Chapter 2B:
1. Revised the Department modifications to the AASHTO Standard Practice for Designing Stone Matrix Asphalt (SMA) including the following:
-- AASHTO R 46, Section 4.6, Review of Job-Mix Formula (JMF) - Added reference to new Appendix J in the first paragraph (Page 2B-2).

E. Appendix J:
1. Added completely new Appendix J - Annual Asphalt Concrete Mix Design Submittal Procedure (Pages J-1 to J-8).

CANCEL AND DESTROY THE FOLLOWING:	ADDITIONAL COPIES ARE AVAILABLE FROM:
Front Cover Page. Index and Introduction - Pages i to ii - Change 4. Chapter 2 - Page 2-3 - Change 1. Chapter 2 - Page 2-4 - Initial Edition. Chapter 2 - Pages 2-23 to 2-26 - Change 3. Chapter 2A - Pages 2A-3 to 2A-4 - Change 4. Chapter 2A - Pages 2A-5 to 2A-6 - Change 3. Chapter 2B - Pages 2B-1 to 2B-4 - Change 4.	☒ PennDOT SALES STORE (717) 787-6746 phone (717) 787-8779 fax ra-penndotsalesstore@state.pa.us ☒ PennDOT website - www.dot.state.pa.us *Click on Forms, Publications & Maps* ☒ DGS warehouse (PennDOT employees ONLY)
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Chapter 2A

Design and Control of Hot-Mix Asphalt (HMA) Mixtures Using the Superpave Asphalt Mixture Design and Analysis System with the Additional Requirement of Performance Testing

1. General Scope

The Department has established procedures for the design and control of Hot-Mix Asphalt (HMA) based on the Superpave Asphalt Mixture Design and Analysis System, with the addition of performance related physical testing to help ensure that asphalt mixtures achieve optimum performance. Superpave considers the interaction of traffic, climate, and pavement structure within the paving mix. The mix design and structural design are truly better integrated into a single system. There are three main components to the system: the performance graded asphalt binder specification, the Superpave volumetric mix design procedures, and the additional mix testing and analysis. The purpose of these procedures is to provide uniform guidance in the use of a more complex and currently incomplete, performance-related design system for Department work.

Currently, the Superpave asphalt binder specification and the Superpave volumetric mix design procedures are available and will be used by the Department. The additional mix testing and analysis is currently not ready for Department use. Nationally, the additional mix testing and analysis is still undergoing research refinements, validation work, and the development of performance models. Once completed, the additional mix testing and analysis will provide performance predictions of mixture designs. These predictions can then be used to enable the Department to specify hot-mix asphalt pavements with greater confidence that the mix will perform well for defined traffic and climate conditions over realistic and planned life cycles.

The Department will follow the Superpave mix design procedure and Superpave specifications contained in the Standard Practice for Superpave Volumetric Design for HMA (AASHTO R 35) and Standard Specification for Superpave Volumetric Mix Design (AASHTO M 323) except as revised herein. All AASHTO standard practices, specifications and test procedures are implied to reference the most current approved and published version available at the time of project bid letting.

2. Department Revisions to AASHTO R 35 - Standard Practice for Superpave Volumetric Design

for HMA AASHTO R 35, Section 3. Terminology

Revise Section 3 by adding new Subsections as follows:

3.18 Durability - a measure of resistance to disintegration by weather or traffic conditions. The most important factor with respect to durability is the amount of binder. An HMA mixture is resistant to action of air and water in direct proportion to the degree that they are kept out of the mix. It is desirable that the mix should contain as high a binder content as is consistent with balanced strength, strain, and voids for the expected life cycle of traffic load and environmental factors. This can be achieved with high Voids in the Mineral Aggregate (VMA). This will give the pavement maximum durability and prevent raveling because of a deficiency of asphalt binder. This binder content is referred to as the optimum.

3.19 Flexibility - the ability of the HMA mixture to bend repeatedly without cracking and to conform to changes in the base course. To have flexibility, a mix must contain the proper amount of binder. Open-graded mixtures are more flexible than dense-graded mixtures. Also, a mixture consisting of a softer binder grade is more flexible than the same mixture made with a harder binder grade.

3.20 Workability - the property that enables the efficient placement without segregation, and compaction of the mixture. Harsh or stiff mixtures can result from an excess of coarse aggregate, low VMA, low binder content, or an excess of minus 75 μm (No. 200) sieve fraction.

3.21 Friction Number - a measure of the sliding force exerted on a tire when a vehicle's brakes are locked. HMA wearing courses must have the highest possible friction number obtainable with the combination of aggregates available in the area. The type of coarse aggregate has the greatest effect on friction number. Aggregates that polish rapidly and repeatedly produce a low friction number before the normal service life is complete should not be used. An excessive binder content can produce a flushed surface resulting in low friction number.

3.22 Superpave Gyratory Compactor (SGC) - a mechanical compaction device used to mold and compact 150 mm (6 inch) diameter mixture specimens. It compacts the specimens using a loading ram which applies a loading pressure of 600 kPa to the specimen. The mold is held at an angle during compaction. The SGC gyrates the specimen during compaction at a constant speed of 30 revolutions per minute. The complete test procedure is found in AASHTO T 312.

3.23 Initial number of gyrations (N_{ini}) - the number of gyrations applied by the SGC to the mixture specimens early in the compaction process and is generally considered useful in identifying tender or poorly graded mixtures which may compact too readily or mixtures that are too harsh and require excessive compaction effort in the field.

3.24 Design number of gyrations (N_{des}) - the number of gyrations, which when applied to the design mixture specimens, results in 4.0 percent air voids and determines the design asphalt content if N_{ini} and N_{max} requirements are satisfied. This compaction level is generally considered to represent the pavement's expected air void content several years after construction, assuming the correct traffic level and climate are accounted for in design. It is also used to select the design asphalt content.

Maximum number of gyrations (N_{max}) - the maximum number of gyrations applied during the SGC compaction cycle and represents the maximum level the mix is expected to compact to in the pavement assuming the correct traffic level and climate are accounted for in design. The maximum density requirement at N_{max} ensures that the mix will not compact excessively under the design traffic, become plastic, and produce permanent deformation. The air voids content must be 2.0 percent or greater.

AASHTO R 35, Section 4. Summary of the Practice

Revise Subsection 4.1 by adding the following to Note 4:

When using RAP or manufacturer waste Recycled Asphalt Shingles (RAS), the Department's modified design procedures (See Appendix H) shall be followed exclusively.

Revise Subsection 4.2 by adding the following to Note 5:

Also, other recognized procedures may be used to select trial blends or recommend a design aggregate structure. One such method is the "Bailey Method for Gradation Selection in Hot-Mix Asphalt Mixture Design," by W.R. Vavrik, G. Huber, W.S. Pine, S.H. Carpenter and R. Bailey. Transportation Research Circular E-C044, October 2002. Copies may be obtained by contacting National Research Council, Business Office, 500 Fifth Street, N.W. Washington D.C. 20001. Tel: (202) 334-3213 or email TRBsales@nas.edu. This publication is also available on the Internet at http://www.trb.org and following the links for "Resources" then "TRID" and searching for "E-C044".

Revise Subsection 4.4 by adding the following to the end:

All mixtures shall include either a compatible, heat stable, amine-based liquid anti-strip, hydrated lime or another compatible alternate anti-strip additive. Incorporate the anti-strip additive at least at the minimum dosage rate published on the anti-strip additive's technical data sheet from the anti-strip manufacturer (typically 0.25% by mass of asphalt).
Mixtures that incorporate both coarse and fine aggregates classified as a type of Sandstone, Siltstone, Slag, Quartz, Shale, or Gravel shall include either a compatible, heat stable, amine-based liquid anti-strip, hydrated lime or another compatible alternate anti-strip additive incorporated at a dosage rate one level higher than the minimum recommended dosage rate recommended by the manufacturer (typically 0.50% by mass of the total asphalt).
The producer may elect to perform additional testing for mixtures that incorporate both coarse and fine aggregates classified as a type of Sandstone, Siltstone, Slag, Quartz, Shale, or Gravel with an anti-strip agent dosage rate one level higher than the minimum dosage rate recommended by the manufacturer compared to the test results that incorporate anti-stripping agent at the minimum dosage rate. If all of the following bullet points are true, then design the JMF with the higher dosage rate.

- The TSR of the higher dosage mixture is greater than the TSR of the minimum dosage mixture.

- The conditioned and unconditioned tensile strength of all AASHTO T 283 tests are above the minimum tensile strength requirement in section 11.3

The design shall meet the tensile strength ratio requirement of M 323.

If visual stripping of the asphalt film is observed from the T 283 specimens and estimated to be 5% or greater of the specimen face area, further evaluate moisture susceptibility by performing test procedure ASTM D3625 (Boiling Water Test). (Uncoated areas due to fractured aggregate should not be recorded as stripped). When asphalt binder coating is less than 95%, as determined by ASTM D3625, retest the mixture in accordance with Section 11. All collected specimens and test data should be carefully reviewed prior to determining acceptability. If there is any doubt concerning the mixture's susceptibility, the recommended approach is to consider the mix moisture susceptible.
The DME/DMM may allow JMFs that conform to the Performance Testing Limits in the Department's added AASHTO M 323, Section 7.4, Table 9 to use the exceptions in the Department's added AASHTO M 323, Section 7.4, Table 10.

Revise Section 4 by adding a new Subsection as follows:

4.5 Evaluating Rutting Performance - Perform rut testing according to AASHTO T 324 as modified in the Department's modifications to AASHTO M 323, Section 7.4.

4.6 Evaluating Cracking Performance – Perform crack testing according to ASTM D8225 as modified in the Department's modifications to AASHTO M 323, Section 7.4.

4.7 Review of Job-Mix Formula (JMF) - The contractor will be solely responsible to design a mix that meets all Department requirements. The contractor will submit the required test results, the composition of the mixtures and the combined aggregate gradation curves proposed for use in the production of base, binder, and wearing courses, to the District Materials Manager/Materials Engineer (DME/DMM) for review at least three weeks prior to the scheduled start of work. Submit mix designs to the DME/DMM for review following the procedures outlined in Appendix J. The acceptability of the asphalt concrete produced from any mix design is determined as specified in Publication 408, Section 413 in addition to the criteria specified herein.

Whenever the Contractor's gradations and calculations do not check, the DME/DMM shall request the Contractor to do additional testing and/or recalculate and submit the correct mathematical solutions. The DME/DMM may request, at his option, to observe testing of the trial mix. He may also require that materials be submitted to the Laboratory Testing Section (LTS) for evaluation of the mix. The Department reserves the right to review any design through plant production, prior to using for Department work, at no additional cost to the Department. See Department Revisions to AASHTO R 35, Section 12 (page 2A-9) for Evaluating Mix Characteristics. Also, see Department Revisions to AASHTO M 323 Section 7 (page 2A-14) for a recommended procedure for the statistical evaluation of a JMF through plant production.

AASHTO R 35, Section 6. Preparing Aggregate Trial Blend Gradations

Revise Subsection 6.1 completely as follows:

6.1 Select Performance Graded Binders (PG-Binders) as specified in the project Contract, meeting the requirements of AASHTO M 332, except as revised in the applicable sections of Department Publication No. 37 (Bulletin 25). Obtain material from currently approved producers and sources listed in Department Publication No. 35 (Bulletin 15). If 16% or more RAP is included in the mixture or, if 5% or more RAP and 5% RAS is included in the mixture, adjust the PG-Binder grade if necessary, in accordance with the requirements of Appendix H and only as recommended by the LTS.

If two or more mixtures are specified in one project Contract with all things being equal (nominal maximum aggregate size of mixture, ESALs, SRL) except the specified grade of PG-Binder, it is permitted to fully design one of the specified mixtures with one of the specified PG-Binders and then make three specimens in accordance with T 312 at the same JMF asphalt content for the other PG-Binder(s). If the average volumetric properties of the three specimens, such as, air voids at N_{ini}, N_{des} and N_{max}, VMA, and VFA meet the specified Superpave volumetric properties, use the same asphalt content for the other PG-Binders. However, evaluate the mixtures using the different grades of PG-Binders for moisture susceptibility in accordance with AASHTO R 35, Section 11 and as modified herein. If the average volumetric properties of the three specimens do not meet the specified Superpave volumetric criteria, proceed to the following paragraph.

If two or more mixtures are specified in one project contract with all things being equal (nominal maximum aggregate size of mixture, ESALs, SRL) except the specified grade of PG-Binder and the average volumetric properties do not meet the specified Superpave volumetric properties as determined by the procedure in the preceding paragraph, optimum asphalt content must be determined for each grade of PG-Binder. Using the same combined gradation of the aggregate, follow the procedure outlined in AASHTO R 35, Section 10.

Revise Subsection 6.4 and 6.5 as follows:

Change reference of T 27 to PTM No. 616, and reference of T 11 to PTM No. 100.

Revise Subsection 6.6 by adding the following to the end:

Determine the Apparent Specific Gravity of mineral filler, if added separately (T 133). At least three determinations should be made, and the average value used.

Revise Subsection 6.8 by adding the following to the end:

See Note 5 and Department Revisions to Note 5 concerning trial blends. The DME/DMM may, at their discretion, eliminate the need for three trial blends based on a Producer's previous Superpave mix design work with specific aggregate blends.

When preparing trial blends, vary the primary control sieve (PCS) on each trial blend by 4 to 5%.

Note 6A - M 323, Table 5 is incorrect, and the Department revised the table by changing “Max. 90" for the first sieve size smaller than the nominal maximum aggregate size for each gradation to “Max. 89". This change is more consistent with the definition as stated in Subsection 3.9. (See Department Revisions to AASHTO M 323, Section 6.1.2, Table 4). Also see Note 5.

Revise Subsection 6.9 by adding the following to the end:

Source property of Toughness (Abrasion) has been added to aggregate requirements (See Department Revisions to AASHTO M 323, Section 6 - Combined Aggregate Requirements).

Revise Note 7 by adding the following to the end:

It is recommended to perform the fine aggregate quality tests on the combined aggregate trial blend and not estimate the fine aggregate quality tests mathematically from quality tests on each fine aggregate stockpile.

AASHTO R 35, Section 7. Determining an Initial Trial Binder Content for Each Trial Aggregate Gradation

Replace Note 8 with the following:

When using RAP, RAS or a combination of RAP and RAS, the Department’s modified design procedures (see Appendix H) shall be followed exclusively.

AASHTO R 35, Section 8. Compacting Specimens of Each Trial Gradation

Revise the Section 8, Table 1 completely as follows:

Design ESALs[a] (Millions)	Compaction Parameters			Typical Roadway Application
	$N_{initial}$	N_{design}	N_{max}	
<0.3	6	50	75	Applications include roadways with very light traffic volumes, such as local roads, county roads, and city streets where truck traffic is prohibited or at a very minimal level. Traffic on these roadways would be considered local in nature, not regional, intrastate, or interstate. Special purpose roadways serving recreational sites or areas may also be applicable to this level.
0.3 to <3	7	75	115	Applications include many collector roads or access streets. Medium-trafficked city streets and the majority of county roadways may be applicable to this level.

3 to <30	7	75	115	Applications include many two-lane, multilane, divided, and partially or completely controlled access roadways. Among these are medium to highly-trafficked city streets, many state routes, U.S. highways, and some rural Interstates.
≥30	7	75	115	Applications include the vast majority of the U.S. Interstate system, both rural and urban in nature. Special applications such as truck-weighing stations or truck-climbing lanes on two lane roadways may also be applicable to this level.
All ESAL Levels for Base Course Mixtures	7	75	115	

a. The anticipated project traffic level expected on the design lane over a 20-year period. Regardless of the actual design life of the roadway, determine the design ESALs for 20 years.
b. As defined by *A Policy on Geometric Design of Highways and Streets*, 2004, AASHTO.

Replace Subsection 8.2 with the following:

Condition the mixtures according to Bulletin 27, Appendix I, and compact the specimens to N_{design} gyrations in accordance with T 312. Record the specimen height to the nearest 0.1 mm after each revolution.

Replace reference to AASHTO T 166 with PTM No. 715, typical throughout.

Replace reference to AASHTO T 275 with PTM No. 716, typical throughout.

Revise Subsection 8.3 by adding the following:

Note 10A – When the estimated design traffic level is between 0.3 and <3 million ESALs, the District may, at its discretion, specify $N_{initial}$ at 6, N_{Design} at 50, and N_{max} at 75.

In the event a discrepancy occurs between lab test data, PTM No. 715, Method A will be the referee method. Notes 10 and 11 in reference to Table 1 apply.

AASHTO R 35, Section 10. Selecting the Design Binder Content

Revise Subsection 10.1 by adding the following:

When a design using less than 16% RAP or a design using 5% RAS with no RAP is developed based on a previously approved virgin aggregate design of similar composition (gradation, aggregate source, binder content), only specimens with estimated design binder content may be necessary, as directed in the Department's modified design procedure. (See Appendix H)

Replace Subsection 10.2 with the following:

Condition the mixtures according to Bulletin 27, Appendix I, and compact the specimens to N_{design} gyrations in accordance with T 312. Record the specimen height to the nearest 0.1 mm after each revolution.

Replace Subsection 10.7.1 with the following:

Condition the mixtures according to Bulletin 27, Appendix I, and compact the specimens according to T 312 to the maximum number of gyrations, N_{max}, from Table 1.

Revise Section 10 by adding the following Subsections:

10.7.3 Prepare replicate (Note 9) specimens composed of the design aggregate structure at the design binder content to confirm that $\%G_{mm\ design}$ satisfies the design requirements in M 323.

10.7.4 Condition the mixtures according to Appendix I, and compact the specimens according to T 312 to the design number of gyrations, N_{design}, from Table 1.

10.7.5 Determine the average specimen relative density at N_{design}, $\%G_{mm\ design}$, by using Equation 15A, and confirm that $\%G_{mm\ design}$ satisfies the volumetric requirement in M 323.

$$\%G_{mm\ design} = 100 \frac{G_{mb}}{G_{mm}} \qquad (15A)$$

Where:
$\%G_{mm\ design}$ = relative density at N_{design} gyrations at the design binder content.

10.7.6 Place each replicate specimen gyrated to N_{design} on a separate pan and place each pan in an oven set at the midpoint of the minimum and maximum mixture temperature range for the PG Binder Grade. Heat each specimen until it is sufficiently soft to separate with a spatula or trowel. Warm the asphalt mixture until it can be handled or mixed. Determine the asphalt content and gradation of each specimen according to PTM No. 757 or PTM No. 702 and PTM No. 739. Compare the gradation of each specimen to the original gradation of the prepared specimens and the JMF. If the gradation of the specimens is not within the single and multiple sample tolerances of Pub. 408, Section 413, Table A, when compared to the JMF, either the specimens were not prepared with enough precision to properly represent the JMF or, significant breakdown of the aggregate has occurred during laboratory compaction if a finer gradation is determined.

If it is determined that the sample preparation was not precise, repeat Section 10 starting at Section 10.7.3 until precision is obtained with each specimen meeting the multiple sample tolerances in Pub. 408, Section 413, Table A. If it is determined that the sample preparation was not precise, review laboratory procedures to ensure specimen preparation is precise and repeat any work where precision was not maintained.

If it is determined that the laboratory compaction resulted in breakdown of the aggregate and the gradation after compaction no longer meets the single and multiple sample tolerances of Pub. 408, Section 413, Table A, the mixture should be considered suspect. Either the aggregate structure of the mixture results in a "harsh" mixture that is not conducive to compaction or the aggregate quality is poor. Harsh mixtures should be redesigned to make them more workable. Poor quality aggregates should be investigated in cooperation with the District and not used until the investigation is completed.

AASHTO R 35, Section 11. Evaluating Moisture Susceptibility

Revise Section 11 by adding Notes as follows:

Note 19A - It has been shown that the chemical composition of asphalt binders, aggregates and any mixture additives can have a strong influence on the results obtained from these testing procedures. Therefore, it is recommended that the sources of materials (binder and additives) used in the design process be the same as the materials that will be incorporated in the mixture during production. If either of these components change at the time of production, the actual production mixture must be verified by retesting, initially with ASTM D3625 (Boiling Water Test) as a screening test. Otherwise, the design testing may not be representative.

Note 19B— If multiple mix designs use the same aggregate combination and the same PG binder but differ in optimal asphalt content, the DME/DMM may elect to require moisture susceptibility evaluation of only the mix with the lowest asphalt content. The "same aggregate combination" can be defined as mix designs with gradation targets differing by less than the multiple sample tolerances of Publication 408, Section 413, Table A.

Note 19C -All moisture susceptibility sampling and testing shall be directly witnessed and documented by PennDOT inspection personnel unless otherwise approved, in writing, by the DME/DMM.

Revise Subsections 11.1 and 11.2 by completely deleting existing language and replacing with language as follows:

11.1 Prepare either laboratory-mixed, laboratory-compacted specimens or field- mixed (plant-mixed), laboratory-compacted specimens according to AASHTO T 283 with modifications as follows:

AASHTO T 283, Section 6. 5, add the following to the end:
Prepare batches composed of the design aggregate structure at the design binder content.

AASHTO T 283, Section 6.5, revise the compaction method as follows:
Compact the specimens according to T 312.

AASHTO T 283, Section 7.3, revise completely as follows:
Field-mixed (plant-mixed) samples are only permitted to be obtained from asphalt production plants and evaluated for moisture susceptibility prior to shipment to any PennDOT funded project location. Obtain a large enough sample according to PTM No. 746 to split the sample and prepare the required six compacted specimens, to test the sample according to PTM No. 757 or PTM No. 702 and PTM No. 739, and to perform two tests according to AASHTO T 209 as required in AASHTO T 283, Section 9.1. Compare the gradation and asphalt content of the tested material to the multiple sample (n2:3) tolerances in Publication 408, Section 413, Table A. If any of the individual sieve size gradations or asphalt content are outside of the multiple sample (n2:3) tolerances in Publication 408, Section 413, Table A, the complete sample is invalid and must be discarded.

AASHTO T 283, Section 7.4, revise the first three sentences completely as follows:
No loose-mix curing as described in Section 6.4 shall be performed on the field-mixed samples. After sampling, divide the sample to obtain the desired size in accordance with R 47. Next, place the mixture in an oven for

2 h ± 10 min at the compaction temperature ±3°C (5°F) prior to compaction.

AASHTO T 283, Section 8, delete Section 8 in its entirety including Sections 8.1, 8.2 and 8.3.

11.2 Evaluate and group, precondition, test, and calculate the tensile strength ratio according to AASHTO T 283 with modifications as follows. The design shall meet the tensile strength ratio requirement of AASHTO M 323.

AASHTO T 283. Section 9.1, revise completely to read as follows:

After curing and/or heating the mixture samples to the compaction temperature as described in Sections 6.4 and 6.5 or Section 7.4, as appropriate, determine the theoretical maximum specific gravity (Gmm) of those samples according to AASHTO T 209 as modified by Bulletin 27, Appendix I except the sample conditioning required for Gmm in Bulletin 27, Appendix I is not required. Determine Gmm on a minimum of two samples and average the results for calculating percent air voids of the specimens.

AASHTO T 283, Section 9.4, revise first sentence completely as follows**:**

Determine the bulk specific gravity (Gmb) of each specimen according to PTM No. 715.

AASHTO T 283. Section 9.5, revise completely to read as follows:

Calculate the percentage of air voids (Pa) in accordance with T 269 using the bulk specific gravity (Gmb) and the theoretical maximum specific gravity (Gmm) as determined in the revised AASHTO T 283 Sections 9.4 and 9.1

AASHTO T 283. Section 10.3.l, add new Note 5 and Table as follows:

Note 5-The following table is provided to help with understanding vacuum pressure readings and understanding weaker and stronger vacuum.

Understanding Vacuum Gauge Pressure Readings				
Vacuum Gauge Type	Unit of Measure	Vacuum Reading with No Vacuum Applied	Vacuum Reading with Weakest Vacuum Applied	Vacuum Reading with Strongest Vacuum
Partial/Relative	Inches of Mercury (Hg)	0 (Zero)	10 in. Hg	26 in. Hg
Partial/Relative	mm of Mercury (Hg)	0 (Zero)	254 mm Hg	660 mm Hg
Absolute	Inches of Mercury (Hg)	Approximately 29.9 in. Hg	19.9 in. Hg	3.9 in. Hg
Absolute	mm of Mercury (Hg)	Approximately 760 mm Hg	506 mm Hg	97.5 mm Hg

AASHTO T 283, Section 10.3.2, revise completely to read as follows:

Determine the mass of the saturated, surface-dry specimen after partial vacuum saturation (B') by PTM No. 715.

AASHTO T 283, Section 12.l, add new Subsection 12.1.1 as follows:

12.1.1 Calculate the average (x) and standard deviation (s) of tensile strengths for both the dry group of specimens and the freeze-thaw group. Calculate the Coefficient of Variation (C.V.) for each group by dividing the standard deviation by the average:

$$C.V. = \frac{s}{x} (\%)$$

If the C.V. is greater than 12% for the dry group, or 24% for the freeze-thaw group, the test results should be viewed as suspect and a new subset of specimens prepared and tested.

If only one of the results is suspect and analysis according to PTM No. 4 identifies that result as an outlier, a replacement is initially only required for that specimen. If the C.V. considering the replacement specimen in place of the outlier is still greater than the acceptable limit, prepare and test an entire subset of new specimens. Each group of specimens, dry or freeze-thaw, is defined as a subset.

Revise Subsection 11.3 by adding the following to the end:

If the average dry strength for mixtures containing PG 64S-22 or PG 64E-22 is less than 80 psi (552 kPa) or the average dry strength for mixtures containing PG 58S-28 is less than 65 psi (448 kPA), the mix is unacceptable. Any mixture with an average wet/freeze strength less than 50 psi (345 kPa) is unacceptable. Moisture susceptibility testing must be reevaluated, at a minimum, once every five years, if mixture components, sources, and JMF targets remain the same, to account for variations in aggregate sources and other mix components. When component material sources change or component material proportions or JMF targets significantly change, as determined by the DME/DMM, moisture susceptibility must be reevaluated.

If any JMF fails to meet any of the requirements above or in AASHTO T 283, any retest or testing of JMF versions of the same aggregate combination (outlined in note 19B above) must be approved by the DME/DMM.

Compute the dosage rate of liquid anti-stripping agent as follows:

- For mixtures that contain no RAP or RAS, or conform to Tier 1 of appendix H, compute the anti-strip dosage rate based on the virgin asphalt added to the mixture.
- For mixtures that contain RAP and / or RAS, and fall into Tier 2 or Tier 3 of Appendix H, compute the anti-strip dosage rate based on the total asphalt in the mixture.

All warm mix asphalt (WMA) versions of JMFs must have separate evaluations for moisture susceptibility testing from the hot mix asphalt (HMA) parent JMF. In all cases of a WMA mixture produced by a WMA Technology categorized as a foaming additive or process (e.g., foaming additive or mechanical foaming), if the HMA version of the JMF requires an anti-strip additive to meet the moisture susceptibility requirements, the WMA version of that JMF is required to contain the same minimum amount of anti-strip additive required in the HMA version of the JMF.

If the Producer elects to use an alternate anti-strip additive that is not a typical amine-based anti-strip additive, contact the DME/DMM at least three weeks prior to start of work. If directed by the DME/DMM, perform moisture sensitivity analysis with the alternate anti-strip additive incorporated at the alternate anti-strip manufacturer's recommended dosage rate. Demonstrate, by the moisture sensitivity test results that the alternate anti-strip additive meets the specified moisture sensitivity requirements. If directed by the DME/DMM, provide written documentation (e.g., research or project evaluation reports) from the manufacturer of the alternate anti-strip additive showing successful use of the alternate anti-strip additive in asphalt mixtures at the same dosage rate as is being recommended for the JMF.

If the DME/DMM determines that moisture susceptibility results are suspect or inconsistent with historical data or field performance, a specified level of anti-strip additive may be required in a mixture at no additional cost to the Department prior to approval.

AASHTO R 35, Section 12. Adjusting the Mixture to Meet Properties

Revise Subsection 12.1 by adding the following to the end:

See Department Revisions to AASHTO R 35, Subsection 4.2, Note 5. The suggested reference may assist in adjusting the aggregate skeleton.

Revise Section 12 by adding the following new Subsections:

12.4 Evaluating Mix Characteristics - Although a mix may satisfy all the Superpave volumetric design criteria at design asphalt binder content, it may be unacceptable because of the following considerations:

Brittleness - Mixes with abnormally high values of Tensile Strength and abnormally high binder stiffness values due to thin apparent asphalt film thickness (low binder content) are undesirable because pavements of such mixes tend to be more rigid or brittle and may crack under heavy volumes of traffic. This is particularly true where base and subgrade deflections are such as to permit moderate to relatively high deflections of the pavement. As a guideline to ensure there is sufficient asphalt binder in the mixture, calculate the apparent asphalt film thickness according to the procedure in the reference book entitled Hot Mix Asphalt Materials, Mixture Design and Construction, TB-1, Second Edition, 1996 by Roberts, Kandhal, et al. and available through the National Asphalt Pavement Association (NAPA), as part of the mix design process. As a guideline, mixtures with a calculated apparent asphalt film thickness ranging from 9 to 12 microns should provide enhanced durability. If the calculated apparent asphalt film thickness is not within the guideline range, the mixture's other properties should be further scrutinized to ensure mixture durability. Apparent asphalt film thickness should not be used as the sole parameter to reject the mixture. Adjustments in the aggregate gradation [particularly the percentages passing the 2.36 mm and 75 μm (No. 8 and No. 200) sieves] should be made to increase the VMA so that more asphalt can be incorporated in the mix. This may be done by deviating further from the maximum density line (Fuller's curve). If the minus 75μm (No. 200) sieve content is high, a reduction in this fraction will increase the aggregate voids.

12.4.1. Mixture Volumetric Properties Sensitivity to Asphalt Binder Content - Some mixes, such as mixes with aggregate gradation close to the maximum density line (Fuller's curve), are very sensitive to slight variations in asphalt content. If a +/- 0.5% change in asphalt binder content relative to the estimated design content (see Section 10) results in VMA outside the criteria in AASHTO M 323, Table 7, or voids that are outside of the Department's production specifications (Publication 408, Section 413) the mix should be considered suspect. If a mix changes from dry to gummy with a 0.5% increase in the asphalt content, the mix should also be considered suspect. Such mixes may be reduced in sensitivity by adjustments to the aggregate gradation, usually by deviating further from the maximum density line.

12.4.2. Tenderness - These mixes tend to pull and shove during the compaction operation resulting in hairline cracking, usually consisting of transverse hairline cracks several inches apart, sometimes accompanied by longitudinal cracking. A poor aggregate gradation often is a leading contributor to tender (slow-setting) or unstable mixes. Tender mixes are frequently typified by the following:

(a) An excess of the middle-size fraction in the material passing the 4.75mm (No. 4) sieve. A hump in the grading curve caused by the excess sand could appear on nearly any sieve below the 4.75 mm (No. 4) sieve and above the 150 μm (No. 100) sieve. This condition is most critical when occurring near the 600 μm (No. 30) sieve. A change in the gradation of the fine aggregate(s) is necessary to remove the hump.

(b) Close proximity of the aggregate gradation to the maximum density line and/or major portion of gradation line relatively straight. These mixes generally have low VMA. Some easily compactable gravel mixes attain the desired maximum density (lowest possible VMA) with one or two passes of the roller, and then start to decompact and deform. A change in the gradation of the mix may be necessary to alleviate this situation.

Poor Handling and/or Constructability Characteristics. Such mixes are difficult to handle from production to field application without segregating and/or difficult to achieve acceptable and uniform compaction. Often these mixes have aggregate gradations that are not uniform or have characteristics as stated previously. Avoiding humps and gaps in gradation typically corrects this condition. Otherwise, aggregate shape and texture characteristics should be investigated. Plant produced materials should be sampled and evaluated relative to design values, if production material variability is suspected. Evaluate apparent asphalt film thickness as directed in 12.4.1 and compare to design values.

AASHTO R 35, Section 13. Report

Revise Section 13 by adding new Subsections as follows:

13.5 Report the JMF and plot the mixture gradation on the most current Form TR-448A or on a form acceptable to the Department. Provide all design laboratory test results for review by the Department.

13.5.1 As part of the JMF report, the Producer is to provide the ignition furnace correction factors for percent asphalt binder (C_f) and for percent passing the 75 μm (No. 200) sieve (200 C_f) for the JMF. Determine these correction factors according to PTM No. 757 and document the process on the form included in the Electronic State Book (ESB) or on another form provided by the Department. Include this form as part of the JMF documentation submitted to the Department for review. The HMA Producer is responsible for determining the frequency or identifying the criteria that triggers when they determine new or revised ignition furnace correction factors for each JMF. The ignition furnace correction factor documentation submitted as part of the JMF report is to be the HMA

Producer's correction factors that they determined best represent the current raw material components of the JMF and current compositional targets of the JMF.

13.5.2 If ignition furnace correction factors cannot be determined for percent asphalt binder or for percent passing the 75 µm (No. 200) sieve due to potential problematic aggregate conditions in the JMF, the HMA Producer must immediately notify the District Materials Engineer/Manager, and as part of the JMF submission, submit a request to change the test method from PTM No. 757 to PTM No. 702, Modified Method D with comprehensive documentation supporting that problematic aggregates may exist for the JMF. Upon District review of the comprehensive documentation, witnessing the HMA Producer's attempt to determine ignition furnace correction factors, and concurrence that a potential problematic aggregate condition exists, the District will submit all the comprehensive documentation to the LTS. The LTS will make the final determination if problematic aggregates exist. The LTS, at its discretion, may request samples of the problematic aggregates for testing and verification of the potential problematic aggregate condition.

3. **Department Revisions to AASHTO M 323 - Standard Specification for Superpave Volumetric Mix Design**

AASHTO M 323, Section 4. Significance and Use

Revise Section 4 by adding the following to the end:

Under the Department's Research initiative, currently referred to as Superpave Special Studies or Superpave Validation Studies, and with the approval of the Asphalt Paving Quality Improvement Committee, this standard and specified requirements, in part or whole, may be revised.

AASHTO M 323, Section 5. Binder Requirements

Revise Section 5 completely as follows:

Delete M 323, Tables 1, 2, and 3. Requirements are as previously specified in the Department Revisions to AASHTO R 35, Subsection 6.1 and Department Publications 242 (Chapter 5.8) and Bulletin 25. Adjustments made for RAP, RAS or a combination of RAP and RAS usage will be in accordance with the Department's requirements found in Appendix H.

AASHTO M 323, Section 6. Combined Aggregate Requirements

Revise Subsection 6.1.2 by revising the referenced Table 4 as follows:

Table 4 - Aggregate Gradation Control Points

	Nominal Maximum Aggregate Size - Control Point (Percent Passing)									
	37.5 mm		25.0 mm		19.0 mm		12.5 mm		9.5 mm	
Sieve Size	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
50.0 mm	100	--	--	--	--	--	--	--	--	--
37.5 mm	90	100	100	--	--	--	--	--	--	--
25.0 mm	--	89*	90	100	100	--	--	--	--	--
19.0 mm	--	--	--	89*	90	100	100	--	--	--
12.5 mm	--	--	--	--	--	89*	90	100	100	--
9.5 mm	--	--	--	--	--	--	--	89*	90	100
4.75 mm	--	--	--	--	--	--	--	--	--	89*
2.36 mm	15	41	19	45	23	49	28	58	32	67
0.075 mm	0	6	1	7	2	8	2	10	2	10

* The maximum percent passing on these sieves have been revised from Table 4 in AASHTO M 323 to better conform with the written definition of the nominal maximum aggregate size provided in AASHTO R 35 Section 3.9 and AASHTO

M 323 Section 3.6. (Refer to Department Revisions to AASHTO R 35, Subsection 6.8, Note 6A)

Revise Subsection 6.6 completely as follows:

Refer to the Department's modified design procedures and requirements (see Appendix H) when RAP, RAS or a combination of RAP and RAS is used in the mixture.

Revise Section 6 by adding a new Subsection as follows:

6.7 Toughness Requirements, Coarse Aggregates - The aggregates shall meet the abrasion requirements specified in Table 6A. The percentage of weight loss will be determined in accordance with AASHTO T 96.

Table 6A - Coarse Aggregate Toughness Criteria (AASHTO T 96)

Estimated Traffic (million ESALs)	Abrasion (Maximum % Loss)
<3	45
3 to < 30	40
≥30	35

Revise the Section 6 Table 6 Row 5 for Design ESALs ≥30 Million and Columns for Fractured Faces, Coarse Aggregate, Percent Minimum as follows:

Table 6 – Superpave Aggregate Consensus Property Requirements

Design ESALs[a] (Million)	Fractured Faces, Coarse Aggregate,[c] Percent Minimum	
	Depth from Surface	
	≤ 100 mm	> 100 mm
≥30	95/90	95/90

AASHTO M 323, Section 7. Asphalt Mixture Design Requirements

Revise Subsection 7.1 by adding the following to the end: "and as

modified herein."

Revise Subsection 7.2 completely as follows:

The asphalt mixture design, when compacted in accordance with AASHTO T 312, shall meet the relative density, VMA, VFA, and dust to binder ratio requirements specified in Table 7 and the minimum effective asphalt requirements in Table 8.

Table 7 – Superpave Asphalt Mixture Design Requirements

Design ESALs (Million)	Required Relative Density, Percent of Theoretical Maximum Specific Gravity[d]			Voids in the Mineral Aggregate (VMA), Percent Minimum — Nominal Maximum Aggregate Size, mm						Voids Filled with Asphalt (VFA) Range,[b] Percent	Dust-to-Binder Ratio Range[c]
	$N_{initial}$	N_{design}	N_{max}	37.5	25.0	19.0	12.5	9.5	4.75		
<0.3	≤91.5	96.0[a]	≤98.0	12.0	13.0	14.0	15.0	16.0	16.0	70-78	0.6-1.2
0.3 to <3	≤90.5	96.0[a]	≤98.0	12.0	13.0	14.0	15.0	16.0	16.0	65-78	0.6-1.2
3 to <10	≤89.0	96.0[a]	≤98.0	12.0	13.0	14.0	15.0	16.0	16.0	65-75[e,f,g]	0.6-1.2
10 to <30	≤89.0	96.0[a]	≤98.0	12.0	13.0	14.0	15.0	16.0	16.0	65-75[e,f,g]	0.6-1.2
≥30	≤89.0	96.0[a]	≤98.0	12.0	13.0	14.0	15.0	16.0	16.0	65-75[e,g]	0.6-1.2

[a] The Required Relative Density at N_{design} may vary if the requirements of Tables 7, 8, and 9 are met and incorporated into the design.

[b] For 37.5-mm nominal maximum aggregate size mixtures, the specified lower limit of the VFA range shall be 65 percent for all design traffic levels.
For 25.0-mm nominal maximum aggregate size mixtures, the specified lower limit of the VFA range shall be 68 percent for all design traffic levels.
For 19.0-mm nominal maximum aggregate size mixtures, the specified lower limit of the VFA range shall be 70 percent for all design traffic levels.
For 12.5-mm nominal maximum aggregate size mixtures, the specified lower limit of the VFA range shall be 72 percent for all design traffic levels.

[c] For 4.75-mm nominal maximum size mixtures, the dust-to-binder ratio shall be 1.0 to 2.0, for design traffic levels <3 million ESALs, and 1.5 to 2.0 for design traffic levels ≥3 million ESALs.

[d] For 4.75-mm nominal maximum size mixtures, the relative density (as a percent of the theoretical maximum specific gravity) shall be within the range of 94.0 to 96.0 percent.

[e] For design traffic levels > 3 million ESALs, 9.5-mm nominal maximum aggregate size mixtures, the specified VFA range shall be 74 to 77 percent and for 4.75-mm nominal maximum aggregate size mixtures shall be 75 to 78 percent.

[f] For design traffic levels >0.3 million ESALs, and for 4.75-mm nominal maximum size mixtures, the specified VFA range shall be 66 to 77 percent.

[g] For design traffic levels ≥3 million ESALs, and for 9.5-mm nominal maximum size mixtures, the specified VFA range shall be 74 to 81 percent and for 12.5-mm nominal maximum size mixtures, the specified VFA range shall be 72 to 80.

Table 8 - Minimum Effective Asphalt (Pbe) for 9.5mm and 12.5mm Superpave Asphalt Mixtures.

	Minimum Pbe[(1)]	
Combined Aggregate Bulk Specific Gravity (Gsb)	**9.5 mm Superpave Mixes**	**12.5 mm Superpave Mixes**
2.250 to 2.274	6.2	5.8
2.275 to 2.324	6.1	5.7
2.325 to 2.374	6.0	5.6
2.375 to 2.424	5.9	5.5
2.425 to 2.474	5.8	5.4
2.475 to 2.524	5.7	5.3
2.525 to 2.574	5.6	5.2

2.575 to 2.624	5.5	5.1
2.625 to 2.674	5.4	5.0
2.675 to 2.724	5.3	4.9
2.725 to 2.774	5.2	4.8
2.775 to 2.824	5.1	4.7
2.825 to 2.874	5.0	4.6
2.875 to 2.924	4.9	4.5
2.925 to 2.974	4.8	4.4
2.975 to 3.024	4.7	4.3
3.025 to 3.074	4.6	4.2

(1) The DME/DMM may approve mixtures with N_{Design} Air Voids from 3.5 percent to 4.0 percent.

Revise Section 7 by adding the following new Subsections to the end:

7.4 Performance Testing – Submit the results of AASHTO T 324 and ASTM D8225 performance testing for each JMF at the design binder content including all binder additives. Oven condition loose laboratory prepared asphalt mixture for 2 h ± 5 min at 285 ± 5F (140 ± 3C) for PG 58S-28, 293 ± 5F (145 ± 3C) for PG 64S-22, or 308 ± 5F (153 ± 3C) for PG 64E-22 final asphalt binder grade of the JMF. Compact specimens to 7.0 ± 0.5 percent air voids according to AASHTO T 312. Test compacted test specimens for AASHTO T 324 at a test temperature of 122 ± 2F (50 ± 1C). Test compacted test specimens for ASTM D8225 at a test temperature of 77 ± 2F (25 ± 1C). Additionally, submit results of AASHTO PP 78 Section 7 testing of the JMF blended binder for all JMFs with a recycled binder ratio (RBR) greater than or equal to 0.35.

The DME/DMM may allow JMFs that conform to all of the testing criteria in Table 9 to apply the criteria exceptions in Table 10 to the JMF.

TABLE 9 - Performance Testing Limits

Specification	**AASHTO T 324, Hamburg Wheel Track**				**ASTM D8225, CT_{Index}**	**AASHTO PP 78(1, 2), ΔTc**
Property	**Traffic Level (Millions of ESALs)**	**Maximum Rut Depth at 20,000 Passes (mm)**	**SIP (minimum passes)**	**Minimum Passes at 12.5mm Rut Depth**	**CT_{Index}(3)**	**ΔTc**
Rutting & Moisture Susceptibility	<3	≤15	N/A	N/A		
		≤20	14,000	10,000		
		≤25	16,000	12,000		
	3 and <10	≤10	N/A	N/A		
		≤15	14,000	12,000		
		≤20	16,000	14,000		
	≥10	≤10	N/A	N/A		
		≤12	16,000	15,000		
Cracking(3)	<3				>70	

	3 and <10 ≥10	>80 >90	
High RAP / RAS (≥ 0.35 RBR)(1)	All		>-5.0C

(1) Only applies to JMFs with an RBR greater than or equal to 0.35
Recycled Binder Ratio (RBR) = ((Pb_{RAP} xP_{RAP}) + (Pb_{RAS} x P_{RAS})) / (100 x Pb_{Total})
Where:

Pb_{RAP} = Percent Asphalt in the RAP
P_{RAP} = Percent of RAP by weight in the JMF
Pb_{RAS} = Percent asphalt in the RAS
P_{RAS} = Percent RAS by weight in the JMF
Pb_{Total} = Total Percent of asphalt in the JMF

(2) Compute ΔTc according to AASHTO PP 78, Section 7.2, using Section 7.6 Procedure for Evaluating Specific Mixtures .
(3) ASTM D8225 CT_{Index} Tests with an average peak load result of less than 75 psi is a failing test.

TABLE 10 - Exceptions for JMFs that Meet All Table 9 Requirements

Property	AASHTO Specification	Existing PA Specification Requirement	Specification Requirement if Table 9 Limits are Met
Percent Air Voids at N_{Design}	R 35 Table 2	4.0	3.0 to 4.1
Moisture Susceptibility	R 35 - Sect. 4.4, M 323 - Sect. 7.3, & T 283	<0.80 AASHTO T 283 TSR, mandatory anti-strip	AASHTO T 283 and mandatory anti-strip waived
Asphalt PG Grade	M 323 Sect. 5, and as specified	As specified	PG grade bumping to meet all performance testing limits allowed

Note: The DME/DMM may allow or disallow any or all of the exceptions in Table 10 for any JMF.

7.5 Approved Job-Mix Formula - The JMF is developed specifically for the plant from the reviewed laboratory design. This may require small adjustments to fit the plant and thus ensure production within the tolerance limits. The selected laboratory design must be reproducible within the tolerances specified in Publication 408, Section 413. This design, when verified and proven in production by the process described in Publication 408, Section 413.2 can then be considered an approved JMF as long as the mix characteristics are satisfactory during construction and the material sources, aggregate gradations, asphalt content and test values remain within the specifications and design tolerances. If initial JMF verification is unsuccessful, the following process is recommended for statistical evaluation of the JMF:

7.5.1 Statistical Evaluation of JMF Production

- The contractor must evaluate the JMF based on a minimum of three (preferably five) random samples taken from a single day's plant production using PTM No. 1.

  Evaluate the mix composition (gradation and asphalt binder content) for conformance to Publication 408, Section 413.2, Table A. Using the procedure described in Publication 408, Section 106.03, calculate a PWL for asphalt binder content (Pb), percent passing the 2.36 mm (No. 8) sieve, and percent passing the 75 µm (No. 200) sieve relative to the target values in the JMF. If the resulting PWL for each parameter is 85% or greater, the plant's process control and blending of mixture components is considered satisfactory. If the resulting PWLs are less than 85%, the mix composition's reproducibility is inadequate; take corrective action at the plant to obtain the desired mix composition and then re-evaluate the mix.

- Evaluate the mixture's maximum specific gravity (Gmm) and VMA in accordance with Appendix I. Evaluate VFA and the F/A ratio for conformance to AASHTO M 323, Table 7 and voids for conformance to the Department's production specifications.
- If the mix composition conforms to the JMF but the volumetric data do not meet the above criteria, perform additional testing of each material component in the mix for change in properties and/or verify all test equipment is in proper working order, calibrated within specifications, and test procedures are performed properly. Provide a summary report which includes findings and recommendations to the DME/DMM for review prior to performing any work with such a design.

7.6 Quality Control Requirements for Mix Designs During Production - Prepare and Submit a QC Plan to the DME/DMM for review and approval as specified in Chapter 1, Section 2.1 and Publication 408, Section 413.2. Perform all tests as required therein at the frequencies specified. Control and documentation of Gmm and volumetric properties during production shall be performed as specified in Appendix I.

7.6.1 Ignition Furnace Correction Factors. As part of the HMA Producer's QC plan, it is the HMA Producer's responsibility to regularly monitor and maintain their ignition furnace correction factors to ensure that the correction factors represent the raw material components of the JMF and the JMF compositional targets. The HMA Producer is responsible for determining the frequency of when they monitor, review, or check their ignition furnace correction factors for each JMF or identifying the criteria that trigger the HMA Producer to monitor, review or check their ignition furnace correction factors for each JMF. It is the HMA Producer's responsibility to request correction factor changes to the appropriate District Materials Engineer/Manager with documentation supporting the correction factor change.

If an ignition furnace correction factor for asphalt content or percent passing the 75 µm (No. 200) sieve has changed, the HMA Producer shall immediately submit a request to change the correction factors with supporting data and justification to the District Materials Engineer/Manager. HMA Producers must submit requests for correction factor changes in a timely manner so as not to jeopardize the accurate testing of pending acceptance samples. The District may request that LTS suspend testing of samples that have arrived at the LTS dock but have not been tested, until the District reviews and makes a decision on the correction factor change request. The District must also keep all other samples of the JMF still located within the District until a decision has been made on the correction factor change request and may also decide to suspend shipment of this JMF until a decision has been made on the correction factor change request. This will ensure continued asphalt testing efficiency and testing turnaround time at the LTS.

After reviewing the supporting data, the DME/DMM may grant the request to change the current correction factor(s). Correction factor changes will not be allowed to negate or change a failing acceptance sample test result. In addition, revised correction factors cannot be used for retests. All retests will use the correction factors used on the original mixture acceptance samples. It is imperative for the HMA Producer to notify the District immediately of any issues with correction factors for a particular JMF Year and Number. The District will then immediately notify the LTS Asphalt Lab Manager to stop testing on pending samples for the particular JMF Year and Number. LTS will resume testing of the pending samples upon the District's review and decision of a HMA Producer's request for change of a correction factor and the District's notification to the LTS Asphalt Lab Manager.

7.6.2 Change of Test Method Due to Problematic Aggregates. It is the HMA Producer's responsibility to monitor and maintain their ignition furnace correction factors to ensure that the correction factors represent the raw material components of the JMF and the JMF compositional targets. This monitoring should be included and managed within a HMA Producer's Quality Control Plan. If during this monitoring or during the volumetric mix design process, the HMA Producer identifies potential problematic aggregates, the HMA Producer must immediately notify the District Materials Engineer/Manager of the affected JMF numbers and submit a request to change the test method from PTM No. 757 to PTM No. 702, Modified Method D with comprehensive documentation supporting that problematic aggregates may exist for the JMF. Problematic aggregates may exist if one or more of the following conditions exist:

- Sample burn times of a specific JMF extend well beyond normal burn times for similar NMAS mixtures.
- Samples burn continuously for the JMF and the weight never stabilizes.
- Exploding aggregate is noted during testing or aggregate breakdown is noted in the gradation results.
- Asphalt content results are significantly (2% or more) higher than expected, based on plant recordation or solvent extraction results.
- The asphalt correction factor is in excess of 1.0.
- Attempts to establish a stable correction factor according to the method in PTM No. 757 are unsuccessful.

Upon being notified of JMF numbers with potential problematic aggregates, the District Materials Engineer/Manager must immediately notify LTS to suspend testing of samples that have arrived at the LTS dock but have not been tested and potentially contain the problematic aggregate. The District must also keep all other samples of this JMF that are still located within the District and may also decide to suspend shipment of this JMF until the problematic aggregate issue can be investigated. This will ensure continued asphalt testing efficiency and testing turnaround time at the LTS.

The District will conduct an investigation including a review of the supporting documentation provided by the HMA Producer and witnessing the HMA Producer's testing of each JMF number to verify one or more of the above problematic aggregate conditions exist. Upon completing its investigation and if the District concurs that potential problematic aggregates exist, the District will submit a written request to change the test method from PTM No. 757 to PTM No. 702 Modified Method D for a JMF to the LTS. The request must include all supporting data to justify the request for a change in test method. The LTS will make the final determination if problematic aggregates exist. The LTS, at its discretion, may request samples of the problematic aggregates for verification testing.

As part of the HMA Producer's quality control plan, it must periodically test problematic aggregate mixtures to verify that the problematic aggregate conditions continue to exist. If the problematic aggregate conditions cease to exist, the HMA Producer must immediately notify the District Materials Engineer/Manager of the affected JMF numbers and submit a request to change the test method from PTM No. 702 Modified Method D to PTM No. 757 with comprehensive documentation supporting that problematic aggregate conditions no longer exist for the JMF.

The District will conduct an investigation including a review of the supporting documentation provided by the HMA Producer and witnessing the HMA Producer's testing of each JMF number to verify that problematic aggregate conditions cease to exist. Upon completing its investigation and if the District concurs that problematic aggregates cease to exist, the District will submit a written request to change the test method from PTM No. 702 Modified Method D to PTM No. 757 for a JMF to the LTS. The request must include all supporting data to justify the request for a change in test method. The LTS will make the final determination if problematic aggregates cease to exist. The LTS, at its discretion, may request samples of the problematic aggregates for verification testing.

7.7 Quality Control Requirements for P.G. Binder Supply and Handling During Production

7.7.1 Same grade PG-Binders may be commingled in the same hot mix asphalt producer storage tank only when compatible (i.e., the PG-Binders can become homogeneous through agitation or circulation and remain the same grade of PG- Binder). Before commingling same grade PG 64E-22 from different suppliers, or any other modified PG-Binders from different suppliers, producers are to obtain written verification of material compatibility from the approved supplier(s).

7.7.2 Different grade PG-Binders may be commingled in the same hot mix asphalt producer storage tank only when the former PG-Binder is compatible (i.e. the PG-Binder can become homogeneous through agitation or circulation with the different grade PG-Binder) and has been drained as low as practical prior to introducing a different grade PG-Binder. Add a minimum of two full tanker loads (three if feasible) of new different grade PG-Binder, and circulate well before using.

7.7.3 If the storage tank is not dedicated to a specific grade, producers of asphalt mixtures are to maintain a log of shipments or notify the respective DME/DMM when receiving and storing a PG-Binder of a different grade or different modifier.

7.7.4 When a supply change occurs during production, evaluate the mixtures using same grade PG-Binders supplied from a different primary supplier (i.e., United vs. PBF) for moisture susceptibility in accordance with ASTM D3625 (Boiling Water Test) as a screening test. When asphalt binder coating is less than 95%, as determined by ASTM D3625, the mixture shall be retested in accordance with AASHTO R 35, Section 11 and as modified herein. Same grade PG-Binders supplied from different storage facilities or terminals of the same primary source (e.g., Citgo) do not require additional testing unless there is evidence of a problem that may relate to a supply change.

> **Note 9A**- Use of ASTM D3625 as a screening test is intended as a time saving alternative to be used primarily during high volume production at the HMA facility. If an approved mix design was only tested for moisture susceptibility in accordance with Section 11, using a PG Binder supplied from a different primary supplier, a recommended best practice is to conduct testing according to Section 11 as soon as time permits using the new primary PG Binder Supplier.

7.7.5 Provide Department Quality Assurance (QA) teams P.G. Binder samples as required.

> **Note 9B**- When the purpose of the sample is to verify the quality of the binder being incorporated into a production mix, the preferred location for asphalt sampling at an HMA plant is at the asphalt pump. A sample valve located at the HMA plant asphalt pump guarantees the asphalt QC sample represents the asphalt added to the mix. It is important to note that taking samples from this location requires coordination between the HMA plant operator and the QC person to insure the sample is taken while the plant is producing the mix to be tested. Manufacturers typically provide sample port locations on the piping at the pump. Connection of the sample valve to the pump piping with a very short pipe nipple will keep the valve hot and prevent safety concerns during sampling. The short connection between the sample valve and the asphalt line also can help minimize the amount of waste material required to insure a representative sample. A QC asphalt sample from an HMA plant storage tank indicates if the material in that tank meets the required PG asphalt. It does not ensure that valves were set correctly and that this asphalt grade was added to the HMA mix.

7.7.6 Prepare and maintain a QC Plan at each production facility for P.G. Binder including all of the following elements:

1. A schematic drawing showing all tanks, pumps, piping, valves, sampling points and heat system components. Each individual item (tank, valve, etc.) should be clearly labeled and/or numbered on the drawing and in the field.

2. Specific procedures for movement of asphalt into and out of each storage tank. The procedures should clearly identify all pumps and valves used for the desired flow of asphalt binder and indicate pump direction and valve positions.

3. Specify sampling location and sampling procedure. The sampling procedure should include the need for any Personal Protective Equipment and safe practices when sampling hot asphalt.

4. Establish storage temperatures for each PG asphalt binder to be stored at the HMA plant. Identify heat system controls and settings to obtain the desired temperatures and institute a monitoring procedure to insure proper temperatures are maintained.

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Chapter 2B

Design and Control of Stone Matrix Asphalt (SMA) Mixtures

1. General Scope

The Department has established procedures for the design and control of Stone Matrix Asphalt (SMA). SMA is a hot-mix asphalt consisting of two parts, a coarse aggregate skeleton and a rich asphalt binder mortar. The mortar is a mixture of asphalt binder, mineral filler and a stabilizing additive. SMA mixtures must have an aggregate skeleton with coarse aggregate-on-coarse aggregate contact, generally referred to as stone-on-stone contact. Much of the design and control of SMA is consistent with the procedures for Superpave outlined in Chapter 2A, but there are some differences as well. The purpose of these procedures discussed in Chapter 2B is to provide guidance for the design and use of Stone Matrix Asphalt for Department work.

The Department will follow the Stone Matrix Asphalt mix design procedure and specifications contained in the AASHTO R 46, Standard Practice for Designing Stone Matrix Asphalt (SMA) and the AASHTO M 325 Standard Specification for Stone Matrix Asphalt (SMA) except as revised herein. All AASHTO standard practices, specifications and test procedures are implied to reference the most current approved and published version available at the time of bid letting.

2. Department Revisions to AASHTO R 46 – Standard Practice for Designing Stone Matrix Asphalt (SMA)

AASHTO R 46, Section 3. Terminology

Revise Section 3 by adding a new Subsection as follows:

3.8 Design Number of Gyrations (N_{des}) – The number of gyrations which, when applied to the design mixture specimens, results in 3.5 – 4.0 percent air voids and determines the asphalt content.

AASHTO R 46, Section 4. Summary of the Practice

Revise Subsection 4.2 as follows:

Replace the fourth sentence with “Where no previous history is available, it is recommended that an initial trial asphalt binder content be selected according to Table C of Publication 408, Section 419.”

Revise Subsection 4.3 as follows:

Delete Note 2. Mixes must meet the minimum asphalt content requirements of Table C in Publication 408, Section 419.

Revise Section 4 by adding a new Subsection as follows:

4.6 Review of Job-Mix Formula (JMF) – The contractor will be solely responsible to design a mix that meets all Department requirements. The contractor shall submit the required test results, the composition of the mixture and the combined aggregate gradation curves proposed for use in the production of the mixture to the District Materials Manager/Materials Engineer (DMM/DME) for review at least three weeks prior to the scheduled start of work. Submit mix designs to the DME/DMM for review following the procedures outlined in Appendix J. The acceptability of the bituminous concrete produced from any mix design is determined as specified in Publication 408, Section 419 in addition to the criteria specified herein.

Whenever the Contractor's gradations and calculations do not check, the DMM/DME will request the Contractor to do additional testing and/or recalculate and submit the correct mathematical solutions. The DMM/DME may request, at his option, to observe testing of the trial mix. He may also request that materials be submitted to the Materials and Testing Division (MTD) for the evaluation of the mix. The Department reserves the right to review any design through plant production, prior to using for Department work, at no additional cost to the Department. See Bulletin 27, Chapter 2A and the revisions for AASHTO M 323, Section 7 for the procedure on the statistical evaluation of a JMF through plant production and replace the references to Publication 408, Section 409 with equivalent values from Section 419.

AASHTO R 46, Section 6. Selection of Trial Gradations

Revise Subsection 6.1 as follows:

Replace both references to M 325 for gradation with the gradation ranges as specified in Table B of Publication 408, Section 419.

AASHTO R 46, Section 7. Selection of Trial Binder Content

Revise Subsection 7.1 completely as follows:

A binder content should be selected according to Table C of Publication 408, Section 419.

AASHTO R 46, Section 9. Selection of Desired Gradation

Revise Subsection 9.1 as follows:

Replace reference to AASHTO T 166 with PTM No. 715, typical throughout

AASHTO R 46, Section 10. Selection of Optimum Binder Content

Revise Subsections 10.1 and 10.2 as follows:

Replace AASHTO M 325 criteria with that outlined in Tables B and C of Publication 408, Section 419.

AASHTO R 46, Section 11. Moisture Susceptibility

Revise Section 11 by adding a Note as follows:

Note 7 - It has been shown that the chemical composition of asphalt binders, aggregates and any mixture additives can have a strong influence on the results obtained from these testing procedures. Therefore, it is recommended that the sources of materials (binder and additives) used in the design process be the same as the materials that will be incorporated in the mixture during production. If either of these components change at the time of production, the actual production mixture must be verified by retesting, initially with ASTM D 3625 (Boiling Water Test) as a screening test. Otherwise, the design testing may not be representative.

Revise Subsection 11.1 completely as follows:

11.1 Prepare at least six mixture specimens (half to be tested dry and the other half to be tested after partial saturation and freeze-thaw conditioning) composed of the design aggregate structure at the design binder content. Condition the mixtures in accordance with the revised mixture conditioning for volumetric mixture design and production quality control testing time (Appendix I herein) plus an additional 2 hours. After conditioning, compact the specimens to 6 ± 1.0 percent air voids in accordance with T 312 to the number of gyrations specified in Pub. 408, Section 419, Table B.

11.2 Test the specimens within 24 hours of completion of T 312 in accordance with T 283, starting with Section 9.6 of the procedure with the following exceptions:

(a) Revise T 283, Section 10.3.1 vacuum application time to apply a vacuum of 254 mm (10 in.) mercury partial pressure for 30 minutes to the conditioned specimens, regardless of air voids and percent final saturation. (See Note 8)

(b) Delete T 283, Sections 10.3.5 and 10.3.6

Note 8 – The following table explains the proper vacuum settings and readings.

Vacuum Gauge Type	Measurement Scale	Vacuum Reading with No Vacuum Applied	Vacuum Reading with Proper Vacuum Applied
Partial	Inches of Mercury	0 (Zero)	10
Partial	mm of Mercury	0 (Zero)	254
Absolute	Inches of Mercury	Approximately 29.9	19.9
Absolute	mm of Mercury	Approximately 760	506

Calculate the average ($\bar{x}$) and standard deviation (s) of tensile strengths for both the dry group of specimens and the freeze-thaw group. Calculate the Coefficient of Variation (C.V.) for each group by dividing the standard deviation by the average:

$$C.V. = \frac{s}{\bar{x}} \quad (\%)$$

If the C.V. is greater than 12% for the dry group, or 24% for the freeze-thaw group, the test results should be viewed as suspect and a new subset of specimens prepared and tested.

If only one of the results is suspect and analysis according to PTM No. 4 identifies that result as an outlier, a replacement is initially only required for that specimen. If the C.V. considering the replacement specimen in place of the outlier is still greater than the acceptable limit, prepare and test an entire subset of new specimens. Each group of specimens, dry or freeze-thaw, is defined as a subset.

11.3 If the average dry strength is less than 80 psi (552 kPa) or the average wet/freeze strength is less than 50 psi (345 kPa), the mix is unacceptable.

11.4 The design shall meet the tensile strength ratio (TSR) requirement listed in AASHTO M 325, Section 9.3

11.5 If visual stripping of the asphalt film is observed from the T 283 specimens and estimated to be 5% or greater of the specimen face area, further evaluate moisture susceptibility by performing test procedure ASTM D 3625 (Boiling Water Test). (Uncoated areas due to fractured aggregate should not be recorded as stripped). When asphalt binder coating is less than 95%, as determined by ASTM D 3625, retest the mixture according to AASHTO T 283 as outlined above. All collected specimens and test data should be carefully reviewed prior to determining acceptability. If there is any doubt concerning the mixture’s susceptibility, the recommended approach is to consider the mix moisture susceptible.

APPENDIX J

ANNUAL ASPHALT CONCRETE MIX DESIGN SUBMITTAL PROCEDURE

***Prior to ANY Annual Mix Design Submittals*:**

Submit the following to the District Materials Engineer/Manager (DME/DMM):

1) Submit the most current aggregate bulk specific gravity (Gsb) values determined according to AASHTO T 84 and AASHTO T 85 for Fine Aggregate and Coarse Aggregate, respectively for each aggregate to be used in all the asphalt mixture producer's JMFs for the upcoming or current calendar year. The most current Gsb values may have been determined by the aggregate producer, the asphalt mixture producer, or the MTD (current Bulletin 14 values). If the Gsb values are determined by the aggregate producer or asphalt mixture producer, perform the minimum number of tests as indicated in Table J-1 to determine the average specific gravity and absorption values submitted to the DME/DMM. When either the aggregate producer or asphalt mixture producer determined Gsb value differs from the MTD determined Gsb value by more than the tolerances in Table J-1, then follow-up testing is required and shall be performed.

Table J-1

Material	Test Method	Minimum Number of Tests to Determine the Producer Average Aggregate Gsb Value	Maximum Difference Between Producer and MTD Average Aggregate Gsb Values
Fine Aggregate	AASHTO T 84	3	0.038
Coarse Aggregate	AASHTO T 85	2	0.027

a) Follow-up testing: If either the aggregate producer or asphalt mixture producer average aggregate Gsb value(s) differ from the MTD average aggregate Gsb value(s) by more than the Table J-1 tolerances, the Department Representative will lift aggregate samples from current stockpiles that best represent the material that will be used for asphalt mixture production for specific gravity and absorption testing according to AASHTO T 84 or AASHTO T 85. The Department Representative will either witness the asphalt mixture producer perform the AASHTO T 84 and AASHTO T 85 testing on the aggregate samples in the presence of the Department Representative or submit the aggregate samples to the MTD for AASHTO T 84 and AASHTO T 85 testing. If the asphalt mixture producer performs the AASHTO T 84 or AASHTO T 85 testing, the asphalt mixture producer shall perform the minimum number of tests as indicated in Table J-1. The average bulk specific gravity and absorption values from this follow-up testing will be the values used on the asphalt mixture producer's JMFs.

2) Submit the current aggregate producer, asphalt mixture producer, or MTD determined aggregate consensus property values [Coarse Aggregate Angularity, Fine Aggregate Angularity, Clay Content (Sand Equivalent Test), and Flat & Elongated Particles] and aggregate physical property values [average gradation, Los Angeles Abrasion, Sodium Sulfate Soundness, Deleterious Material Content (Shale, Clay Lumps, Friable Particles, Coal or Coke). Determine consensus property and physical property test result values according to the requirements specified in Section 409.2(b), Section 419.2(b), Section 703, or other applicable Publication 408 Specification or special provision as appropriate.

3) Submit the previous calendar year's asphalt mixture production quality control (QC) test results [gradation, asphalt content, F/A ratio, volumetric analysis (air voids, VMA, VFA), and maximum theoretical specific gravity] for each existing mix design intended to be submitted for approval in the upcoming or current calendar year. This may be done electronically using the Electronic State Book (ESB) files.

New Mix Design - Submittal Process:

Procedure: Follow Bulletin 27 Chapter 2A and applicable Appendices.

Software: Within the current version of the ESB, use the MS Excel filename: PA Superpave Design

Existing Mix Design - Submittal Process:

A. 0 to ≤ 4 Production Quality Control Volumetric Analysis Test Results from the Previous Calendar Year

Procedure:

1. Re-calculate the current combined Gsb for the JMF.

   a. If the current combined Gsb value differs by ≤ 0.015 from the previous calendar year's combined Gsb value (value submitted with the annual or initial JMF submission) then, re-calculate the VMA, VFA, effective binder content, and F/A ratio using the previous year's JMF Gmm value. If all these parameters meet Bulletin 27 criteria, calculate the Gmb to 4.0% air voids using the average of the previous year's QC Gmm values (if two or more QC Gmm values available). If there are less than two QC Gmm values for the JMF from the previous calendar year's production, calculate the Gmb to 4.0% air voids using the JMF Gmm value from the previous calendar year and submit a new TR-448A with the re-calculated values. Otherwise, go to Section A.1.b.

b. If the current combined Gsb value differs by > 0.015 from the previous calendar year's combined Gsb value (value submitted with the annual or initial JMF submission) or, the recalculated VMA or VFA from Section A.1.a do not meet the Bulletin 27 design requirements, perform laboratory testing of the existing JMF as indicated in Section C below.

<u>Existing Mix Design – Submittal Process</u>:

B. ≥ 5 Production Quality Control Volumetric Analysis Test Results from the Previous Calendar Year

Procedure:

1. Re-calculate the current combined Gsb for the JMF.

   a. If the current combined Gsb value differs by ≤ 0.015 from the previous calendar year's combined Gsb value (value submitted with the annual or initial JMF submission) then, re-calculate the VMA, VFA, effective binder content, and F/A ratio. Ensure these values meet the design requirements of Bulletin 27. Then, go to Section B.2 below.

      i. If the recalculated VMA, VFA, effective asphalt content, or F/A ratio do not meet the Bulletin 27 design requirements, then make proportional or gradational adjustments to the JMF and perform laboratory testing of the adjusted JMF as indicated in Section C below.

   b. If the current combined Gsb value differs by > 0.015 from the previous calendar year's combined Gsb value (value submitted with the annual or initial JMF submission), then perform laboratory testing of the JMF as indicated in Section C below.

2. If the previous calendar year's production QC test results for the JMF in the ESB meet all of the following:

   a. average air voids are from 3.5% to 4.5%,

   b. air voids PWL is ≥ 90,

   c. averages for asphalt content and gradation of all sieves meet the n≥3 tolerances in Pub. 408, Section 409, Table A, and

   d. gradation (for all sieves) and asphalt content PWL are all ≥ 90%,

   then, calculate the Gmb to 4.0% air voids using the average of the previous calendar year's QC Gmm values. No other work is necessary. Submit a new TR-448A with the re-calculated values. Otherwise, go to Section B.3 below.

3. If the previous calendar year's production QC test results for the JMF in the ESB meet all of the following:

   a. average air voids are < 3.5% or > 4.5%, or air voids PWL is < 90

   b. average asphalt content and average gradation of all sieves meet the n≥3 tolerances in Pub. 408, Section 409, Table A, and

   c. gradation (of all sieves) and asphalt content PWL are all ≥ 90%,

   then, make proportional or gradational adjustments to the JMF and perform laboratory testing of the adjusted JMF as indicated in Section C below. Otherwise, go to Section B.4 below.

4. If the previous calendar year's production QC test results for the JMF in the ESB meet all of the following:

   a. average air voids are from 3.5% to 4.5%

   b. air voids PWL is ≥ 90

   c. average asphalt content or average gradation of any sieve does NOT meet the n≥3 tolerances in Pub. 408, Section 409, Table A or the asphalt content PWL or gradation PWL of any sieve is < 90%,

   then, perform laboratory testing of the existing JMF as indicated in Section C below. Otherwise, go to Section B.5 below.

5. If the previous calendar year's production QC test results for the JMF in the ESB meet all of the following:

   a. average air voids are < 3.5% or > 4.5%, or air voids PWL is < 90

b. average asphalt content or average gradation of any sieve does NOT meet the n≥3 tolerances in Pub. 408, Section 409, Table A or the asphalt content PWL or gradation PWL of any sieve is < 90%,

then, produce a complete new mix design according to Bulletin 27 or contact the DME/DMM for other alternate requirements.

6. For any existing JMF with ≥ 5 Production Quality Control Volumetric Analysis Test Results from the Previous Calendar Year and not falling under any of the above conditions, produce a complete new mix design according to Bulletin 27 or contact the DME/DMM for other alternate requirements.

7. If the PWL for any individual sieve is less than 90%, the DME/DMM may elect for that sieve to require a change to JMF target value from the previous calendar year.

C. Laboratory Testing of the Existing JMF or Adjusted JMF.

Perform the following:

1. Collect samples of current production JMF component materials.

2. Laboratory mix the JMF component materials targeting the existing JMF or adjusted JMF as appropriate.

3. Prepare enough laboratory mixture for a minimum of 2 Gmm samples and a minimum of 2 gyratory compacted specimens.

4. Determine Gmm according to Bulletin 27, Appendix I on a minimum of 2 samples and average the results.

5. Prepare, compact, and determine Gmb on a minimum of 2 gyratory specimens according to AASHTO T 312 except condition the mixture according to Bulletin 27, Appendix I. Calculate air voids, VMA, and VFA according to Bulletin 27 on each specimen and average the results.

6. Analyze the volumetric properties of the laboratory mixed, laboratory compacted specimens.

   i. If the laboratory mixed, laboratory compacted specimen air void results meet Table J-2, Condition A (both single and multiple), and the calculated VMA and VFA meet the minimum design requirements in Bulletin 27, and all other Bulletin 27 mixture design requirements are met, no other work is necessary. Submit a new TR-448A with the adjusted JMF and the re-calculated values.

a. If the laboratory mixed, laboratory compacted specimen air voids meet Table J-2, Condition A (both single and multiple, but VMA and VFA do not meet the Bulletin 27 design requirements, make additional or different proportional or gradational adjustments to the JMF. Perform the laboratory testing of the adjusted JMF as indicated in Section C above.

ii. If the laboratory mixed, laboratory compacted specimen air void results meet Table J-2, Condition B (both single and multiple), then make additional or different proportional or gradational adjustments to the JMF. Perform the laboratory testing of the adjusted JMF as indicated in Section C above.

a. Immediately notify the DME/DMM when multiple adjustments to the JMF and multiple volumetric analyses of gyratory specimens continue to meet Table J-2, Condition B.

iii. If the laboratory mixed, laboratory compacted specimen air void results meet Table J-2, Condition C (both single and multiple), produce a new mix design using a selected design aggregate structure (Trial Blends are NOT necessary for this level of re-design), determine a design binder content, evaluate moisture susceptibility, and submit a new TR-448A.

Table J-2

Acceptable Ranges of Air Voids (Va) for Laboratory Mixed, Laboratory Compacted Specimens for Evaluating JMFs from the Previous Calendar Year.

Condition	Range of Air Voids (Va) for each Single (n=1) Laboratory Mixed, Laboratory Compacted Specimen, %	Range of Air Voids (Va) for the Average of Multiple (n≥2) Laboratory Mixed, Laboratory Compacted Specimens, %
A	4.0 ± 0.5	4.0 ± 0.2
B	4.0 ± 1.0	4.0 ± 0.5
C	N/A	< 3.5 or > 4.5

Note: For questionable mixes as determined by the DME/DMM, additional testing, as determined by the DME/DMM, may be required. See Bulletin 27, Chapter 2A, and the PennDOT modifications to AASHTO R 35, Section 4.5 Review of Job-Mix Formula (JMF) and Bulletin 27, Chapter 2A, and the PennDOT modifications to AASHTO R 35, Section 12.4 Evaluating Mix Characteristics for guidance. In addition, the DME/DMM may require an existing mix design to be redesigned due to poor performance in the field after placement.

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WORKSHOP
AGGEGATE GRADATION ANALYSIS

A sample of No. 8 aggregate is taken from the plant stockpile. It is quartered to a sample size of 5013.2 grams. The sample is then sieved to give the following weight passing each sieve:

Sieve Size (mm)	Sieve Size English	Cumulative Mass Retained (g)	Mass Passing (g)	Percent Passing Each Sieve
12.5	½"	5001.7		
9.5	3/8"	5001.7		
4.75	No. 4	4351.5		
2.36	No. 8	700.3	250.1	
1.18	No. 16	250.1	2.0	
Pan	Pan	2.0	----	

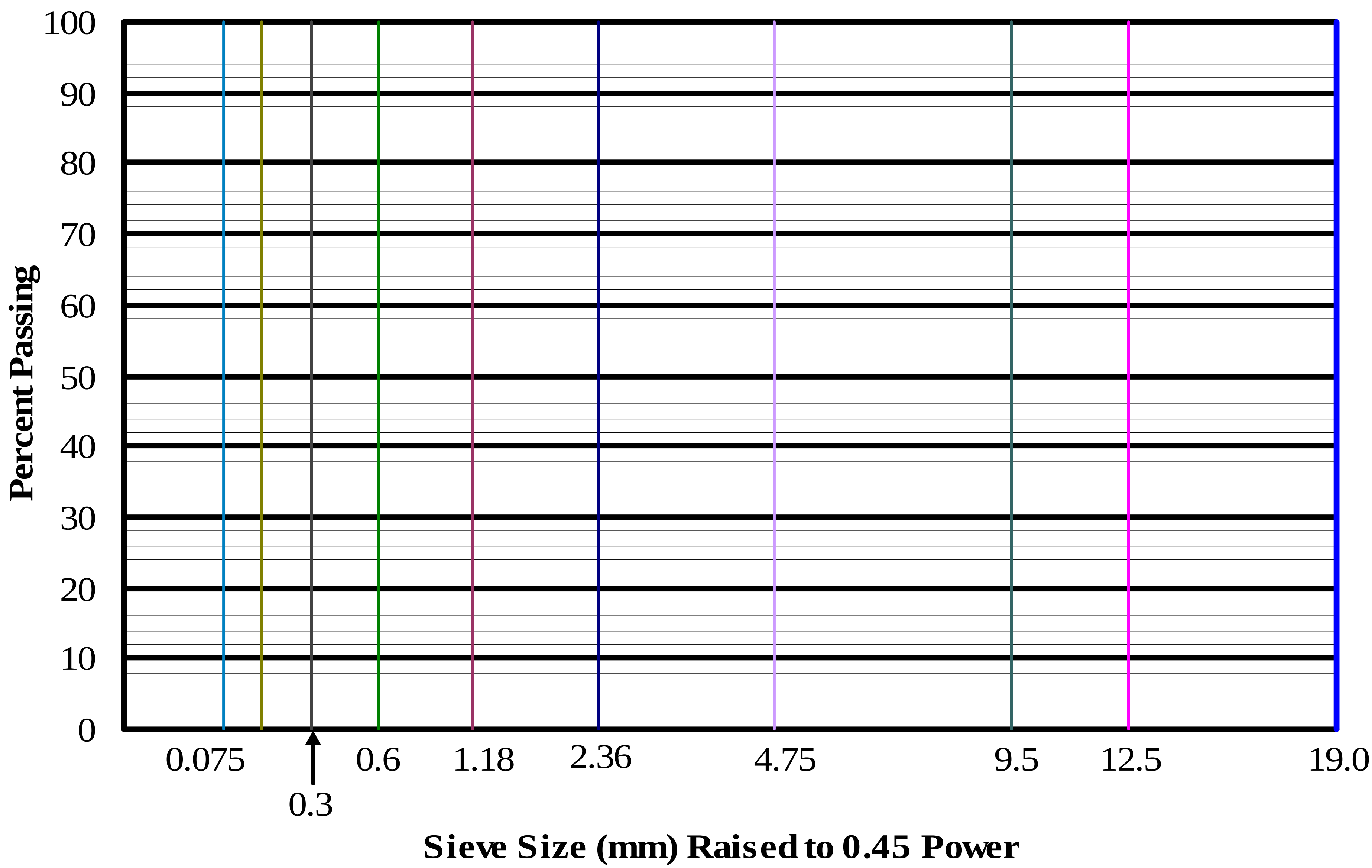
1. Determine the mass passing for the 12.5, 9.5, and 4.74 mm sieves. Determine the percent passing for all sieves.

2. Plot the gradation curve on 0.45 power chart.

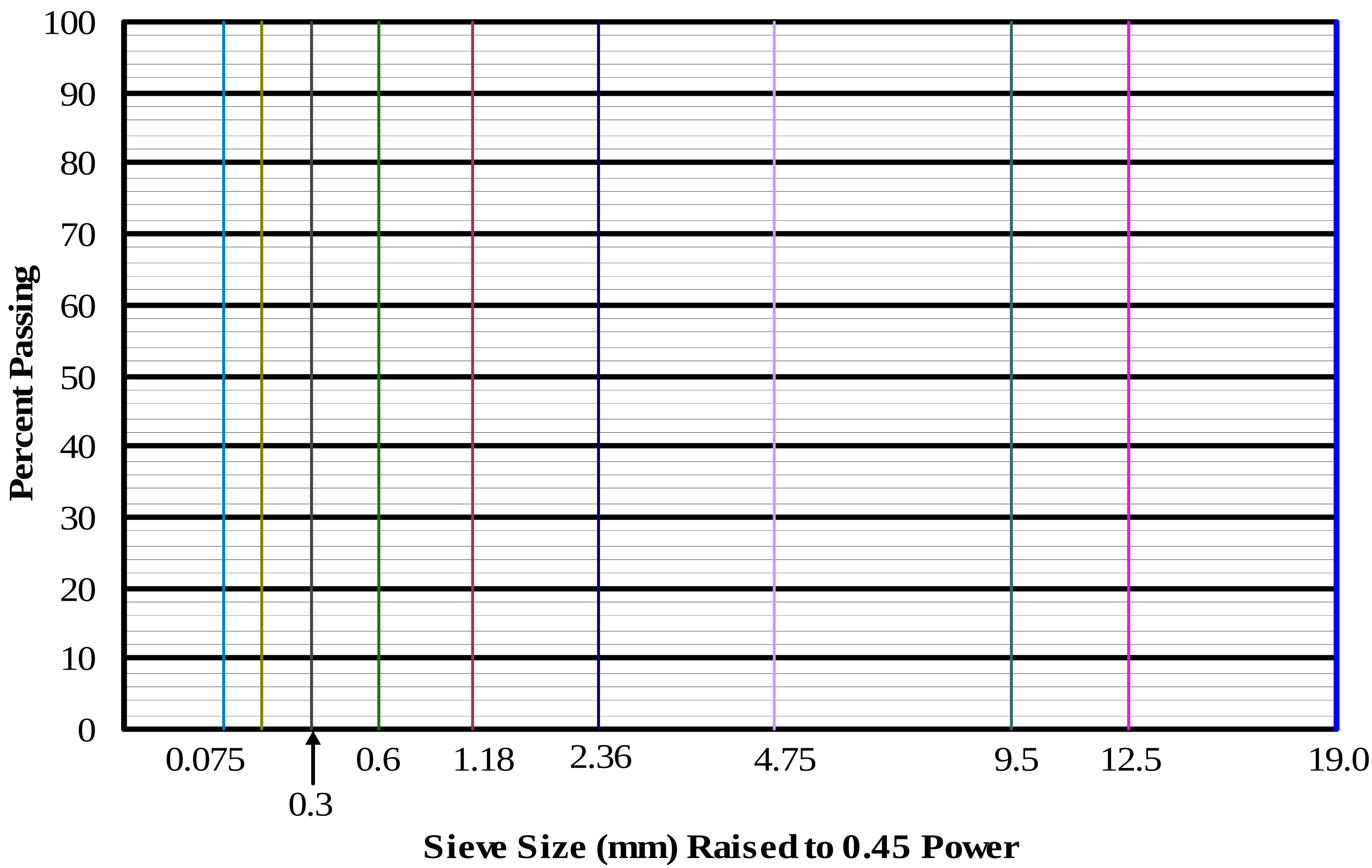
3. Does this aggregate meet PennDOT Spec 703 or AASHTO Spec M43, for a No. 8 aggregate?

4. What is the loss or error for this analysis? Is this acceptable according to PTM 616?

Gradation Chart



Gradation Chart



Aggregate Blending
Workshop Problem

The gradations of two aggregates are as follows:

Sieve Size	F.A. #1	C.A
75 µm	2.2	0.2
150 µm	3.0	0.3
300 µm	14.2	0.5
600 µm	47.7	0.9
1.18 mm	66.0	2.2
2.36 mm	85.0	2.9
4.75 mm	97.2	14.0
9.5 mm	100.0	91.0
12.5 mm		100.0

Problem 1: Find Proportions of these two aggregates needed to give a final blend with 45 percent passing the 2.36 mm sieve.

Form for Blending Two Aggregates

- % passing control sieve, target ....
- \- % passing control sieve, CA ....

= X =

- % passing control sieve, FA ....
- \- % passing control sieve, CA ....

= Y =

- $P_{FA} = (X / Y) \times 100\ \%$ ....
- $P_{CA} = 100 - PFA$ ....

Form for Blending Two Aggregates

- % passing control sieve, target ....
- \- % passing control sieve, CA ....

= X =

- % passing control sieve, FA ....
- \- % passing control sieve, CA ....

= Y =

- $P_{FA} = (X / Y) \times 100\ \%$ ....
- $P_{CA} = 100 - PFA$ ....

Aggregate Blending
Using Criss-Cross Form
Example No. 1

- Two aggregates
- Step-by-step:

1. Always fill out top of form: project, Mix ID, etc.

2. Select one control sieve (2.36 mm).

3. Select one “dummy” sieve for which all aggregates pass 100 percent (12.5 mm).

4. Fill out percent passing for aggregate A and B at the top of the form.

5. Aggregate C is a “dummy” aggregate, and the percent passing should be zero for both sieves.

6. Fill out percent passing for target on control sieves (45 percent on 2.36 mm, 100 percent on 12.5 mm).

Aggregate Blending
Example No. 1, continued

7. Fill out percent passing values on remainder of form, noting that order of aggregates changes in each section.

8. Calculate diagonal products; there are six for each section.

9. Add upper and lower diagonal products for each section.

Aggregate Blending

Example No. 1, continued

10. Subtract upper diagonal product from lower diagonal product and place in “D,” “Da,” “Db,” etc.

11. Calculate percent of each aggregate at bottom of form (48.6 percent of aggregate “A,” 51.4 percent of aggregate “B”); in this case, the percent of aggregate C will be zero, since this was a “dummy” aggregate.

12. Check your results by calculating the percent passing for the blend for the target sieve

Aggregate Blending "Criss-Cross" Form

Project: _XYZ   Mix ID: 009 xyz   Date:

Tech:

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Agg. C	% Passing Target
12.5mm	100.0	100.0	0.0	100.0
2.36mm	8.0	80.0	0.0	45.0

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Agg. C	% Passing Agg. A
Diagonal Products				
12.5mm				
2.36mm				
Diagonal Products				

Sum U

Sum L

D=L-U

Sieve Size	% Passing Target	% Passing Agg. B	% Passing Agg. C	% Passing Target
Diagonal Products				
12.5mm				
2.36mm				
Diagonal Products				

Sum Ua

Sum La

Da=La-Ua

Sieve Size	% Passing Agg. A	% Passing Target	% Passing Agg. C	% Passing Agg. A
Diagonal Products				
12.5mm				
2.36mm				
Diagonal Products				

Sum Ub

Sum Lb

Db=Lb-Ub

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Target	% Passing Agg. A
Diagonal Products				
12.5mm				
2.36mm				
Diagonal Products				

Sum Uc

Sum Lc

Dc=Lc-Uc

Check:

P_a=% Agg. A = Da/D X 100%=

P_b=% Agg. B = Db/D X 100%=

P_c=% Agg. C = Dc/D X 100%=

SUM

Target1=(PaXPPa1+PbXPPb1+PcXPPc1)/100=

Target2=(PaXPPa2+PbXPPb2+PcXPPc2)/100=

NOTE: PP is Percent Passing for a Specific Aggregate

Aggregate Blending "Criss-Cross" Form

Project: _XYZ **Mix ID: 009 xyz** **Date:**

Tech:

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Agg. C	% Passing Target
12.5mm	100.0	100.0	0.0	100.0
2.36mm	8.0	80.0	0.0	45.0

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Agg. C	% Passing Agg. A		Sum U	
Diagonal Products			800.0	0.0	0.0	800.0	
12.5mm	100.0	100.0	0.0	100.0			D=L-U
2.36mm	8.0	80.0	0.0	8.0		Sum L	
Diagonal Products			8000.0	0.0	0.0	8000.0	

Sieve Size	% Passing Target	% Passing Agg. B	% Passing Agg. C	% Passing Target		Sum Ua	
Diagonal Products			4500.0	0.0	0.0	4500.0	
12.5mm	100.0	100.0	0.0	100.0			Da=La-Ua
2.36mm	45.0	80.0	0.0	45.0		Sum La	
Diagonal Products			8000.0	0.0	0.0	8000.0	

Sieve Size	% Passing Agg. A	% Passing Target	% Passing Agg. C	% Passing Agg. A		Sum Ub	
Diagonal Products			800.0	0.0	0.0	800.0	
12.5mm	100.0	100.0	0.0	100.0			Db=Lb-Ub
2.36mm	8.0	45.0	0.0	8.0		Sum Lb	
Diagonal Products			4500.0	0.0	0.0	4500.0	

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Target	% Passing Agg. A		Sum Uc	
Diagonal Products			800.0	8000.0	4500.0	13300.0	
12.5mm	100.0	100.0	100.0	100.0			Dc=Lc-Uc
2.36mm	8.0	80.0	45.0	8.0		Sum Lc	
Diagonal Products			8000.0	4500.0	800.0	13300.0	

Check:

P_a=% Agg. A = Da/D X 100%=		Target1=(PaXPPa1+PbXPPb1+PcXPPc1)/100=	
P_b=% Agg. B = Db/D X 100%=		Target2=(PaXPPa2+PbXPPb2+PcXPPc2)/100=	
P_c=% Agg. C = Dc/D X 100%=		NOTE: PP is Percent Passing for a Specific Aggregate	
SUM			

Aggregate Blending "Criss-Cross" Form

Project: _XYZ **Mix ID: 009 xyz** **Date:**

Tech:

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Agg. C	% Passing Target
12.5mm	100.0	100.0	0.0	100.0
2.36mm	8.0	80.0	0.0	45.0

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Agg. C	% Passing Agg. A		Sum U	
Diagonal Products			800.0	0.0	0.0	800.0	
12.5mm	100.0	100.0	0.0	100.0			D=L-U
2.36mm	8.0	80.0	0.0	8.0		Sum L	7200.0
Diagonal Products			8000.0	0.0	0.0	8000.0	

Sieve Size	% Passing Target	% Passing Agg. B	% Passing Agg. C	% Passing Target		Sum Ua	
Diagonal Products			4500.0	0.0	0.0	4500.0	
12.5mm	100.0	100.0	0.0	100.0			Da=La-Ua
2.36mm	45.0	80.0	0.0	45.0		Sum La	3500.0
Diagonal Products			8000.0	0.0	0.0	8000.0	

Sieve Size	% Passing Agg. A	% Passing Target	% Passing Agg. C	% Passing Agg. A		Sum Ub	
Diagonal Products			800.0	0.0	0.0	800.0	
12.5mm	100.0	100.0	0.0	100.0			Db=Lb-Ub
2.36mm	8.0	45.0	0.0	8.0		Sum Lb	3700.0
Diagonal Products			4500.0	0.0	0.0	4500.0	

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Target	% Passing Agg. A		Sum Uc	
Diagonal Products			800.0	8000.0	4500.0	13300.0	
12.5mm	100.0	100.0	100.0	100.0			Dc=Lc-Uc
2.36mm	8.0	80.0	45.0	8.0		Sum Lc	0.0
Diagonal Products			8000.0	4500.0	800.0	13300.0	

Check:

P_a=% Agg. A = Da/D X 100%=	48.6	Target1=(PaXPPa1+PbXPPb1+PcXPPc1)/100=	100
P_b=% Agg. B = Db/D X 100%=	51.4	Target2=(PaXPPa2+PbXPPb2+PcXPPc2)/100=	45.0
P_c=% Agg. C = Dc/D X 100%=	0.0	NOTE: PP is Percent Passing for a Specific Aggregate	
SUM	100.0		

Aggregate Blending

Example No. 2

- Three aggregates
- Step-by-step

1. Fill out project and mix information, and so forth at the top of the form.

2. The percent passing for selected sieves for all three aggregates are presented at the top of the criss-cross form.

   NOTE 1: For this example, sieves 12.5mm and 2.36 mm are selected and percent passing is presented for these two sieves. In many cases, the control sieves for a specific nominal maximum size may be selected. For example, for a 9.5 mm mix, we may choose sieves #200 (0.075 mm) and #8 (2.36 mm) as they are the control sieves.

Aggregate Blending

Example No. 2, continued

- Remaining steps are as for the first example:

3. Fill out percent passing in remaining three sections of form.

4. Calculate diagonal products, and determine sums for upper and lower diagonal products.

5. Determine differences of upper and lower diagonal products

6. Calculate percent passing at bottom of form, and check (30.7 percent of aggregate “A,” 15.9 percent of aggregate “B,” and 53.4 percent of aggregate “C”).

Aggregate Blending "Criss-Cross" Form

Project: _XYZ **Mix ID: 009 xyz** **Date:**

Tech:

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Agg. C	% Passing Target
12.5mm	47.0	90.5	100.0	82.2
2.36mm	0.2	11.4	48.0	27.5

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Agg. C	% Passing Agg. A
Diagonal Products				
12.5mm				
2.36mm				
Diagonal Products				

Sum U

D=L-U

Sum L

Sieve Size	% Passing Target	% Passing Agg. B	% Passing Agg. C	% Passing Target
Diagonal Products				
12.5mm				
2.36mm				
Diagonal Products				

Sum Ua

Da=La-Ua

Sum La

Sieve Size	% Passing Agg. A	% Passing Target	% Passing Agg. C	% Passing Agg. A
Diagonal Products				
12.5mm				
2.36mm				
Diagonal Products				

Sum Ub

Db=Lb-Ub

Sum Lb

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Target	% Passing Agg. A
Diagonal Products				
12.5mm				
2.36mm				
Diagonal Products				

Sum Uc

Dc=Lc-Uc

Sum Lc

Check:

P_a=% Agg. A = Da/D X 100%=		Target1=(PaXPPa1+PbXPPb1+PcXPPc1)/100=
P_b=% Agg. B = Db/D X 100%=		Target2=(PaXPPa2+PbXPPb2+PcXPPc2)/100=
P_c=% Agg. C = Dc/D X 100%=		NOTE: PP is Percent Passing for a Specific Aggregate
SUM		

Aggregate Blending "Criss-Cross" Form

Project: _XYZ   Mix ID: 009 xyz   Date:

Tech:

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Agg. C	% Passing Target
12.5mm	47.0	90.5	100.0	82.2
2.36mm	0.2	11.4	48.0	27.5

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Agg. C	% Passing Agg. A		Sum U	
Diagonal Products			18.1	1140.0	2256.0	3414.1	
12.5mm	47.0	90.5	100.0	47.0			D=L-U
2.36mm	0.2	11.4	48.0	0.2		Sum L	
Diagonal Products			535.8	4344.0	20.0	4899.8	

Sieve Size	% Passing Target	% Passing Agg. B	% Passing Agg. C	% Passing Target		Sum Ua	
Diagonal Products			2488.8	1140.0	3945.6	7574.4	
12.5mm	82.2	90.5	100.0	82.2			Da=La-Ua
2.36mm	27.5	11.4	48.0	27.5		Sum La	
Diagonal Products			937.1	4344.0	2750.0	8031.1	

Sieve Size	% Passing Agg. A	% Passing Target	% Passing Agg. C	% Passing Agg. A		Sum Ub	
Diagonal Products			16.4	2750.0	2256.0	5022.4	
12.5mm	47.0	82.2	100.0	47.0			Db=Lb-Ub
2.36mm	0.2	27.5	48.0	0.2		Sum Lb	
Diagonal Products			1292.5	3945.6	20.0	5258.1	

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Target	% Passing Agg. A		Sum Uc	
Diagonal Products			18.1	937.1	1292.5	2247.7	
12.5mm	47.0	90.5	82.2	47.0			Dc=Lc-Uc
2.36mm	0.2	11.4	27.5	0.2		Sum Lc	
Diagonal Products			535.8	2488.8	16.4	3041.0	

Check:

P_a=% Agg. A = Da/D X 100%=		Target1=(PaXPPa1+PbXPPb1+PcXPPc1)/100=	
P_b=% Agg. B = Db/D X 100%=		Target2=(PaXPPa2+PbXPPb2+PcXPPc2)/100=	
P_c=% Agg. C = Dc/D X 100%=		NOTE: PP is Percent Passing for a Specific Aggregate	
SUM			

Aggregate Blending "Criss-Cross" Form

Project: _XYZ **Mix ID: 009 xyz** **Date:**

Tech:

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Agg. C	% Passing Target
12.5mm	47.0	90.5	100.0	82.2
2.36mm	0.2	11.4	48.0	27.5

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Agg. C	% Passing Agg. A		Sum U		
Diagonal Products			18.1	1140.0	2256.0	3414.1		
12.5mm	47.0	90.5	100.0	47.0				D=L-U
2.36mm	0.2	11.4	48.0	0.2		Sum L		1485.7
Diagonal Products			535.8	4344.0	20.0	4899.8		

Sieve Size	% Passing Target	% Passing Agg. B	% Passing Agg. C	% Passing Target		Sum Ua		
Diagonal Products			2488.8	1140.0	3945.6	7574.4		
12.5mm	82.2	90.5	100.0	82.2				Da=La-Ua
2.36mm	27.5	11.4	48.0	27.5		Sum La		456.7
Diagonal Products			937.1	4344.0	2750.0	8031.1		

Sieve Size	% Passing Agg. A	% Passing Target	% Passing Agg. C	% Passing Agg. A		Sum Ub		
Diagonal Products			16.4	2750.0	2256.0	5022.4		
12.5mm	47.0	82.2	100.0	47.0				Db=Lb-Ub
2.36mm	0.2	27.5	48.0	0.2		Sum Lb		235.7
Diagonal Products			1292.5	3945.6	20.0	5258.1		

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Target	% Passing Agg. A		Sum Uc		
Diagonal Products			18.1	937.1	1292.5	2247.7		
12.5mm	47.0	90.5	82.2	47.0				Dc=Lc-Uc
2.36mm	0.2	11.4	27.5	0.2		Sum Lc		793.3
Diagonal Products			535.8	2488.8	16.4	3041.0		

Check:

P_a=% Agg. A = Da/D X 100%=	30.7	Target1=(PaXPPa1+PbXPPb1+PcXPPc1)/100=	82.2
P_b=% Agg. B = Db/D X 100%=	15.9	Target2=(PaXPPa2+PbXPPb2+PcXPPc2)/100=	27.5
P_c=% Agg. C = Dc/D X 100%=	53.4	NOTE: PP is Percent Passing for a Specific Aggregate	
SUM	100.0		

Aggregate Blending "Criss-Cross" Form

Project: _XYZ **Mix ID: 007 SP12.5** **Date:**

Tech:

Sieve Size	% Passing Agg. A	% Passing Agg.B	% Passing Agg. C	% Passing Target

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Agg. C	% Passing Agg. A

Diagonal Products

					Sum U

Diagonal Products

				Sum L	D=L-U

Sieve Size	% Passing Target	% Passing Agg. B	% Passing Agg. C	% Passing Target

Diagonal Products

					Sum Ua

Diagonal Products

				Sum La	Da=La-Ua

Sieve Size	% Passing Agg. A	% Passing Target	% Passing Agg. C	% Passing Agg. A

Diagonal Products

					Sum Ub

Diagonal Products

				Sum Lb	Db=Lb-Ub

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Target.	% Passing Agg. A

Diagonal Products

					Sum Uc

Diagonal Products

				Sum Lc	Dc=Lc-Uc

Check:

Pa=% Agg. A = Da/D X 100%=		**Target$_1$=($P_{aX}PP_a$)+$P_{bX}PP_{b1}$+$P_{cX}PP_{c1}$)/100=**	
Pb=% Agg. B = Db/D X 100%=		**Target$_2$=($P_{aX}PP_{a2}$+$P_{bX}PP_{b2}$+$P_{cX}PP_{c2}$)/100=**	
Pc=% Agg. C = Dc/D X 100%=		**NOTE: PP is Percent Passing for a Specific Aggregate**	
SUM			

Aggregate Blending "Criss-Cross" Form

Project: _XYZ **Mix ID: 007 SP12.5** **Date:**

Tech:

Sieve Size	% Passing Agg. A	% Passing Agg.B	% Passing Agg. C	% Passing Target

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Agg. C	% Passing Agg. A

Sum U

Diagonal Products

D=L-U

Sum L

Diagonal Products

Sieve Size	% Passing Target	% Passing Agg. B	% Passing Agg. C	% Passing Target

Sum Ua

Diagonal Products

Da=La-Ua

Sum La

Diagonal Products

Sieve Size	% Passing Agg. A	% Passing Target	% Passing Agg. C	% Passing Agg. A

Sum Ub

Diagonal Products

Db=Lb-Ub

Sum Lb

Diagonal Products

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Target.	% Passing Agg. A

Sum Uc

Diagonal Products

Dc=Lc-Uc

Sum Lc

Diagonal Products

Check:

Pa=% Agg. A = Da/D X 100%=

Pb=% Agg. B = Db/D X 100%=

Pc=% Agg. C = Dc/D X 100%=

SUM

$Target_1=(P_{aX}PP_a)+P_{bX}PP_{b1}+P_{cX}PP_{c1})/100=$

$Target_2=(P_{aX}PP_{a2}+P_{bX}PP_{b2}+P_{cX}PP_{c2})/100=$

NOTE: PP is Percent Passing for a Specific Aggregate

Workshop

Part One
Aggregate Specific Gravity

Fine aggregate:

- oven-dry Wt.: 1,122.0 g
- SSD Wt.: 1,140.3 g; Wt.
- Wt. of Pycn. + water: 751.3 g
- Wt. of Pycn. + water + sample: 1467.8 g

Coarse aggregate:

- oven-dry Wt.: 2007.2 g
- SSD Wt.: 2014.2 g
- Wt. in water: 1197.6 g

Determine

- Absorption for fine aggregate
- Bulk Sp. Gr. for fine aggregate
- Apparent Sp. Gr. for coarse aggregate

AASHTO T – 84
Specific Gravity of Fine Aggregate

$$G_{sb} = \frac{A}{(B + S - C)}$$

$$G_{sa} = \frac{A}{(A + B - C)}$$

$$Absorption(\%) = \frac{S - A}{A} x100$$

A = Weight of oven dried sample

S = Weight of saturated surface dry (SSD) sample

C = Weight of flask with sample & water

B = Weigh of flask with water only

AASHTO T – 85
Specific Gravity of Coarse Aggregate

$$G_{sb} = \frac{A}{(B - C)}$$

$$Ga = \frac{A}{(A - C)}$$

$$Absorption(\%) = \frac{B - A}{A} x100$$

A = Weight of oven dried sample

B = SSD Weight of saturated surface dry (SSD) sample

C = Weight of sample in water

Workshop

Part Two
Mixture Specific Gravity

HMAC sample - Loose mix for Gmm:

- Wt. in air = 2000.0 g;
- Wt. of Pycnometer + water = 7347.5 g;
- Wt. of Pycnometer + water + sample = 8571.5 g.

Compute Gmm

HMAC sample - Compacted sample for Gmb:

- Dry Wt.: 1,300.4 g;
-
- SSD Wt.: 1,303.0 g;
-
- Wt. of sample + water: 1,881.0 g;
-
- Wt. of water in volumeter: 1,118.2 g.
-

Compute G_{mb} and % Air Voids

Workshop

Density and Void Analysis

Lab Measurements For Aggregates:

- **Agg. 1 (56.4 % of total aggregate, 53.1% of mix),**
- **bulk Sp. Gr. = 2.683,**
  Abs. 0.5 %.

- **Agg. 2 (43.6 % of total aggregate, 41.0% of mix),**
- **bulk Sp. Gr. = 2.701,**
  Abs. 0.4%

- **Asphalt, 5.9 % by Wt. of Mix,**
  Sp. Gr. = 1.023

Lab Measurements For Gmb:

- **Wt. of sample in air: 1235.3 g**
- **SSD Wt.: 1239.9 g**
- **Wt. of sample + water in volumeter: 1836.2 g**
- **Wt. of water in volumeter (calibration): 1114.8 g**
- **Volume of volumeter: 1118.2 cm3**

Lab Measurements for Gmm:

- **Wt. of mix in air: 2010.7 g**
- **Wt. of Pyc. + water: 7385.2 g**
- **Wt. of Pyc. + sample + water: 8582.2 g**

Find effective asphalt content, air voids, VMA, VFA
Determine Gsb, Gmb, and Gmm
Determine Gse and Air Voids (Pa)
Determine, Pba, Pbe , VMA, VFA

Formulas and Equations for Calculating HMA Design Parameters

$$G_{sb} = \frac{100}{\frac{P_1}{G_{sb1}} + \frac{P_2}{G_{sb2}} + ... + \frac{P_n}{G_{sbn}}} \qquad [1]$$

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}} \qquad [2]$$

$$G_{mm} = \frac{100}{\frac{P_s}{G_{se}} + \frac{P_b}{G_b}} \qquad [3]$$

$$P_{ba} = 100 \times \frac{G_{se} - G_{sb}}{G_{se} \times G_{sb}} \times G_b \qquad [4]$$

$$P_{be} = P_b - \left(\frac{P_{ba}}{100} \times P_s \right) \qquad [5]$$

$$VMA = 100 - \frac{G_{mb} \times P_s}{G_{sb}} \qquad [6]$$

$$V_a = 100 \times \frac{G_{mm} - G_{mb}}{G_{mm}} \qquad [7]$$

$$VFA = \left(\frac{VMA - V_a}{VMA} \right) \times 100 \qquad [8]$$

%Density : $$\%G_{mm} = \left(\frac{G_{mb}}{G_{mm}} \right) \times 100 \qquad [9]$$

DEFINITION OF TERMS FOR CALCULATION OF VOLUMETRICS

G_b = specific gravity of asphalt binder

G_{sa} = apparent specific gravity of the aggregate

G_{sb} = bulk specific gravity of the aggregate

G_{se} = effective specific gravity of the aggregate

G_{mm} = maximum theoretical specific gravity of mixture

G_{mb} = bulk specific gravity of compacted mixture

P_a = air voids in compacted mixture, percent of total volume

P_b = total asphalt binder content, percent by weight of mixture

P_{ba} = absorbed asphalt, percent by weight of aggregate

P_{be} = effective asphalt content, percent by total weight of mixture

P_s = aggregate content, percent by total weight of mixture

VMA = voids in the mineral aggregate, percent of bulk volume

VFA = voids filled with asphalt, percent of VMA

PLANT Technician Certification Program

QUIZ: SPECIFICATIONS, PTM/AASHTO Test Procedures, Bulletin 27

1. Which PTM covers Method of Test for PROBABILITY SAMPLING?

   a. PTM 001 b. PTM 004 c. PTM 005 d. PTM 646

2. Random sampling is needed for quality assurance but not for quality control

   a. TRUE b. FALSE

3. Which PTM covers Random Number Table?

   a. PTM 001 b. PTM 004 c. PTM 005 d. PTM 646

4. What should be the sampling tonnage for the first 500-ton sublot if the generated random number for this sublot is 0.45.

   a. 100 b. 170 c. 225 d. unknown

5. Method of Test for SAMPLING BITUMINOUS MATERIALS is covered under

   a. AASHTO T-40 b. AASHTO T-209 c. PTM 731 d. PTM 740

6. Sampling Bituminous paving mixture from truck according to PTM 746 should be done at least at three locations in the truck.

   a. TRUE b. FALSE

7. The minimum mass of 19-mm mix needed for asphalt content determination based on PTM 757 (AASHTO 308) is

   a. 1200 grams b. 1500 grams c. 2000 grams d. 2500 grams

8. Which chapter in PennDOT Bulletin 27 covers moisture damage testing of Superpave mixes?

   a. Chapter 1 b. Chapter 2A c. Chapter 2B d. Chapter 3

9. Which AASHTO Test Procedure is used to determine moisture damage susceptibility of Superpave mixes?

   a. AASHTO T 166 b. AASHTO T 209 c. AASHTO T 283 d. AASHTO T 312

10. Which section of PennDOT Specification 409 covers aggregates?

   a. Section 309 b. Section 409 c. Section 483 d. Section 703

PennDOT Plant Technician Certification Program
QUIZ ON
VIDEO: HOW AN HMA PLANT WORKS

1. When moving aggregate from stockpiles to the cold-feed bins, front-end loader operators should

a) always take aggregate from the bottom of the stockpile
b) avoid taking aggregate from the bottom of the stockpile
c) ensure aggregate is picked up only from the top of the stockpile
d) avoid a full load of aggregate

2. In the batch tower of a typical batch plant, the bin #1 is always the bin

a. with the largest size aggregate
b. with the smallest size aggregate
c. The sequence does not matter

3. The following could help to reduce potential for bridging of fine material in cold feed bins

a. The bin opening is made variable in size
b. The sides of the bin are made at different angles
c. Compressed air is used
d. All of the above

4. The moisture content of aggregate after it passes through the dryer drum should not exceed

a. 3 percent
b. 2 percent
c. 1 percent
d. 0.5 percent

5. A drum in which the aggregate travels in the same direction as the burner flame is called

a. a burner-end drum
b. a burner-entry drum
c. a parallel-flow drum
d. a counter-flow drum
e. a mixer drum

6. The main function of flights in a dryer drum is

a. To ensure proper aggregate speed towards the mixing zone
b. To create an aggregate veil to ensure sufficient drying
c. To ensure proper mixing with the RAP material
d. None of the above

7. If RAP is to be introduced in a drum mix, it must be entered

a. at the same location aggregate enters the drum
b. at the combustion zone
c. at the asphalt aggregate mixing zone
d. at a location after the combustion zone and before the mixing zone

PennDOT Plant Technician Certification Program
QUIZ ON
VIDEO: HOW AN HMA PLANT WORKS

8. **A "gob-hopper" is used**
a. In front of the baghouse to clean off accumulated fuel from the fabric in the baghouse
b. at the top of silo for proper dumping of mix to prevent segregation
c. At the bottom of weigh box in batch plant to feed the pug-mill
d. At the top of batch tower to feed the hot aggregate bins

9. During an unusually humid week in August, the foreman on a job complains to the plant every morning some of the mix delivered contains large gobs of fines which are causing problems in compacting and finishing the mat. The likely cause of this problem is
a. Sweating and clumping of the fine aggregate to the hot bin walls, followed by falling off into the bin
b. Insufficient mixing time
c. Contamination in the trucks used to haul the hot-mix to the job site
d. Improper feeding from cold bins

10. A metal plate is sometimes welded part-way across the number one hot bin to
a. protect the bottom of the bin from abrasion by coarse aggregate particles
b. prevent overloading the bin
c. collect oversize material before it gets into the bin
d. help keep the dust down in this bin, which contains fine aggregate
e. help prevent segregation by directing the finest material towards the center of the bin

11. What is the correct level to fill a pugmill in a batch plant?
a. up to the center of the revolving paddles
b. at the 1/3 height of the revolving paddle
c. at the 2/3 height of the revolving paddle
d. fully covering the revolving paddle and slightly above the top of it

12. What is typical mixing time in a pugmill?
a. 10 to 25 seconds
b. 30 to 60 seconds
c. 2 to 3 minutes
d. None of the above

13. In general, use of storage silos in batch plant operations
a. slightly increases plant capacity
b. significantly increases plant capacity
c. does not impact plant capacity

2019 Plant Technician Acronyms

1. AASHTO: American Association of State Highway Transportation Officials (www.transportation.org)
2. ADT: Average Daily Traffic
3. AET: Asphalt Emulsion Tack
4. AI: Asphalt Institute (www.asphaltinstitute.org)
5. ATPBC: Asphalt Treated Permeable Base Course
6. CT: Clearance Transmittal
7. DME/DMM: District Materials Engineer/District Materials Manager
8. ESB: Electronic State Book
9. ESAL: Equivalent Single Axle Load
10. ETI: Engineering Technology & Information
11. FHWA: Federal Highway Administration (www.fhwa.dot.gov)
12. FDR: Full Depth Repair/Replacement
13. Gmb: Bulk Specific Gravity of Mix
14. Gmm: Theoretical Maximum Specific Gravity
15. Gsb: Bulk Specific Gravity of Aggregate
16. HMA: Hot Mix Asphalt
17. JMF: Job Mix Formula
18. LTS: (PennDOT) Laboratory Testing Section
19. MTV: Materials Transfer Vehicle
20. NAPA: National Asphalt Paving Association (www.asphaltpavement.org)
21. NECEPT: Northeast Center of Excellence for Paving Technology (www.superpave.psu.edu)
22. NMAS: Nominal Maximum Aggregate Size
23. OSHA: Occupational Safety and Health Administration (www.osha.gov)
24. PAPA: Pennsylvania Asphalt Pavement Association (www.pahotmix.org)
25. PG: Performance Grade
26. PTM: Pennsylvania Test Method (ftp://ftp.dot.state.pa.us/public/pdf/BOCM_MTD_LAB/PUBLICATIONS/PUB_19/PTM_TOC.pdf)
27. PWL: Percent Within Limits
28. QC/QA: Quality Control / Quality Assurance
29. RPS: Restricted Performance Specifications
30. RAM: Reclaimed Aggregate Material
31. RAP: Reclaimed Asphalt Pavement
32. RAS: Recycled Asphalt Shingles
33. SGC: Superpave Gyratory Compactor

2019 Plant Technician Acronyms

34. SMA: Stone Matrix Asphalt (Stone Mastic Asphalt)
35. SOL: Strike Off Letter
36. SRL: Skid Resistance Level
37. SSP: Special Standard Provision
38. TSR: Tensile Strength Ratio
39. VFA: Voids Field with Asphalt
40. VMA: Voids in the Mineral Aggregate
41. WMA: Warm Mix Asphalt

Causes

Problem	(1) Fluctuating Head of Material	(2) Feeder Screws Overloaded	(3) Finisher Speed Too Fast	(4) Too Much Lead Crown in Screed	(5) Too Little Lead Crown in Screed	(6) Overcorrection of Thickness Control Screws	(7) Excessive Play in Screed Mechanical Connection	(8) Screed Riding on Lift Cylinders	(9) Screed Plates Worn Out or Warped	(10) Screed Plates Not Tight	(11) Cold Screed	(12) Moldboard on Strikeoff Too Low	(13) Running Hopper Empty Between Loads	(14) Feeder Gates Set Incorrectly	(15) Kicker Screws Worn Out or Mounted Incorrectly	(16) Incorrect Nulling of Screed	(17) Screed Starting Blocks Too Short	(18) Screed Extensions Installed Incorrectly	(19) Vibrators Running Too Slow
Wavy Surface—Short Waves (Ripples)	✓	✓	✓				✓	✓		✓									
Wavy Surface—Long Waves	✓	✓				✓	✓	✓					✓	✓					
Tearing of Mat—Full Width			✓						✓		✓								
Tearing of Mat—Center Streak					✓				✓		✓			✓	✓				
Tearing of Mat—Outside Streaks				✓					✓		✓	✓		✓				✓	
Mat Texture—Nonuniform	✓	✓	✓					✓	✓	✓	✓		✓					✓	✓
Screed Marks							✓												
Screed Not Responding to Correction			✓				✓	✓		✓									
Auger Shadows		✓																	
Poor Precompaction			✓					✓											✓
Poor Longitudinal Joint	✓	✓				✓		✓											
Poor Transverse Joint		✓					✓	✓		✓						✓	✓		
Transverse Cracking (Checking)																			
Mat Shoving Under Roller																			
Bleeding or Fat Spots In Mat																			
Roller Marks																			
Poor Mix Compaction																			

Problem	(20) Grade Control Mounted Incorrectly	(21) Grade Control Hunting (Sensitivity Too High)	(22) Grade Control Wand Bouncing on Reference	(23) Grade Reference Inadequate	(24) Sitting Long Period Between Loads	(25) Improper Joint Overlap	(26) Improper Mat Thickness for Max. Agg. Size	(27) Trucks Bumping Finisher	(28) Truck Holding Brakes	(29) Improper Base Preparation	(30) Improper Rolling Operation	(31) Reversing or Too Rapidly Turning Rollers	(32) Parking of Roller on Hot Mat	(33) Improper Mix Design (Aggregate)	(34) Improper Mix Design (Asphalt)	(35) Mix Segregation	(36) Moisture in Mix	(37) Variation of Mix Temperature	(38) Cold Mix Temperature
Wavy Surface—Short Waves (Ripples)	✓	✓	✓	✓						X	X			X	X	X		X	
Wavy Surface—Long Waves	✓			✓	✓			X	X	X		X	X			X		X	
Tearing of Mat—Full Width							X							X	X	X	X	X	X
Tearing of Mat—Center Streak																			X
Tearing of Mat—Outside Streaks																			X
Mat Texture—Nonuniform					✓		X			X				X	X	X		X	X
Screed Marks								X	X										
Screed Not Responding to Correction	✓						X											X	X
Auger Shadows														X	X	X			
Poor Precompaction							X			X									X
Poor Longitudinal Joint	✓	✓	✓			✓					X								X
Poor Transverse Joint											X								X
Transverse Cracking (Checking)										X	X			X	X		X	X	
Mat Shoving Under Roller										X	X	X		X	X		X	X	
Bleeding or Fat Spots In Mat														X	X		X	X	
Roller Marks										X	X	X	X					X	
Poor Mix Compaction										X	X	X	X	X	X		X	X	X

1. Find problem above.
2. Checks indicate causes related to the paver. X's indicate other problems to be investigated.

NOTE: Many times a problem can be caused by more than one item; therefore, it is important that each cause listed be eliminated to ensure that the problem will be solved.

HMA Paving Handbook 2000

Types of Pavement Imperfections That May Be Encountered In Laying Plant Mix Paving Mixtures.	Insufficient or Non-Uniform Tack Coat	Improperly Cured Prime or Tack Coat	Mixture Too Coarse	Excess Fines in Mixture	Insufficient Asphalt	Excess Asphalt	Improperly Proportioned Mixture	Unsatisfactory Batches in Load	Excess Moisture in Mixture	Mixture Too Hot or Burned	Mixture Too Cold	Poor Spreader Operation	Spreader in Poor Condition	Excessive Moisture in Subsoil	Excessive Prime Coat or Tack Coat	Excessive Hand Raking	Labor Careless or Unskilled	Excessive Segregation in Laying	Operating Finishing Machine Too Fast
Bleeding						X	X	X							X				
Brown, Dead Appearance					X				X	X									
Rich or Fat Spots						X	X	X							X			X	
Poor Surface Texture			X	X			X	X			X	X	X			X	X	X	X
Rough Uneven Surface	X	X	X				X	X			X	X	X			X	X	X	X
Honeycomb or Raveling			X		X		X	X			X	X	X			X	X	X	
Uneven Joints			X								X	X	X			X	X	X	
Roller Marks				X		X	X				X						X		
Pushing or Waves	X	X		X		X	X	X	X			X	X			X			
Cracking (Many Fine Cracks)				X	X		X							X					
Cracking (Large Long Cracks)														X					
Rocks Broken by Roller			X				X				X	X	X						
Tearing of Surface During Laying			X		X		X			X	X	X	X					X	X
Surface Slipping on Base	X	X		X		X	X		X		X			X	X				

FIGURE 5.20—Typical Mat Problems and Their Probable Causes.

Aggregates Too Wet	Inadequate Bunker Separation	Aggregate Feed Gates Not Properly Set	Over-Rated Dryer Capacity	Dryer Set Too Steep	Improper Dryer Operation	Temp. Indicator Out of Adjustment	Aggregate Temperature Too High	Worn Out Screens	Faulty Screen Operation	Bin Overflows Not Functioning	Leaky Bins	Segregation of Aggregates in Bins	Carryover in Bins Due to Overloading Screens	Aggregate Scales Out of Adjustment	Improper Weighing	Feed of Mineral Filler Not Uniform	Insufficient Aggregates in Hot Bins	Improper Weighing Sequence	Insufficient Asphalt	Too Much Asphalt	Faulty Distribution of Asphalt to Aggregates	Asphalt Scales Out of Adjustment	Asphalt Meter Out of Adjustment	Undersize or Oversize Batch	Mixing Time Not Proper	Improperly Set or Worn Paddles	Faulty Dump Gate	Asphalt and Aggregate Feed Not Synchronized	Occasional Dust Shakedown in Bins	Irregular Plant Operation	Faulty Sampling	*Types of Deficiencies That May Be Encountered In Producing Plant-Mix Paving Mixtures.*
		A												B	B				A	A	A	B	C	B	B	B		C			A	Asphalt Content Does Not Check Job Mix Formula
	A	A						B	B	B	B	A	A	B	B	B	A							B		B	B	C	B		A	Aggregate Gradation Does Not Check Job Mix Formula
	A	A							B	B	B	A	A	B	B	B	A							B	B			C	B		A	Excessive Fines in Mix
A			A	A	A	A	A																							A		Uniform Temperatures Difficult to Maintain
											B			B	B									B								Truck Weights Do Not Check Batch Weights
														B	B					A	A	B	C	B		B		C				Free Asphalt on Mix in Truck
																		B									B					Free Dust on Mix in Truck
A			A	A	A	A													A		A	B	C	B	B	B		C		A		Large Aggregate Uncoated
									B	B	A	A	A	B	B	B	A	B			A	B	C		B	B	B	C	B	A		Mixture in Truck Not Uniform
																		B			A			B	B	B				A		Mixture in Truck Fat on One Side
					A															A	A	B	C	B				C		A		Mixture Flattens in Truck
		A			A	A	A																							A		Mixture Burned
A			A	A	A	A			B										A			B	C	B				C		A		Mixture Too Brown or Gray
														B	B	B	A			A	A	B	C	B				C		A		Mixture Too Fat
					A	A	A																							A		Mixture Smokes in Truck
A			A	A	A	A																								A		Mixture Steams in Truck
					A	A	A												A										A	A		Mixture Appears Dull in Truck

FIGURE 4.23—Possible Causes of Deficiencies in Hot Plant-Mix Paving Mixtures. A—Applies to Batch and Drum Mix Plants; B—Applies to Batch Plants; C—Applies to Drum Mix Plants.

ITEM	EFFECT	CORRECTIONS*
Aggregate		
• Smooth Surfaced	Low interparticle friction	Use light rollers Lower mix temperature
• Rough Surfaced	High interparticle friction	Use heavy rollers
• Unsound	Breaks under steel-wheeled rollers	Use sound aggregate Use pneumatic rollers
• Absorptive	Dries mix—difficult to compact	Increase asphalt in mix
Asphalt		
• Viscosity		
— High	Particle movement restricted	Use heavy rollers Increase temperature
— Low	Particles move easily during compaction	Use light rollers Decrease temperature
• Quantity		
— High	Unstable & plastic under roller	Decrease asphalt in mix
— Low	Reduced lubrication—difficult compaction	Increase asphalt in mix Use heavy rollers
Mix		
• Excess Coarse Aggregate	Harsh mix—difficult to compact	Reduce coarse aggregate Use heavy rollers
• Oversanded	Too workable—difficult to compact	Reduce sand in mix Use light rollers
• Too Much Filler	Stiffens mix—difficult to compact	Reduce filler in mix Use heavy rollers
• Too Little Filler	Low cohesion—mix may come apart	Increase filler in mix
Mix temperature		
• High	Difficult to compact—mix lacks cohesion	Decrease mixing temperature
• Low	Difficult to compact—mix too stiff	Increase mixing temperature
Course Thickness		
• Thick Lifts	Hold heat—more time to compact	Roll normally
• Thin Lifts	Lose heat—less time to compact	Roll before mix cools Increase mix temperature
Weather Conditions		
• Low Air Temperature	Cools mix rapidly	Roll before mix cools Increase mix temperature increase lift thickness
• Low Surface Temperature	Cools mix rapidly	
• Wind	Cools mix—crusts surface	

* Corrections may be made on a trial basis at the plant or job site. Additional remedies may be derived from changes in mix design.

FIGURE 6.23—Summary Table of Influences of Compaction.

NECEPT Frequently Asked Questions
Bituminous Technician Certification Program

1. Which publication covers the initial certification, certification renewal, and application procedures? **PennDOT Publication 351**

2. Where can I find Publication 351? **It can be downloaded from the PennDOT web site (www.PennDOT.gov/) by clicking on the link for "Forms, Pubs & Maps", then click the search button and type "Pub 351", then click the magnifying glass, and then select "Publication 351" from the search results. It is also available on the NECEPT website under training: http://www.superpave.psu.edu/Training/.**

3. The initial certification and subsequent certification renewal periods will be for how many years? **Five (5) years**

4. In order to qualify for a Level 1 Plant Technician – Initial Certification, the applicant must have how many hours of documented experience in asphalt testing? **A minimum 500 hours obtained within the past three (3) years.**

5. What are the requirements for certification renewal of a Field Technician or Level 1 Plant Technician? **The applicant must have 500 hours of documented technician experience in asphalt paving within the previous five (5) years of certification. The applicant must also have attended one (1) NECEPT Update/Refresher Course and one (1) PennDOT approved asphalt-related annual conference, seminar, or workshop within the previous five (5) years or received a Certificate of Training from NECEPT's Technician Update/Refresher Course for two (2) out of the previous five years. Then, submit either an online registration or a completed and PennDOT signed Certification Renewal Application Form after all requirements have been met.**

6. How many retests is each applicant allowed before they have to repeat the corresponding 2-1/2 day review and certification course? **One (1)**

7. I lost my card. What do I do? **Submit a request in writing to NECEPT and include your name, NECEPT ID#, mailing address, and type of certification.**

8. I do not have the 500 hours of documented experience in asphalt paving required for certification renewal. Will I get certification renewal? **No, you will have to apply and attend the appropriate Bituminous Field Technician or Level 1 Plant Technician Initial Review & Certification Course.**

9. This is my one and only Update/Refresher Course. My certification expires in a few months. What do I do? **Attend a PennDOT approved asphalt-related conference, seminar, or workshop before your certification expires or you have to apply and attend the appropriate Bituminous Field Technician or Level 1 Plant Technician Initial Review & Certification Course and meet the requirements for the Review and Certification Course.**

10. What counts as continuing education? **Please refer to PennDOT Publication 351.**

11. How do I document my 500 hours and who is responsible for maintaining those records? **Keep a diary of projects, time & locations, and if possible, have it documented/signed by a Project Supervisor. The individual certified technician is responsible for maintaining their own records.**

12. Who checks my 500 hours? **PennDOT**

13. No one has ever checked my certification on the job site. Why do I need this? **PennDOT may check it tomorrow; however, one of the reasons you may not have been checked is because the District knows your history.**

14. I am the Lead Inspector and I never get out near the paver. What do I do for 500 hours experience? **It is your responsibility to make sure PennDOT works with you to meet the requirements. If not, you have to start the certification process over.**

15. What do I do with my paper certification renewal application after I get it signed by PennDOT? **Submit the signed application, record of hours, list of training, and payment for NECEPT fees to NECEPT c/o PSU/The Larson Transportation Institute, 201 Transportation Research Bldg, University Park, PA 16802.**