



PENNDOT  
ASPHALT TECHNICIAN CERTIFICATION  
PROGRAM

LEVEL 1 BITUMINOUS PLANT TECHNICIAN  
PROGRAM HANDOUT  
2020

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](http://www.superpave.psu.edu)*



**PennState**



**PENNDOT ASPHALT LEVEL 1 PLANT TECHNICIAN  
REVIEW AND CERTIFICATION COURSE  
REVIEW & CERTIFICATION  
2020**

The PENNDOT Bituminous Level 1 Plant Technician Review and Certification Course includes a two-day review course for technicians directly involved with bituminous pavement mixture design, hot mix asphalt (HMA) production, process control and/or quality assurance testing, 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 HMA, and not a training course on HMA. Therefore, a working knowledge of basic principles and procedures for hot-mix asphalt design is necessary. Recommendation by signature of a Certified Bituminous Plant Technician and of a PENNDOT District Materials Engineer/District Materials Manager, and a minimum of one year of work experience related to HMA plants are required to qualify for this program. The certification period is five years. Renewal 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, design of Stone Mastic Asphalt, and introduction to Warm Mix 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 and true/false questions. There will be at least two versions of the test. Each participant **scoring 75 (seventy-five) percent** or better will be send a PENNDOT Bituminous Level 1 Plant Technician certificate, wallet card, and hard had sticker within approximately 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.
- Participants should bring a calculator and pencils/pens to the class. A No. 2 pencil is required to fill out the exam answer sheets for computer grading.
- Frequent informal breaks will be given at the instructor’s discretion. Morning beverages/snack will be provided all three days; lunch and afternoon beverage/snack breaks will be provided the first two days.

**Level 1 Plant Technician Review & Certification Course Agenda**

01- Technician’s Responsibilities
02- Safety First
03- Asphalt Binders
04- Aggregate Testing and Gradation
05- Aggregate Blending
06- Specific Gravity and Absorption
07- Density and Void Analysis
08- Pennsylvania Asphalt Specifications
09- Pennsylvania and AASHTO Test Methods
10- PennDOT Bulletin 27
11- Plant Quality Control
12- Asphalt Mix Plant Operation
13- Segregation
14- Stone Mastic Asphalt

**\*Agenda is subject to change**

# **Asphalt Pavement Construction Program**


## **Bituminous Plant Technician Certification**

**Presented By**

**Northeast Center of Excellence for Pavement  
Technology**

**2020**






**Asphalt Pavement  
Construction Program**

**Bituminous Plant Technician Certification**


Presented By  
**Northeast Center of Excellence for Pavement  
Technology**

2020



1

1



**NECEPT WEB SITE**

[www.superpave.psu.edu](http://www.superpave.psu.edu)

**Training**

- **PENNDOT Certification Program**
- **Calendar of Courses**
- **On-Line Registration**
- **Course Material**
- **Exam Grades**

2

2



**On-Line Registration**

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

TRAINING NEAUP RESEARCH ABOUT NECEPT USEFUL LINKS

Training

3

3

**Northeast Center of Excellence for Pavement Technology**

NECEPT is the Northeast Regional Superpave Center. It is located at the Thomas D. Larson PA Transportation Institute at the Pennsylvania State University.

The preferred way to contact NECEPT is by email. During the busy season (October through March) we do our best to maintain an efficient response time, but due to high call volume, a response may be delayed. Your understanding is appreciated.

**Courses Affected by Inclement Weather**

**Exam Grades**

Exam grades can be found on the Exam Grades page. Please search for your course ID number and then your NECEPT ID number. If you need assistance in locating your grade, please call 814-863-1293

- TBA

**Retest Information**

Retest information can be found on the designated training category pages - Aggregate, Asphalt Field, Asphalt Plant L1, Superpave, and Concrete.

Aggregate retests must be completed no earlier than 30 days and no later than three months from the original test date.

Asphalt and Concrete retests must be completed no earlier than 30 days and no later than four months from the original test date.

**Registration Notes**

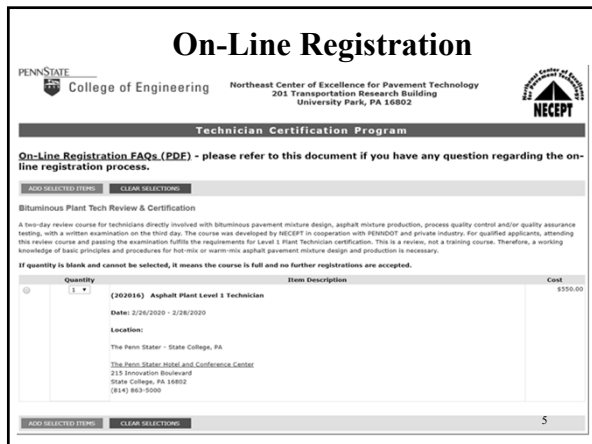
Online Registration

- If you choose to register online, you must pay with a credit card at the time of registration.

**NECEPT Contact**  
Office Address: 201 Transportation Research Building, University Park, PA 16802.  
Phone: 814-863-1293  
Fax: 814-865-3039  
E-Mail: [superpave@psu.edu](mailto:superpave@psu.edu)  
Access your Account: [my.necept.org](http://my.necept.org)

4

4



**On-Line Registration**

PennState College of Engineering | Northeast Center of Excellence for Pavement Technology  
201 Transportation Research Building, University Park, PA 16802

**Technician Certification Program**

**On-Line Registration FAQs (PDE)** - please refer to this document if you have any question regarding the on-line registration process.

ADD SELECTED ITEMS CLEAR SELECTIONS

**Bituminous Plant Tech Review & Certification**

A two-day review course for technicians directly involved with bituminous pavement mixture design, asphalt mixture production, process quality control and/or quality assurance testing, 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 fulfill the requirements for Level 1 Plant Technician certification. This is a review, not a training course. Therefore, a working knowledge of basic principles and procedures for hot mix or warm mix asphalt pavement mixture design and production is necessary.

If quantity is blank and cannot be selected, it means the course is full and no further registrations are accepted.

Quantity	Item Description	Cost
1	(202014) Asphalt Plant Level 1 Technician	\$550.00

Date: 2/26/2020 - 2/28/2020

Location:  
The Penn State - State College, PA  
The Penn State Hotel and Conference Center  
215 Innovation Boulevard  
State College, PA 16802  
(814) 863-0500

ADD SELECTED ITEMS CLEAR SELECTIONS 5

5

**Exam Grades**

**2020 Training Season Exam Grades**

As grades are received and processed, they will be posted below. Please allow approximately two weeks from the course date for grades to be posted. The grades are listed under an individual's NECEPT ID number. Certificates and cards will be mailed out shortly after grades are posted. Please be aware that the certificate and card will be mailed to the address that is listed on the application sent to NECEPT. If you are unable to locate your NECEPT ID number or do not receive your card within three weeks of your results being posted, please contact NECEPT by calling (814) 863-1293 or emailing superpave@psu.edu.

You may also sign-in to MYNECEPT to view your exam results. NECEPT ID number and password required.

**Aggregate Technician**  
Passing Grade: 70%

- Course Number 120966, December 9-10, 2019
- Course Number 120967, January 13-14, 2020

**Asphalt Field Technician**  
Passing Grade: 75%

- Course Number 202007, January 13-14, 2020

6

6



### Certification Categories

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

7

7

### Certification Publications

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

8

8

### PennDOT 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

**Published November 2018**

PUB 351 (11-18)

9

### PennDOT Publication 351

- Publication 351 Covers
  - Requirements for Initial Certification
  - Requirements for Certification Renewal
  - 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

10

10

### PennDOT Publication 351 Code of Ethics

**FOUR PRINCIPALS:**

- **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.

11

11

### Certification Renewal

**Submit:**

- Certification Renewal Application
- With Processing Fee (\$35.00)

[www.superpave.psu.edu](http://www.superpave.psu.edu)

12

12

**Certification Requirements  
Bituminous Level I Plant Technician**

**Pub 351: Section VII**

- **500 documented hours 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**

13

13

**Certification Renewal  
Bituminous Level I Plant Technician**

**Pub 351: Section XI (Option A)**

- Level I certified for previous 5 years.
- **500 documented hours 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.**
- **Within the previous 5 years, attended**
  - Two NECEPT Plant Technician Update/Refresher Courses, or....
  - One NECEPT Update/Refresher Course and one acceptable asphalt-related conference, seminar, or workshop

14

14

**Accepted Asphalt-Related Annual  
Conferences, Seminars, and Workshops**

- Annual APC Conferences
- Annual PAPA Conferences
- Mid-Atlantic States Quality Assurance Workshop
- Nationally Recognized Conferences or Courses
- PennDOT pre-approved Department or Industry sponsored training

15

15

**Plant Technician Certification  
Review & Certification Course Modules**

- 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: Density and Void Analysis
- 8. PennDOT Asphalt Specifications
- 9. PennDOT/AASHTO Test Methods
- 10. PennDOT Bulletin 27
- 11. Plant Quality Control
- 12. Hot Mix Asphalt Plant Operation
- 13. Material Segregation in the Plant
- 14. Stone Mastic Asphalt

16

16

**ACRONYMS**

- 01. AASHTO: American Association of State Transportation Officials ([www.transportation.org](http://www.transportation.org))
- 02. AET: Asphalt Emulsion Tack
- 03. AI: Asphalt Institute ([www.asphaltinstitute.org](http://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](http://www.fhwa.dot.gov))
- 08. HMA: Hot Mix Asphalt
- 09. JMF: Job Mix Formula
- 10. LTS: (PennDOT) Laboratory Testing Section

17


17

**ACRONYMS**

- 11. MTV: Materials Transfer Vehicle
- 12. NAPA: National Asphalt Paving Association ([www.asphaltpaving.org](http://www.asphaltpaving.org))
- 13. NECEPT: Northeast Center of Excellence for Paving Technology ([www.superpave.psu.edu](http://www.superpave.psu.edu))
- 14. NMA: Nominal Maximum Aggregate Size
- 15. OSHA: Occupational Safety and Health Administration ([www.osha.gov](http://www.osha.gov))
- 16. PAPA: Pennsylvania Asphalt Pavement Association ([www.pahotmix.org](http://www.pahotmix.org))
- 17. PG: Performance Grade
- 18. PTM: Pennsylvania Test Method ([ftp://ftp.dot.state.pa.us/public/pdf/BOCM\\_MTD\\_LAB/PUBLICATIONS/PU\\_B\\_19/PTM\\_TOC.pdf](http://ftp.dot.state.pa.us/public/pdf/BOCM_MTD_LAB/PUBLICATIONS/PU_B_19/PTM_TOC.pdf))
- 19. QC/QA: Quality Control / Quality Assurance
- 20. RPS: Restricted Performance Specifications

18

18



**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

19

# Plant Technician Certification Program

## Module 1

### Asphalt Plant Technician's Responsibilities



# Plant Technician Certification Program

## Module 2

# Safety First



**Plant Technician  
Certification Program**


**Module 2**

**Safety First**



NECEPT

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!”**

3

**Safety Concerns  
in  
Handling Asphalt**

4

**Safety Concerns in Handling Asphalt**

- Asphalt Fumes
  - Keep temperatures below Flash Point of material
- Hot Asphalt Liquid or Mix (Burns!)
- Fire & Explosion Hazard from Heated Asphalt
  - Flammable Vapors
  - Water splashing into asphalt

5

**Safety Concerns in Handling Asphalt**

- **Get Training and Use Safe Practice at Work.**
- **Develop laboratory standard operating procedures (SOP).**
- **Know Available Resources.**
- **Read and Follow SDS (or MSDS).**

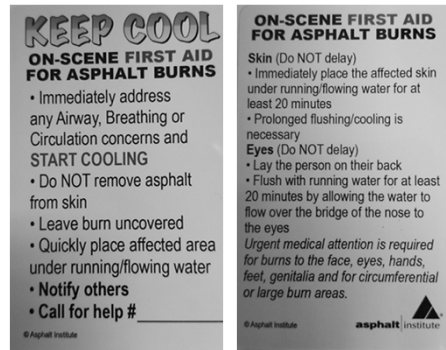
6

## Safety Hot Liquid Asphalt Handling

- Safe Heating Temperature
  - Should be well below Flash Point of material
- Application temperature can be found in
  - SDS – law since 1984
  - PennDOT Bulletin #25
  - Relevant PennDOT Specifications
  - Shipping bill of lading

7

## FIRST AID for Hot Asphalt Burns



The infographic is divided into two main sections. The left section is titled 'KEEP COOL ON-SCENE FIRST AID FOR ASPHALT BURNS' and lists: 'Immediately address any Airway, Breathing or Circulation concerns and START COOLING', 'Do NOT remove asphalt from skin', 'Leave burn uncovered', 'Quickly place affected area under running/flowing water', 'Notify others', and 'Call for help #'. The right section is titled 'ON-SCENE FIRST AID FOR ASPHALT BURNS' and lists: 'Skin (Do NOT delay): Immediately place the affected skin under running/flowing water for at least 20 minutes', 'Prolonged flushing/cooling is necessary', 'Eyes (Do NOT delay): Lay the person on their back', 'Flush with running water for at least 20 minutes by allowing the water to flow over the bridge of the nose to the eyes', and 'Urgent medical attention is required for burns to the face, eyes, hands, feet, genitalia and for circumferential or large burn areas.' The Asphalt Institute logo is at the bottom right.

Source:  
Asphalt Institute

8

## If overcome by Asphalt Fumes

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

9

## 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

10

## Contents of SDS

- 16 Major Sections, appear in order
  1. Product Identification
  2. Hazard Identification
  3. Composition/Information on Ingredients
  4. First Aid Measures
  5. Fire Fighting Measures
  6. Accidental Release Measures
  7. Handling and Storage
  8. Exposure Control, Personal Protection

11

## Contents of SDS

- 16 Major Sections, appear in order
  9. Physical and Chemical Properties
  10. Stability and Reactivity
  11. Toxicological Information
  12. Ecological Information
  13. Disposal Considerations
  14. Transport Information
  15. Regulatory Information
  16. Other Information

12

### Access to SDS and SOP

- Keep SDS and SOP in a place where easily accessible by any individual working in the laboratory.

13

### Protective Equipment, (#8 on SDS)

- 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



14

### 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)

15





# Plant Technician Certification Program

## Module 3


### Introduction to Asphalt Binders



N  
E  
C  
E  
P  
T

## Plant Technician Certification Program

### Module 3 Introduction to Asphalt Binders



1

**Topics to Cover**

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

2

## UNDERSTANDING TERMINOLOGY

3

### So Many of Them!

- Tar (is not asphalt)
- Asphalt, Asphalt Cement, Bitumen
- Binder, Asphalt Binder
- Neat Binder (Virgin Binder)
- Modified Binder
- Polymer Modified Binder (PMB)
  
- Emulsions
- Cutbacks
  
- Asphalt Concrete (Bituminous Concrete)

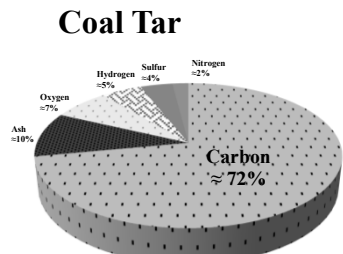
4

### Coal Tar

- Viscous black liquid from destructive distillation of coal
- Contains numerous organic compounds
- Mainly Carbon ( $\approx 70\%$ ), Ash, Oxygen, Hydrogen, Sulfur, Nitrogen, Ash (Clay & Silicate), and Moisture
  
- Applications
  - roofing, waterproofing, and insulating compound
  - raw material for many dyes, drugs, and paints.

5

### Coal Tar



An Example  
of Coal Composition

**destructive distillation: heating solid material (Coal)  
at high temperature without contact with air. Produces  
by-products: Coke, Coal Tar, Amino Acid Liquor, and  
Coal Gas**

6

**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.

7

**Asphalt vs. Asphalt Concrete**

- Asphalt, Asphalt Binder, Asphalt Cement, and Bitumen
  - Sometimes used interchangeably
- “Asphalt binder” sometimes used to refer for “polymer modified asphalt binder”
- Asphalt Concrete
  - Mixture of Asphalt and Aggregate
- The term “Bitumen” or “Asphalt” in British English refers to “Asphalt Concrete”

8

**Asphalt vs. Asphalt Concrete**

The diagram illustrates the composition of asphalt concrete. It features three main components: 1. Asphalt Binder, shown as a dark liquid in a beaker. 2. Asphalt Concrete, shown as a dark, granular mixture. 3. Aggregate, shown as a pile of light-colored particles. Lines connect the labels to their respective images.

9

**Asphalt Emulsions**

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

The image shows two parts: on the left, a microscopic view of numerous small, spherical asphalt droplets of varying sizes dispersed in a water phase; on the right, a photograph of a beaker containing a greyish, milky asphalt emulsion.

10

**Asphalt Cutbacks**

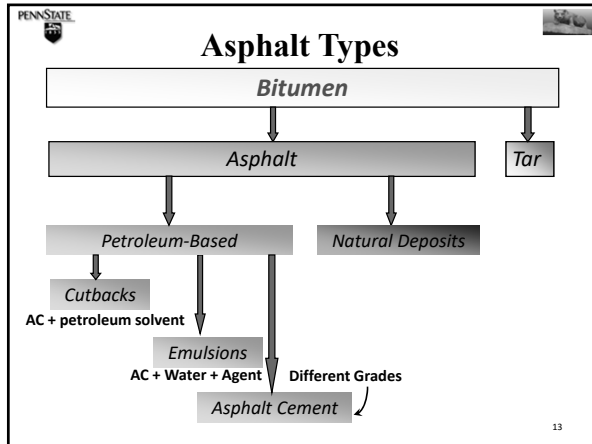
- Blend of Asphalt Cement and a Petroleum Solvent

A photograph of a white plastic jug with a handle, labeled "MC 3000", which is a common type of asphalt cutback.

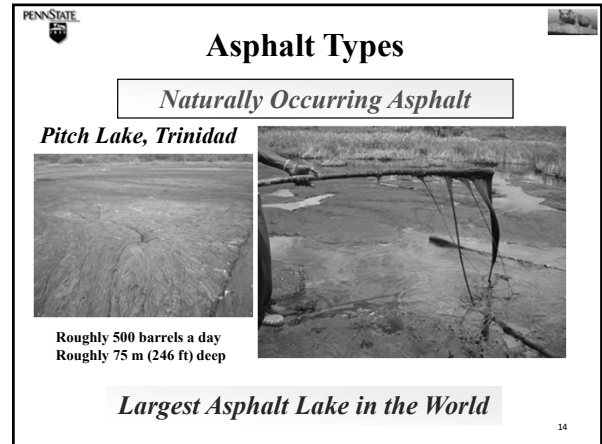
11

**ASPHALT PRODUCTION**

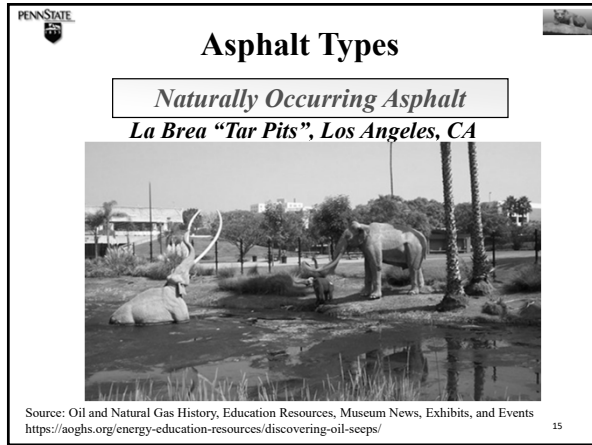
12



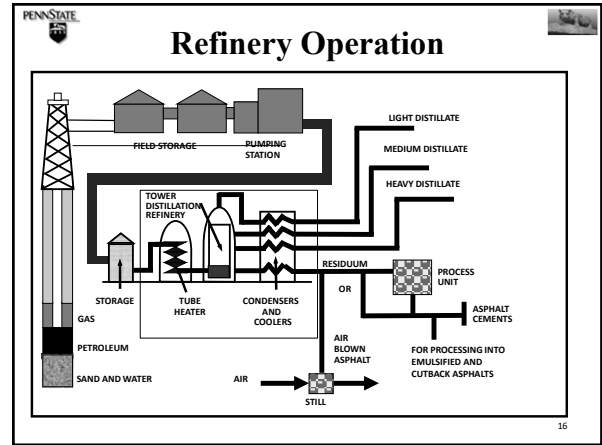
13



14



15



16

**PROPERTIES OF ASPHALT BINDER**

17

**Asphalt Properties**

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

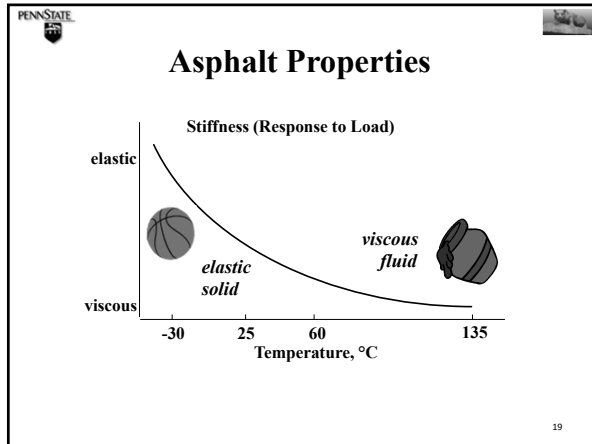
Asphalt Behavior?:

Viscoelastic Response

or

Viscoelastoplastic Response

18



19

**Asphalt Properties**

**Highly Dependent on Time and Temperature**

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

60 C 1 hour

25 C 1 hour 10 hours

20

**Review of**

**CUTBACKS**

**&**

**EMULSIONS**

21

- 
- Making Asphalt Flow**
- **To Make Asphalt Flow, It must be**
  - **Heated with fuel**
  - **Or Cutback** (blended with solvent)
  - **Or Emulsified** (blended with water and emulsifier)

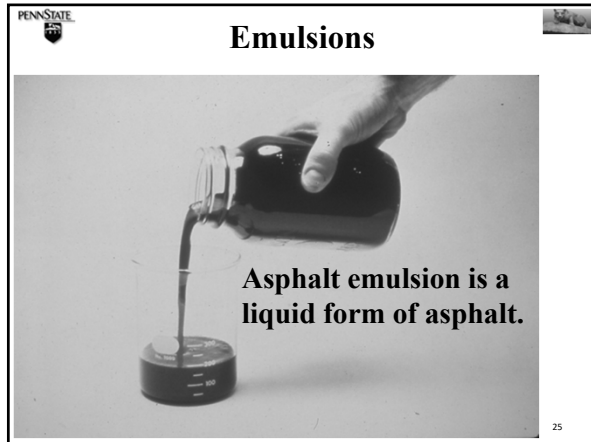
22

- 
- Cutbacks**
- Cutbacks are liquid at room temperature and are manufactured by adding or “cutting” asphalt cements with petroleum solvents.
  - The volatility of the solvent dictates the rate at which the solvent evaporates.
  - How fast the solvent escapes into the atmosphere regulates how fast a mixture of cutback and aggregate will set.
  - Environmental regulations are increasingly limiting the use of these products.

23

- 
- Cutbacks**
- **Rapid Cure (RC)** (Naphtha or Gasoline)
    - High volatility of solvent
    - Tack coats, surface treatments
  - **Medium Cure (MC)** (Kerosene)
    - Moderate volatility
    - Stockpile patching mix
  - **Slow Cure (SC)** (Low viscosity oil)
    - Low volatility
    - Prime coat, dust control

24



25

**Emulsions**

- Emulsions are based on the concept that dissimilar liquids like oil and water usually separate. With the aid of an emulsifier we could keep the oil evenly distributed (dispersed) in water without setting.
- This is also referred to as colloidal dispersion (For example, colloids of asphalt in the water which is the dispersing medium).
- As asphalt emulsion breaks (water evaporates), and asphalt droplets coalesce into an asphalt film.

26

**Asphalt Emulsions**

- Asphalt and water can be mixed in a process called Emulsification.
- Emulsion is a dispersion of minute oil droplets in water.
- Emulsions are an asphalt-based product which is also liquid at room temperature.
- Water is the Continuous phase and Asphalt is the Dispersed phase.

27

**Emulsions**

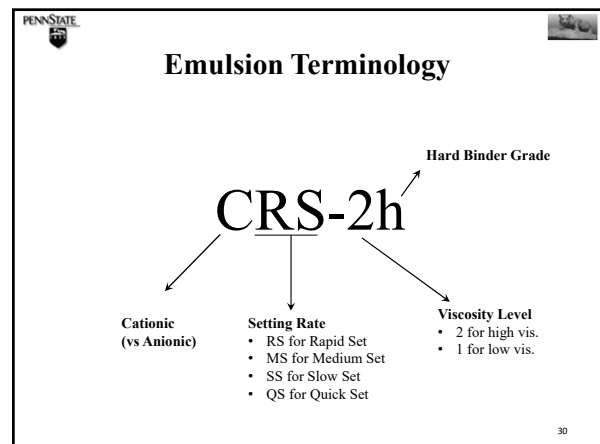
- Emulsifier gives surface charge to asphalt droplets dispersed and suspended in water medium.
  - **Anionic**
    - Negative charge
    - Alkaline
    - Good with limestone (positive charge)
  - **Cationic**
    - Positive charge
    - Acid
    - Good with silica gravels (negative charge)

28

**Common Types**

- RS-2 (Anionic Rapid Setting Emulsion)
- RS-2PM (Anionic Rapid Setting Emulsion – Polymer Modified)
- CRS-2 (Cationic Rapid Setting Emulsion)
- CRS-2PM (Cationic Rapid Setting Emulsion – Polymer Modified)
- MS-2 (Anionic Medium Setting Emulsion)
- CMS-2 (Cationic Medium Setting Emulsion)
- SS-1 (Anionic Slow Setting Emulsion)
- CSS-1H (Cationic Slow Setting Emulsion)

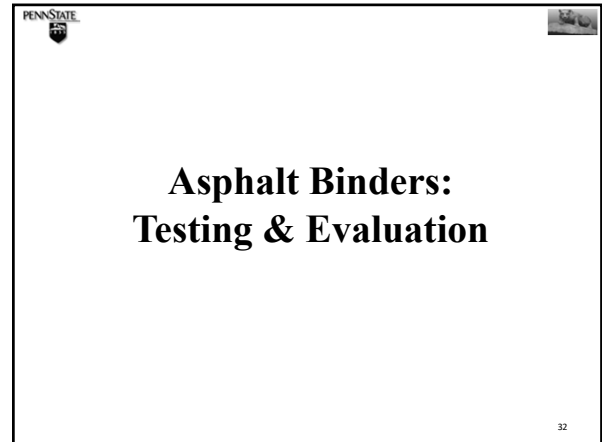
29



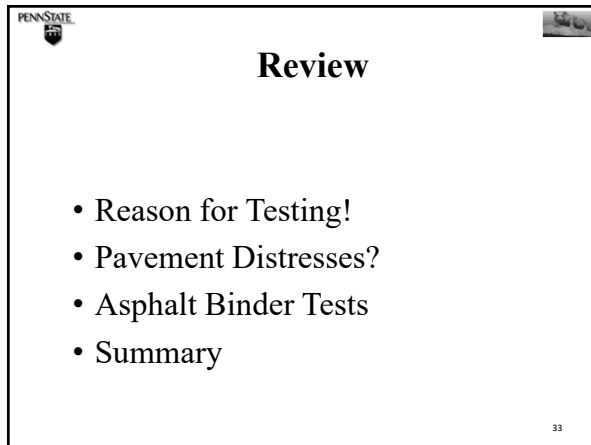
30



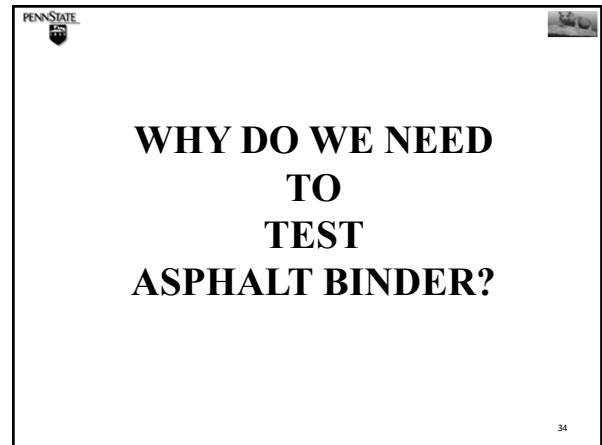
31



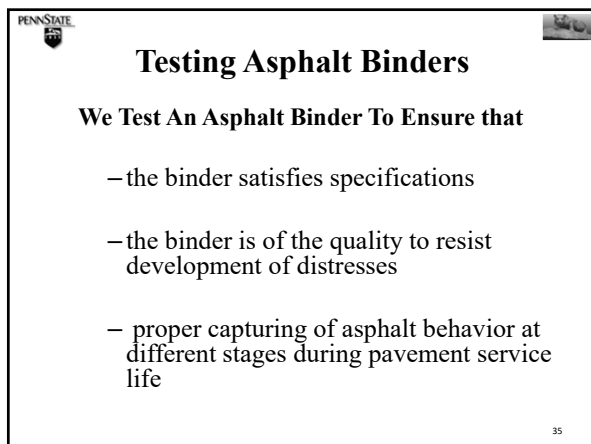
32



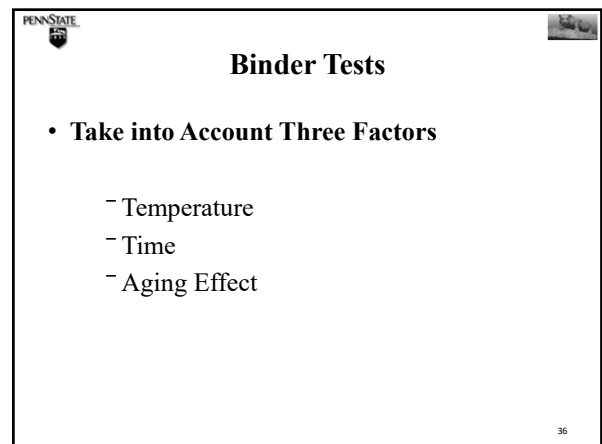
33



34



35



36

PENNSTATE

## 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)-85°F (30°C).
- Low Temperature – typically below 40°F (5°C), sometimes as low as -40°F (-40°C)

37

37

PENNSTATE

## Aging

- **Hardening**
  - Long-Term
  - Changes in properties (chemical and physical) over time
  - MW & quantity of solvents decreases
  - Irreversible
- **Volatilization**
  - Short term
  - Volatile components (lighter petroleum products) evaporate
  - During mixing and construction
  - Irreversible

38

38

PENNSTATE

## Aging, cont'd

- **Oxidation**
  - Long-term
  - Organic molecules react with oxygen
  - Occurs faster in warmer climates
  - Irreversible

39

39

PENNSTATE

## Aging

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

40

40

PENNSTATE

## DISTRESSES IN ASPHALT PAVEMENT

41

41

PENNSTATE

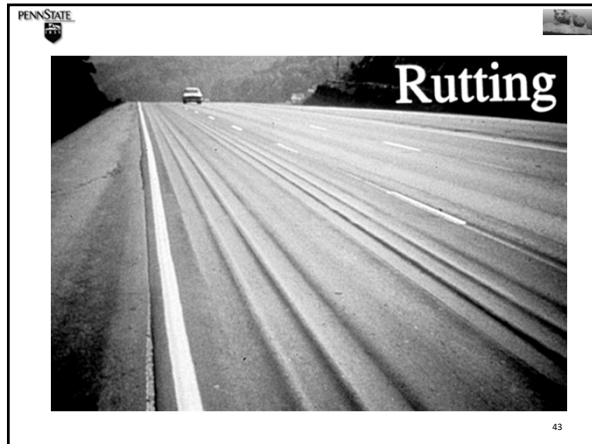
## Primary Distresses in Asphalt Pavements

- Rutting (Permanent Deformation)
- Fatigue Cracking
- Thermal Cracking (Transverse)

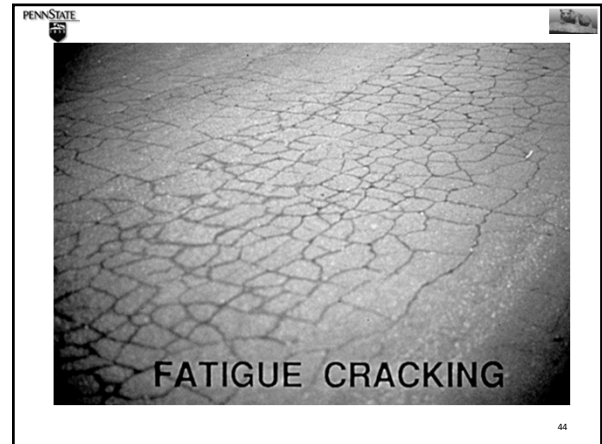
42

42

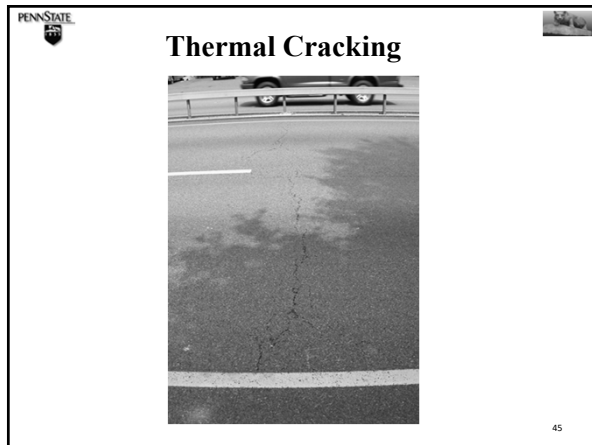




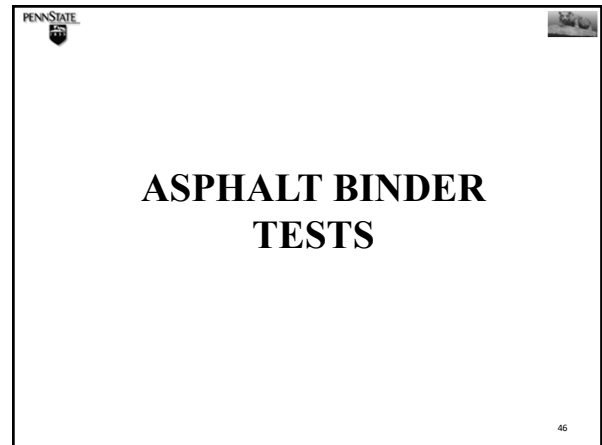
43



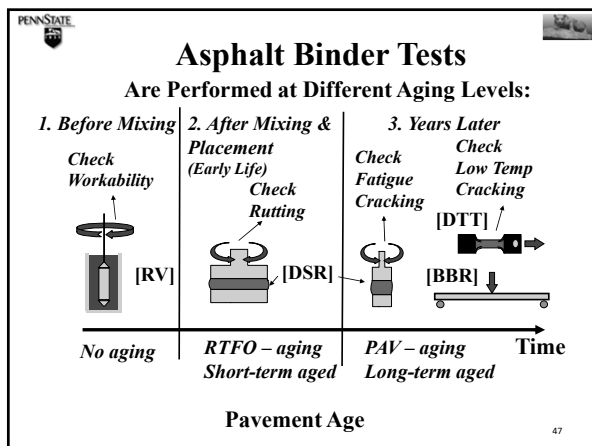
44



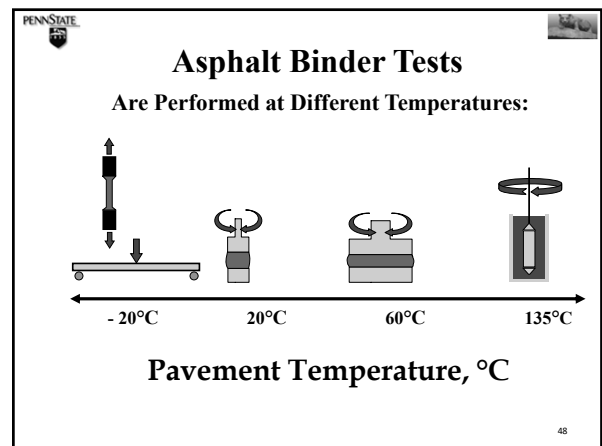
45



46



47



48

PENNSTATE

## Rolling Thin Film Oven (RTFO)

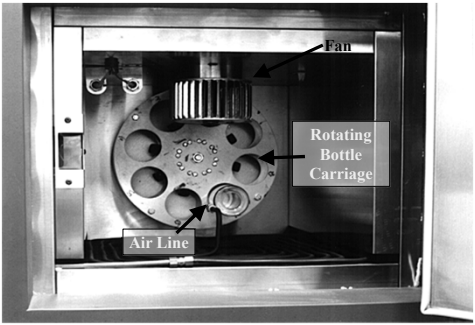
for Short Term Aging  
(During Construction & Placement)

49

49

PENNSTATE

## Rolling Thin Film Oven (for Short Term Aging)



Fan  
Rotating Bottle Carriage  
Air Line

50

50

PENNSTATE

## Rolling Thin Film Oven (RTFO)



51

51

PENNSTATE

## Rolling Thin Film Oven Sample Bottles



Clean Bottle  
Before Loading

After Loading

Coated Bottle  
After Testing

52

52

PENNSTATE

## PRESSURE AGING VESSREL (PAV)

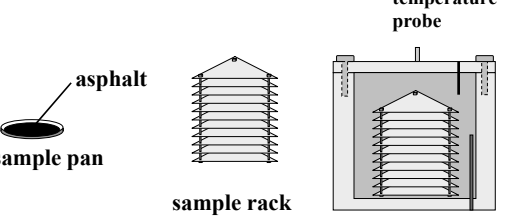
for Long Term Aging  
(During Service Life of the Pavement)

53

53

PENNSTATE

## Pressure Aging Vessel (PAV) (for Long Term Aging)



asphalt  
sample pan

sample rack

temperature probe  
pressure vessel

54

54

**Pressure Aging Vessel (PAV)  
(for Long Term Aging)**

- Simulates aging of an asphalt binder for 7 to 10 years
- 50 gram sample is aged for 20 hours
- Pressure of 2,070 kPa (300 psi)
- At 90, 100 or 110 °C

Oven

Bottom of pressure aging vessel

Rack of individual pans (50g of asphalt / pan)

Vessel Lid Components

55

55

**DYNAMIC SHEAR  
RHEOMETER (DSR)**

**for Determination of Modulus  
and Phase Angle  
(During Service Life of the Pavement)**

56

56

**Dynamic Shear Rheometer (DSR)**

57

57

**Dynamic Shear Rheometer (DSR)**

25 mm Plate with Sample

58

58

**Dynamic Shear Rheometer (DSR)**

59

59

**Rotational Viscometer**

applied torque from motor

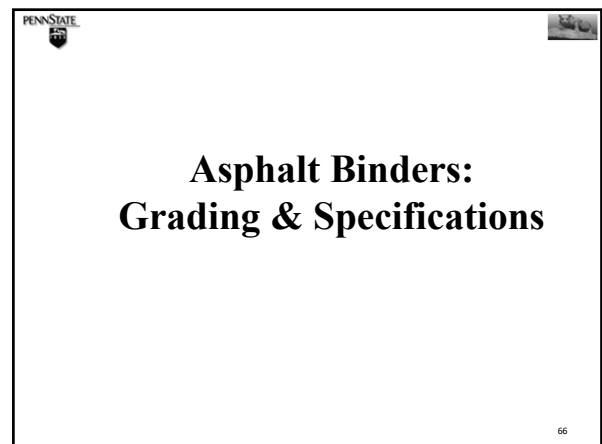
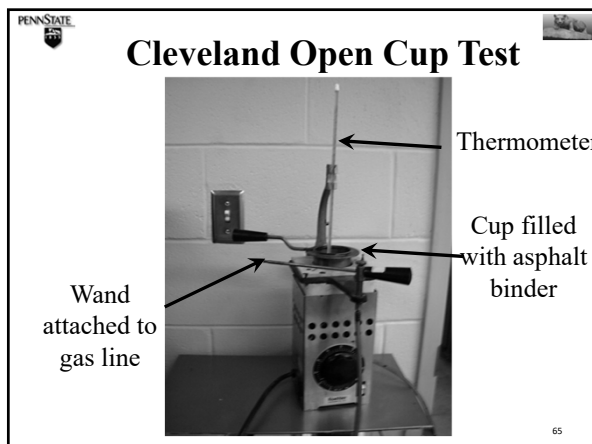
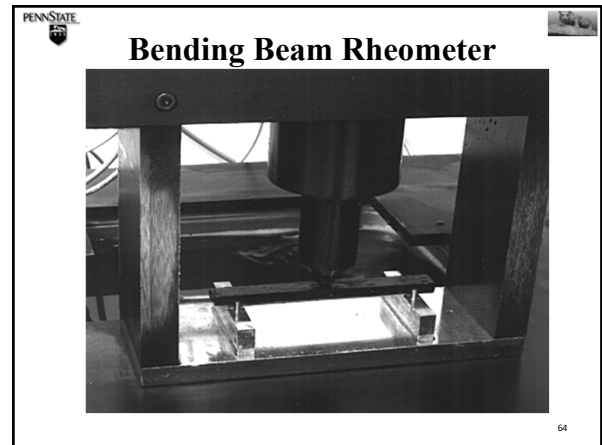
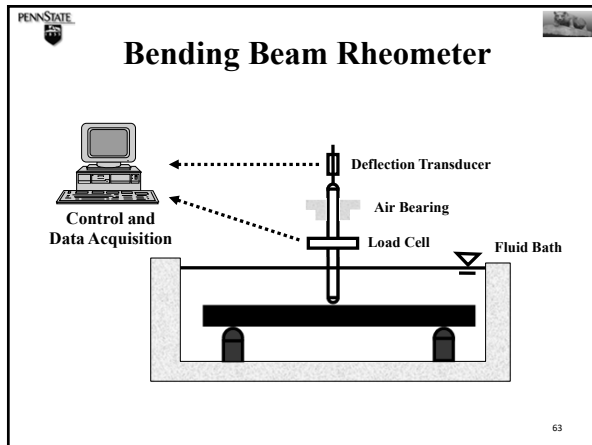
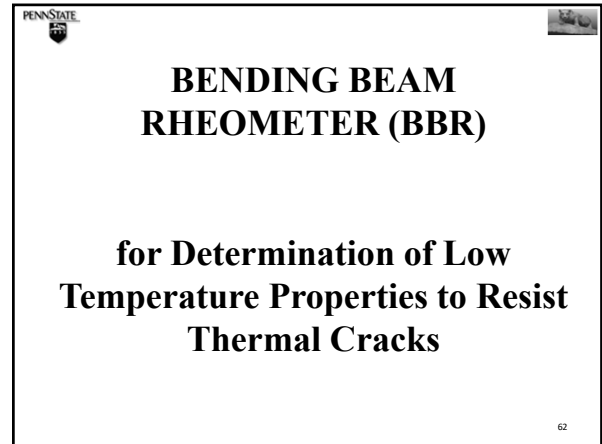
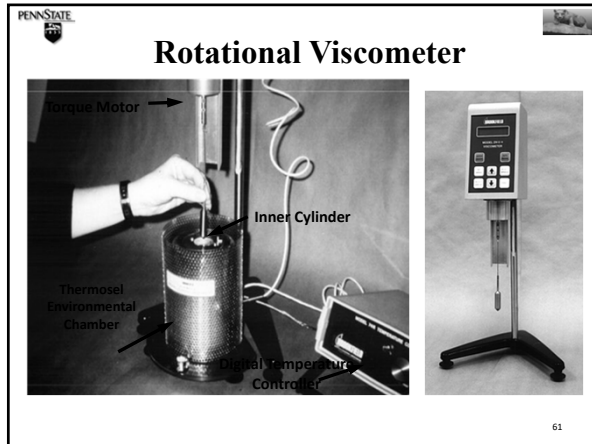
spindle

asphalt sample

sample chamber

60

60



**Review**

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

67

**OLD BINDER GRADING SYSTEMS**

68

**Previous Ways to Characterize and Specify Asphalt Binders**

- Penetration Grading
- Viscosity Grading

69

**Penetration Grading**

Penetration Test (25°C, 77°F)

Measuring penetration of a 100-gram needle after 5 seconds

One Penetration Unit = 0.1 mm

70

**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.

71

**Viscosity Grading**

Viscosity Test (60°C, 140°F)

**Measuring Absolute Viscosity:**  
Measure the time (i.e. flow 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

72

**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.**

73

**SIGNIFICANCE  
OF  
TEMPERATURE & AGING  
IN  
ASPHALT BINDER GRADING**

74

- 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,  $T_{(low)}$ .

75

- 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

76

- 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

77

- 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

78

**Pavement Behavior Aging Effect**

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

79

**Asphalt Cement Grades**

*Moving from  
Old Grading Systems:  
Viscosity Grade  
Penetration Grade  
to  
Superpave:  
Performance Graded Specifications*

80

**SUPERPVAE GRADING SYSTEMS**

We look at the supporting concepts, tests, and use of the Superpave binder specifications.

- Concepts behind the PG binder grading system.
- Tests used for determining performance-related binder properties.
- Specifications and Selection of an appropriate PG binder grade.

81

**Superpave Asphalt Binder Specification**

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

**PG 64 - 22**

Performance Grade (left), Average 7-day maximum pavement temperature (center), Minimum pavement temperature (right)

82

**PG Increments**

Average 7-day Maximum Pavement Temperature						
46	52	58	64	70	76	?
Average 1-day Minimum Pavement Temperature						
+2	-4	-10	-16	-22	-28	?

83

**SUPERPVAE BINDER SPECIFICATION**

84

### Mix Properties Affecting Performance

- Constructability: **Viscosity**
  - Pumping
  - Mixing
  - Compaction
- Distresses: **Stiffness and Strength**
  - Rutting
  - Fatigue Cracking
  - Thermal Cracking

Construct Viscosity-Temperature Relationship Curve

High Temperature

Moderate Temperatures

Low Temperature

85

### Binder Specification

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

86

PERFORMANCE GRADE	PG 46		PG 52		PG 58		PG 64		PG 70		PG 76		PG 82	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Eq. 2-4.2.2 Min. Viscosity (Pa·s)	100	150	100	150	100	150	100	150	100	150	100	150	100	150
Eq. 2-4.2.3 Max. Viscosity (Pa·s)	300	450	300	450	300	450	300	450	300	450	300	450	300	450
Eq. 2-4.2.4 Min. Dynamic Modulus (GPa)	0.15	0.20	0.15	0.20	0.15	0.20	0.15	0.20	0.15	0.20	0.15	0.20	0.15	0.20
Eq. 2-4.2.5 Max. Dynamic Modulus (GPa)	1.0	1.5	1.0	1.5	1.0	1.5	1.0	1.5	1.0	1.5	1.0	1.5	1.0	1.5
Eq. 2-4.2.6 Min. Resilient Modulus (MPa)	100	150	100	150	100	150	100	150	100	150	100	150	100	150
Eq. 2-4.2.7 Max. Resilient Modulus (MPa)	300	450	300	450	300	450	300	450	300	450	300	450	300	450
Eq. 2-4.2.8 Min. Tensile Strength (MPa)	0.15	0.20	0.15	0.20	0.15	0.20	0.15	0.20	0.15	0.20	0.15	0.20	0.15	0.20
Eq. 2-4.2.9 Max. Tensile Strength (MPa)	1.0	1.5	1.0	1.5	1.0	1.5	1.0	1.5	1.0	1.5	1.0	1.5	1.0	1.5
Eq. 2-4.2.10 Min. Fatigue Life (cycles)	100	150	100	150	100	150	100	150	100	150	100	150	100	150
Eq. 2-4.2.11 Max. Fatigue Life (cycles)	300	450	300	450	300	450	300	450	300	450	300	450	300	450

87

### How the PG Spec Works

88

### Summary

- Old Binder Grading Systems
- Pavement Temperature & Reliability in Binder Selection
- Superpave Binder Grading System
- Superpave Binder Specifications

89

### Summary

- Terminology in Asphalt Industry
- Production
- Properties
- Tests & Specifications

90



# Plant Technician Certification Program

## Module 4

### Aggregates

#### Properties, Tests, and Gradation




N  
E  
C  
E  
P  
T

## Plant Technician Certification Program

### Module 4 Aggregates

### Properties, Tests, and Gradation



1

### Topics to Discuss

- Aggregate properties
- Aggregate tests
- Gradation & sieve analysis / workshop
- Aggregate blending

2

### 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

NECEPT

3

### 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

NECEPT

4

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

Sieve Size	Cement Concrete Sand		Bituminous Concrete Sand		Mortar Sand
	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

NECEPT

5

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

NECEPT

6

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.

NECEPT

7

## 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

8

### Aggregate Tests: PTM's

- PTM 510 (AASHTO T 103): Soundness using Sodium Sulfate
  
- PTM 616 (AASHTO T27): Sieve Analysis
  
- PTM 620: Friable Particles in Coarse Aggregate

9

### Aggregate Tests: AASHTO

- **T-11:** Amount of Material Finer than No. 200 Sieve in Aggregate
- **T-27:** Sieve Analysis of Fine and Coarse Aggregates
- **T-30:** Mechanical Analysis of Extracted Aggregate
- **T-84:** Specific Gravity and Absorption of Fine Aggregate
- **T-85:** Specific Gravity and Absorption of Coarse Aggregate
- **T-96:** Los Angeles Abrasion
- **T-176:** Sand Equivalent
- **T-304:** Uncompacted Void Content of Fine Aggregate – Method A

10

### Aggregate Tests: ASTM

- **D 5821** - Percentage of Crushed Fragments

11

## AGGREGATE GRADATION

NECEPT

12

### 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

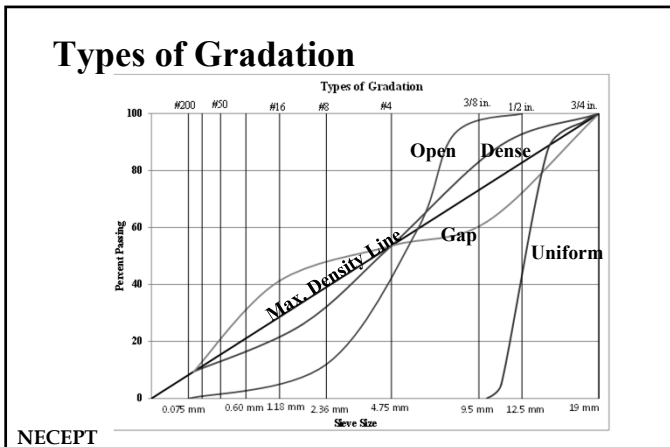
13

### 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

NECEPT

14



15

### Definitions of Nominal Maximum Aggregate Size (NMAS)

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

16

### Definitions (continued)

**Example:**

Aggregate 1		Aggregate 2	
% Passing		% 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%

Labels: Max Sieve (9.5 mm), Nom. Max. Sieve (12.5 mm)

17

### 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

18

**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)

<b>Pros</b>	<b>Cons</b>
<ul style="list-style-type: none"> <li><input type="checkbox"/> High Strength</li> <li><input type="checkbox"/> Low Permeability</li> </ul>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Frost Damage</li> <li><input type="checkbox"/> Minimal space for Cement</li> </ul>

NECEPT

19

**0.45 Power Grading Chart**

Percent Passing

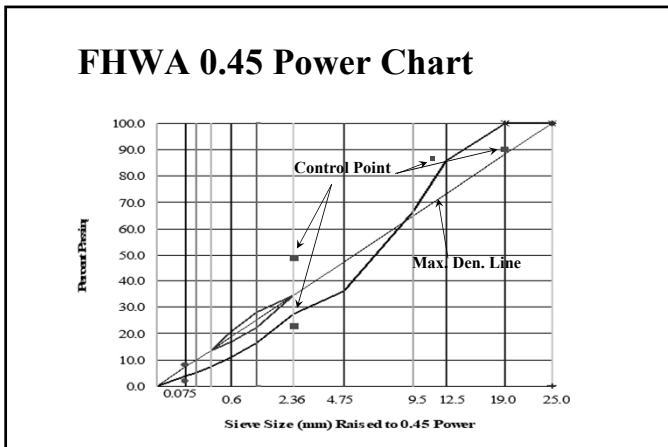
D = 19 mm  
P = 100 (4.75/19)<sup>0.45</sup>  
P = 54%

Example:  
4.75 mm sieve plots at  $(4.75)^{0.45} = 2.02$

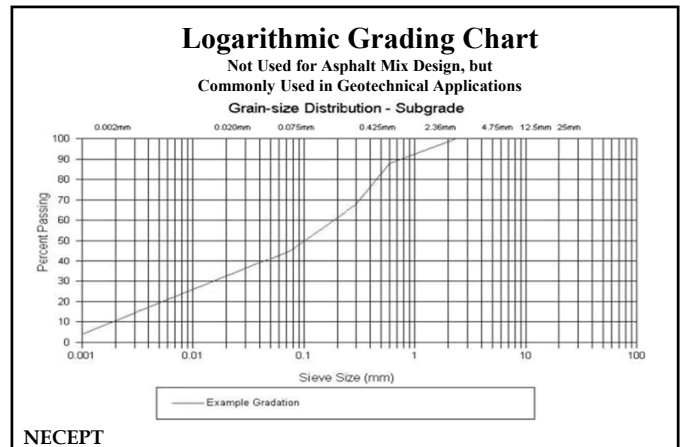
Sieve Size (mm) Raised to 0.45 Power

NECEPT

20



21



22

**SIEVE  
ANALYSIS**

NECEPT

23

**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

NECEPT

24

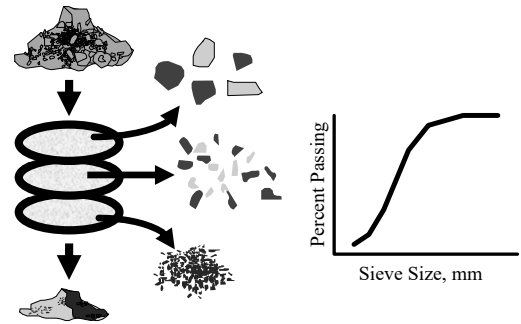
### Why perform sieve analysis?

- 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

NECEPT

25

### Sieve Analysis and Gradation



NECEPT

26

### Mechanical Sieving

Individual Sieve



Stack in Mechanical Shaker



NECEPT

27

### 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	

NECEPT

28

### 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

NECEPT

29

### 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

NECEPT

30

### 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

NECEPT

31

### 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

NECEPT

32

### Notes on Procedure

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

NECEPT

33

### 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 T 27 and PTM 743

NECEPT

34

### AASHTO T27-14

#### Example Sieve Analysis

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	---	---

$$= \frac{4550}{5000} \times 100$$

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

NECEPT

35

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

#### What is percent passing #8 Sieve?

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

NECEPT

36

### AASHTO T27-14 - Sieve Analysis Class Activity

**WORKSHOP  
AGGREGATE 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	1/2"	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 4.75 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?

**NECEPT**

37

### AASHTO T27-14 - Sieve Analysis Class Activity

$\frac{4351.5}{5001.7} \times 100 = 87$

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 =  $(5013.2 - 5001.7) / 5013.2 \times 100\% = 0.23\% < 0.8\%$

**NECEPT**

38


### Summary

- Aggregate Properties important to asphalt mix
- Aggregate Tests to capture properties
- Gradation of aggregate structure
- Various types of gradation
- Sieve analysis and size distribution

**NECEPT**


39

N  
E  
C  
E  
P  
T



**PennState**

## Thank You!



**pennsylvania**  
DEPARTMENT OF TRANSPORTATION

40



# Plant Technician Certification Program


## Module 5 Aggregate Blending



N  
E  
C  
E  
P  
T

**Plant Technician  
Certification Program**

**Module 5  
Aggregate Blending**



1

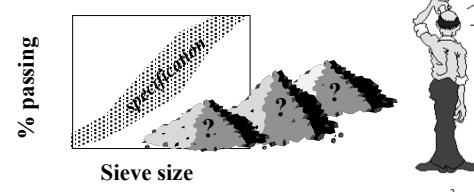
**Aggregate Blending:  
Introduction**

- 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



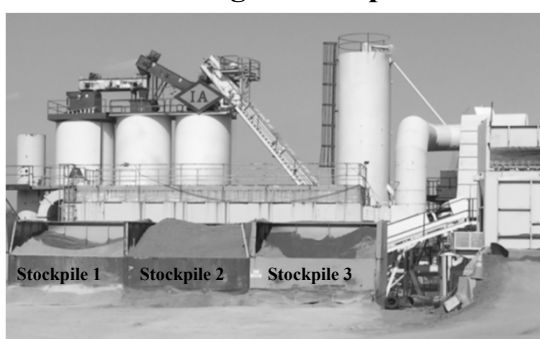
3

**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

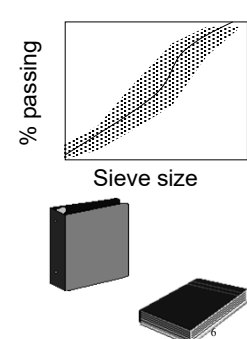
**Blending of Stockpiles**



5

**Determine Target Gradation**

- Contract documents
- Superpave gradations with control points
- AASHTO specifications
- PennDOT specifications
- Experience & judgment



6

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

7

**Determine Percentage of Each Aggregate Needed**

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

**In the Field...**

- 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

10

**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

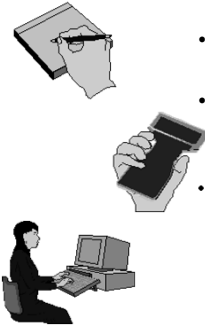
11

**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 calc. blend against specification
- Adjust if necessary and repeat above steps

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*

13

13

### Software for Proportioning Aggregates

- Computer programs
- Custom spreadsheets
- Pinepave and other gyratory software includes blending spreadsheet
- Various versions of Superpave Program can also be used

14

14

### Blending Stockpiles (Graphics)

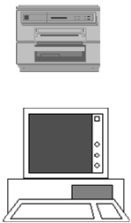
- Plot individual gradations
- Plot specification limits
- Can be used for initial assessment
  - Can blend be made from available materials?
  - Identification of critical sieves
  - Estimate of trial proportions

15

15

### 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



16

16

### Some Comments on Aggregate Blending Methods

- Simultaneous equation method is difficult to use for more than two aggregates.
- Spreadsheet templates and graphical methods can be used for trial-and-error blending of more than three aggregate stockpiles.

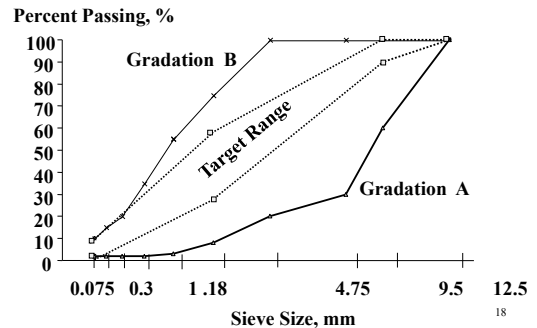


17

17

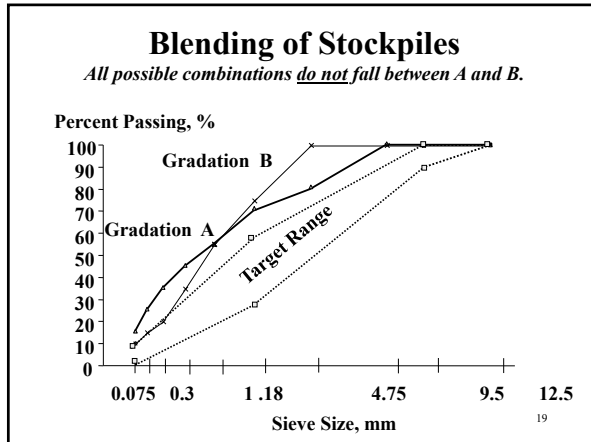
### Blending of Stockpiles

*Most combinations fall between A and B*

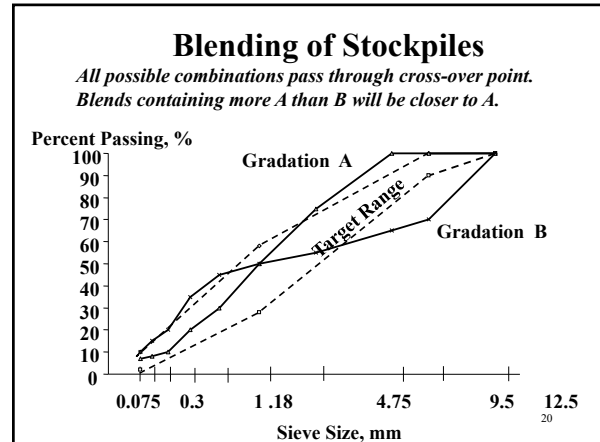


18

18



19



20

### Example Problem 1: Blend must meet Superpave 9.5 mm (3/8") Specification

Sieve Size US (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

21

### Example Problem 1 (Cont'd) Two Stockpiles: Fine Aggregate 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

22

### 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

23

### 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
- $\%FA \times \text{wt. \% passing subject sieve} + \%CA \times \text{wt. \% passing subject sieve} = \%$  of Blend passing subject sieve
- Example:  $\%$  passing #4 (4.75 mm)
  - $(0.5 \times 100\%) + (0.5 \times 22\%) = 61\%$
  - 61% of the 50/50 blend passes the # 4 (4.75 mm) sieve

24

**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

25


**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

26

**Example Problem 1 (Cont'd)**  
**Simultaneous Equations**

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



27

**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
▪ $P_{FA} = (X / Y) \times 100\%$ .....	52.7
▪ $P_{CA} = 100 - P_{FA}$ .....	47.3

28

**Example Problem 2:**  
**Determine Blend using Two Methods**

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

29


**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		

30

### 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




31

31

### Example Problem 2: 2. Simultaneous Equations

- Use No. 8 as *control sieve*
  - $P_{FA} \times 85 + P_{CA} \times 5 = 40$  (Eq. 1)
  - $P_{FA} + P_{CA} = 1.0$
  - $P_{CA} = 1.0 - P_{FA}$  (Eq. 2)
- Put Eq. 2 into Eq. 1:
  - $P_{FA} \times 85 + (1.0 - P_{FA}) \times 5 = 40$
  - $P_{FA} \times 80 = 40 - 5$  (Eq. 3)
- $P_{FA} = 35/80 = 0.438$  or 44%
- $P_{CA} = 100 - 44 = 56\%$



32

32

### 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
▪ $P_{FA} = (X / Y) \times 100\%$ .....	43.8
▪ $P_{CA} = 100 - P_{FA}$ .....	56.2

33

33

### 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

34

34

### 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

35

35

### 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.**

36

36

**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
▪ $P_{FA} = (X / Y) \times 100 \%$ .....	51.3
▪ $P_{CA} = 100 - P_{FA}$ .....	48.7

37

**Specific Gravity  
of Blended Aggregate**

**Important:**

- 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.

38

**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.  $G_s=2.664$

39


**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

40

N  
E  
C  
E  
P  
T



Thank You!



41



# Plant Technician Certification Program

## Module 6

### Specific Gravity and Absorption



N  
E  
C  
E  
P  
T

**Plant Technician  
Certification Program**

**Module 6**

**Specific Gravity and Absorption**



1

**Outline**

- Review concepts and calculations relating to specific gravity of aggregates (Calculation of specific gravity essential to mix design process)
- Review AASHTO T 84, T 85
- Cover definition of specific gravity, types of specific gravity, computation, and a short workshop.

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

3

**What is Specific Gravity?**

- Use “*G*” to present **Specific Gravity**
- Use “*D*” to present **Density**

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

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

4

**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

5

**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 (Fahrenheit) = 25°C (Celsius)

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

6

### Density of Water

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

Temperature (°C), (°F)	Density of Water	
	grams/cm <sup>3</sup>	Lb./ft <sup>3</sup> *
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<sub>m</sub>  
1 lb. = 0.45359 kg = 45359 grams = 16 avoirdupois ounces

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

NECEPT 7

7

### Determining Volume of an Object

□ Weight in water method

□  $W_w = B - C$

□ Pycnometer method

□  $W_w = S - (C - B)$

$W_w$  in grams is almost equivalent to Volume in cm<sup>3</sup>

B = weight in air  
C = weight in Water

Object + Water in Pycnometer

NECEPT 8

8

### Methods for Determining Specific Gravity

□ Weight-in-water:

- PTM 715, 716 (for compacted mix)
- AASHTO T 209 (for loose mix)
- AASHTO T 85 (for coarse aggregate)

□ Pycnometer/volumeter method:

- PTM 715, 716 (for compacted mix)
- AASHTO T 209 (for loose mix)
- AASHTO T 84 (for fine aggregate)

NECEPT 9

9

### Comparing PTMs to AASHTO Tests related to Sp. Gr.

PTM		AASHTO
□ 505 Fine Agg Sp Gr.	→	□ T 84 Fine Agg. Sp. Gr.*
□ 506 Course Agg. Sp. Gr.	→	□ T 85 Course Agg. Sp. Gr. *
□ 715 Mix Bulk Sp. Gr.		□ T 166 Mix Bulk Sp. Gr.
□ 716 Mix Bulk Sp. Gr.		□ T 166 Mix Bulk Sp. Gr.
□ 740 Mix Max. Sp. Gr.	→	□ T 209 Mix Max. Sp. Gr.*
□ 527 Uncompacted Voids of fine Agg.	→	□ T 304 Uncompacted Voids of Fine Agg. *

\* AASHTO tests have replaced PTMs.

NECEPT 10

10

### Specific Gravities of some common materials...

wood 0.6

plastic 1.0

steel 7.8

crushed limestone 2.7

asphalt cement 1.0

NECEPT 11

11

### Specific Gravity of Aggregate (Absorption Effect)

NECEPT 12

12

### Absorption of Aggregate

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

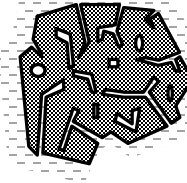


13

13

### Permeable & Impermeable Voids of Aggregate

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



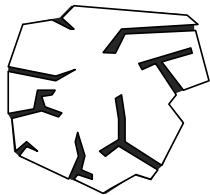
**Saturated, surface-dry (SSD):** condition in which permeable voids in aggregate particles are just filled with water.

14

14

### Water Absorption of Aggregate

- Absorption is the moisture content in the SSD state
- Moisture content when permeable voids just filled with water



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

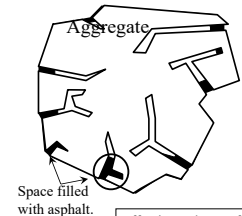
$W_{SSD}$  = Saturated Surface Dry Weight  
 $W_{OD}$  = Oven Dry Weight

15

15

### 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.

16

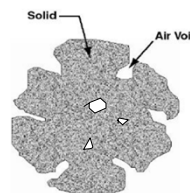
### Types of Aggregate Specific Gravity

- 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

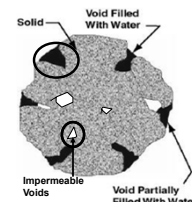
17

17

### Types of Specific Gravities



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



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

NECEPT

18

18

### 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

19

19

### 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  $23 \pm 1.7$  °C
- Watch out for air bubbles in pycnometer

20

20

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

- $G_{sb} = A / (B + S - C)$
- $G_{sa} = A / (A + B - C)$
- $Abs. = (S - A) / A \times 100 \%$
- $G_{sc}$ : 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.

21

21

### 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

22

22

### 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

23

23

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

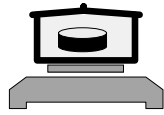
- $G_{sb} = A / (B - C)$
- $G_{sa} = A / (A - C)$
- $Abs. = (B - A) / A \times 100 \%$
- $G_{sc}$ : determined from  $G_{mm}$
- A = oven dry Wt.; B = SSD Wt.; C = Wt. in water

24

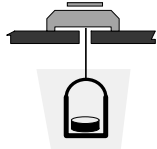
24

### 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)

25

25

### 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

26

26

### 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

27

27

### PTM 716 (continued)

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

28

28

### 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).

29

29

### AASHTO T 209: Theoretical Maximum Specific Gravity of Paving Mixtures

- Heat 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.

30

30

### 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	4000
25.0 (1.0) or 19.0 (0.75)	2500
12.5 (0.5) or smaller	1500

31

31

### Types of Mixture Specific Gravity, AASHTO T 209

- $G_{mm}$  - maximum theoretical 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.

32

32

### 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  $77 \pm 0.9$  °F ( $25 \pm 0.5$  °C.)
- Use good aspirators or maintenance-free vacuum pump.
- Use good residual pressure gages, or calibrate gages against a standard.
- Use mechanical shaker

33

33

### 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 = Wt. of sample and water in volumeter; D = SSD Wt. of sample
- $G_{mm} = A / (A + D - E)$
- A = dry Wt.; D = Wt. of Pycn. with water; E = Wt. of Pycnometer with water & sample

34

34

### 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  $V_a$

35

35

### Workshop, Part One: Aggregate Specific Gravity

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

36

36

**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.

37

37

**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

NECEPT

38

38

**Part One Solution**

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

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

39

39

**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.

NECEPT

40

40

**Part One Solution**

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

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

41

41

**Apparent Sp. Gr. of Coarse Aggregate**

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

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

NECEPT

42

42



**Part One Solution**

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

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

43

43

**Workshop, Part Two:  
Specific Gravity of Asphalt Mixture**

- HMAC (Hot Mix Asphalt Concrete) Sample
- 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  $G_{mm}$

44

44

**Workshop, Part Two:  
Mixture Specific Gravity**

- HMAC Sample
- Compacted Sample for  $G_{mb}$  (PTM 715, Method A)
  - 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

45

45

**Maximum Theoretical 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

NECEPT

46

46

**Part Two Solution**

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

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

47

47

**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 = Wt. of Sample and Water in Volumeter
- D = SSD Weight of Sample

NECEPT

48

48

### Part Two Solution

□ Bulk Sp. Gr. of the Mix,  $G_{mb}$

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

49

49

### Air Void of Compacted Mix

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

NECEPT

50

50

### Part Two Solution

□ Air void content,  $P_a =$

$$[1 - (2.407/2.577)] \times 100 \% = \underline{6.6 \%}$$

51

51

### 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.


NECEPT

52

52



**Thank You!**



53

53

N  
E  
C  
E  
P  
T

# Plant Technician Certification Program

## Module 7

### Analysis of Volumetric Parameters




N  
E  
C  
E  
P  
T

## Plant Technician Certification Program

### Module 7

## Analysis of Volumetric Parameters



1

## Asphalt Mixture Volumetrics

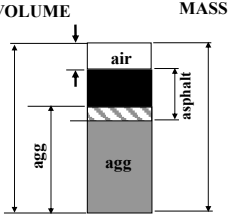
□ Objectives of This Module

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

2

### Air Voids

VOLUME



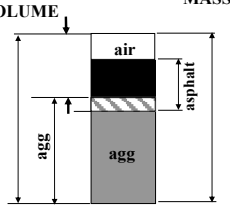
MASS

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

3

### Voids in the Mineral Aggregate (VMA)

VOLUME



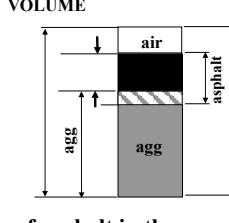
MASS

- Definition
  - volume concentration of *intergranular* void space in a compacted mix
- Reported as percent of the mix volume

4

### Voids Filled with Asphalt (VFA)

VOLUME



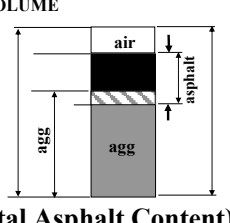
MASS

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

5

### Asphalt Content

VOLUME



MASS

- 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

### Absorbed Asphalt Content

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

7

### 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  $P_{be}$

8

### Specific Gravity

- {mix, agg, and binder}
- Bridge Between Mass and Volume

$$G = \frac{M_o}{V_o}$$

$$\frac{M_w}{V_w} = 1.000 \text{ g/cm}^3 \leftarrow \text{approx density of water at } 25^\circ \text{C}$$

9

### Specific Gravity (G)

- Relates Density of An Object to Density of Water

$$D = G \times 1.000$$

Density in g/cm<sup>3</sup>      specific gravity of object      density of water (g/cm<sup>3</sup>)

10

### Specific Gravity

- Relates Volume

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

volume of object      mass of object      specific gravity of object      density of water

11

### Specific Gravity

- Relates Mass

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

mass of object      volume of object      specific gravity of object      density of water

12

### 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)

Same Mass  
but  
Different Volumes

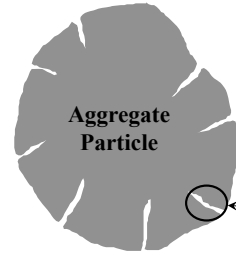


13

### Aggregate Bulk Specific Gravity

“Saturated Surface Dry”

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



Bulk Volume = solid volume + water permeable pore volume

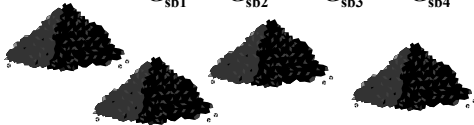
water permeable pore volume

14

### Combined Aggregate Bulk Specific Gravity

Determine Weighted Average

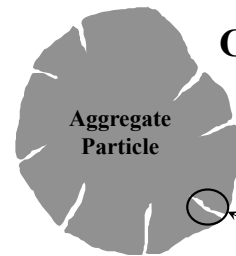
$$G_{sb} \text{ (combined)} = \frac{100}{\frac{P_1\%}{G_{sb1}} + \frac{P_2\%}{G_{sb2}} + \frac{P_3\%}{G_{sb3}} + \frac{P_4\%}{G_{sb4}}}$$



15

### Aggregate Apparent Specific Gravity

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



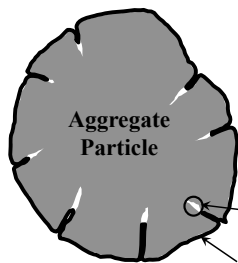
Apparent Volume = volume of solid aggregate particle only

DO Not Include

16

### Aggregate Effective Specific Gravity

$$G_{se} = \frac{\text{Dry Mass}}{\text{Effective Vol.}} \times 1.000 \text{ g/cm}^3$$



Effective Volume = solid volume + volume of pores not filled with asphalt

pores not filled with asphalt

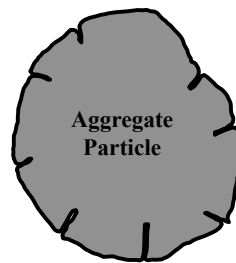
asphalt coating

17

### Aggregate Effective Specific Gravity

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

Measured Max. Theoretical Sp. Gr.      Measured Binder Sp. Gr.



18

### Bulk Specific Gravity of Asphalt Concrete Mix

- **Definition**
  - mass of a unit volume of mix compared to unit volume of water
- Normally Use  $G_{mb}$

19

### Maximum Theoretical Specific Gravity of Asphalt Concrete Mix

- **Definition**
  - mass per volume of material containing no air voids, compared to unit volume of water
- Normally Use  $G_{mm}$

20

### 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  $G_{sc}$  (One gives the other)
  - $G_{mb} = G_{mm}$  at zero air voids.

21

### Phase Diagram

22

### Equations

$$G_{mm} = \frac{100}{\frac{P_s}{G_{sc}} + \frac{P_b}{G_b}} \quad \left| \quad V_a = \left( \frac{G_{mm} - G_{mb}}{G_{mm}} \right) \times 100$$

$$VMA = 100 - \frac{G_{mb} \times P_s}{G_{sb}} \quad \left| \quad VFA = \left( \frac{VMA - V_a}{VMA} \right) \times 100$$

$$P_{ba} = 100 \times \left( \frac{G_{sc} - G_{sb}}{G_{sc} \times G_{sb}} \right) \times G_b \quad \left| \quad P_{bc} = P_b - \frac{P_{ba} \times P_s}{100}$$

23

### Example Problems for Calculating Volumetrics

24

### Workshop Assignment

- Lab Measurements For Aggregates:
  - Agg. 1 (56.4 % of total aggregate),
  - bulk Sp. Gr. = 2.683,
  - Abs. 0.5 %.
- Agg. 2 (43.6 % of total aggregate),
- bulk Sp. Gr. = 2.701,
- Abs. 0.4%
- Asphalt, 5.9 % by Wt. of Mix,
- Sp. Gr. = 1.023

25

### Workshop Assignment (continued)

- Lab Measurements for  $G_{mb}$ , at 77°F:
  - Wt. of sample in air: 1235.3 g
  - SSD Wt. of sample: 1239.9 g
  - Wt. of sample + water in volumeter: 1836.2 g
  - (Weight of Water in Volumeter (Calibration): 1114.86 grams) from which we get the volume.
  - Volume of volumeter (Calibration): 1118.2 cm<sup>3</sup>
    - (This is calculated from weight of water)

26

### 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

27

### 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

28

### Combined Bulk Sp. Gr. of Agg.

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

29

### Combined Bulk Sp. Gr. of Agg.

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

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

30



### Bulk Sp. Gr. of Compacted Mix

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

1.003 is the volume of one gram of water in mL (cm<sup>3</sup>) 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 All in grams and mL (cm<sup>3</sup>)  
 B = Volume of volumeter  
 C = Wt. of sample and water in volumeter  
 D = SSD Weight of sample All testing at 77±1.8°F (25±1.°C)

31

### Bulk Sp. Gr. of Compacted Mix

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

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

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

$$G_{mb} = 2.382$$

32

### Bulk Sp. Gr. of Compacted Mix

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.

33

### Maximum Theoretical Sp. Gr. of Loose Mix

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

All in grams and mL (cm<sup>3</sup>)

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.°C)

34

### Maximum Theoretical Sp. Gr. of Loose Mix

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

$$G_{mm} = 2.471$$

35

### Air Void of Compacted Mix

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

36

**Air Void of Compacted Mix**

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

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

37

**Air Void of Compacted Mix**

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

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

$$\% \text{ Voids, } P_a = 100 - 96.4$$

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

38

**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

39

**Effective Specific Gravity**

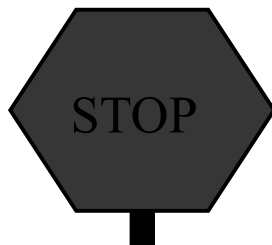
$$G_{se} = \frac{100 - 5.9}{\frac{100}{2.471} - \frac{5.9}{1.023}}$$

$$G_{se} = 2.712$$

40

$G_{se}$  Smaller than  $G_{sb}$ ?

Something Wrong!



41

**Absorbed Asphalt Binder**

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

42

**Absorbed Asphalt Binder**

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

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

43

**Effective Asphalt Binder**

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

$P_{be}$  = Effective Asphalt Binder

44

**Effective Asphalt Binder**

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

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

45

**Voids in the Mineral Aggregate**

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

46

**Voids in the Mineral Aggregate**

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

$$VMA = 16.7$$

47

**Voids Filled with Asphalt**

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

48

### Voids Filled with Asphalt

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

$$\text{VFA} = 78.4 \%$$

49

### Summary of Solution

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

50

### 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 %

51

N  
E  
C  
E  
P  
T

 PennState

**Thank You!**

 **pennsylvania**  
DEPARTMENT OF TRANSPORTATION

52

# Plant Technician Certification Program

## Module 8


# PennDOT Asphalt Specifications



N  
E  
C  
E  
P  
T

**Plant Technician  
Certification Program**

**Module 8  
PennDOT Asphalt Specifications**



1

1

**PennDOT Specifications**

**Which Specs Are the Most Significant?**

- The specifications that cover your project and affect YOU are the most important.
- Be aware of the effective change dates and your project let date.

NECEPT 2

2

**Publication 408/ Pub 408**

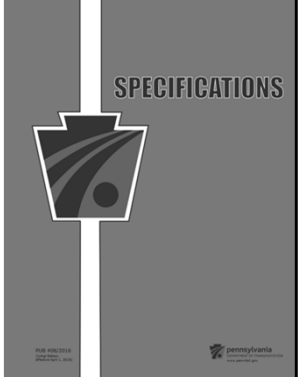
Year (Version)	Effective Dates
2000	April 3, 2000 to September 30, 2003
2003	October 1, 2003 to April 1, 2007
2007	April 2, 2007 to March 31, 2011
2011	April 1, 2011 to March 31, 2016
2016	April 1, 2016 to April 2, 2020
2020	April 10, 2020 to October 6, 2023

3

3

**PennDOT Specifications (Publication 408)**

Pub 408/2016  
(Effective April 1, 2016)




4

4

**Publication 408/2016**

Version	Effective Date
<b>Initial Edition</b>	<b>April 1, 2016</b>
Change No. 1	October 7, 2016
Change No. 2	April 7, 2017
Change No. 3	October 6, 2017
Change No. 4	April 6, 2018
Change No. 5	October 5, 2018
Change No. 6	April 5, 2019
Change No. 7	October 4, 2019



**2016**

5

5

**New Sections 313 and 413**

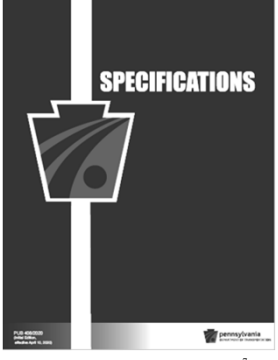
- Initial Edition, April 2020
  - 309 and 311 will merge into new Section 313
  - 409 and 411 will merge into new Section 413
  - Consolidate Information from SSP and SOL
- These will become new specifications for projects with PWL and LTS testing

6

6

### PennDOT Specifications (Publication 408)


Pub 408/2020 – Initial Edition  
(Effective April 10, 2020)



7

### Publication 408/2020


- PennDOT Pub 408/2020 contains Construction Specifications
- for PennDOT Projects Let after April 10, 2020
- PennDOT Website:  
[http://www.dot.state.pa.us/public/PubsForms/Publications/Pub\\_408/408\\_2020/408\\_2020\\_IE/408\\_2020\\_IE.pdf](http://www.dot.state.pa.us/public/PubsForms/Publications/Pub_408/408_2020/408_2020_IE/408_2020_IE.pdf)



8

### PennDOT Specifications (Publication 408)

Version	Effective Date
<b>Initial Edition</b>	<b>April 10, 2020</b>
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**

9

### Sections of Publication 408

**Question:**  
How Many Sections Are There in Spec 408?

**Answer:**  
Twelve

10

### 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

11

### Sections of Publication 408

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

12

**Sections  
Publication 408**

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

NECEPT 13

13

**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

NECEPT 14

14

**Sections of  
Publication 408**

- 300 – Base Courses
  - SP HMA Base design/construction (Section 309)
  - SP WMA Base design/construction (Section 311)
  - Cold Mixes (Sections 341 and 342)
  - Asphalt Treated Permeable Base (Section 360)

NECEPT 15

15

**Sections of  
Publication 408**

- 400 – Flexible Pavements
  - SP HMA design/construction (Section 409)
  - SP HMA design/construction fine graded (Section 410)
  - SP WMA design/construction (Section 411)
  - SMA (Section 419)

NECEPT 16

16

**Sections of  
Publication 408/2016**


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

NECEPT 17

17

**What You Need to Know  
about Specifications**

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



NECEPT 18

18



**See**  
**Publication 408**  
**to find details of specifications**

NECEPT 19

19

**Sections of Publication 408**  
**Containing Asphalt Specifications (2016, Chg. 7)**

106	Controls of Material Statistics
309	Superpave Asphalt Mixture Design, HMA Base Course (Standard)
311	Superpave WMA Design/Construction for Base Course
316	Flexible Base Replacement
320	Aggregate Bituminous Base Course

20

**Sections of Publication**  
**Containing Asphalt Specifications (2016, Chg. 7)**

322	Aggregate-Lime Pozzolan Base Course
341	Cold Recycled Bituminous Base Course (In-Pace)
342	Cold Recycled Bituminous Base Course (Central Plant)
344	Full Depth Reclamation
360	Asphalt Treated Permeable Base

21

**Sections of Publication**  
**Containing Asphalt Specifications (2016, Chg. 7)**

404	Evaluation and Payment of Bituminous Pavement Ride Quality Incentive
405	Evaluation of Bit. Pavement Longitudinal Joint Density, Payment of Incentive/Disincentive
409	Superpave Asphalt Mixture Design HMA Wearing Course, Standard, RPS
410	SP. Mix Design, Stand. and RPS Construction of Plant-Mixed HMA Fine Graded Courses
411	Superpave WMA Design/Construction

22

**Sections of Publication**  
**Containing Asphalt Specifications (2016, Chg. 7)**

412	6.3-mm thin asphalt overlays
419	SMA Design & RPS Construction of Wearing Course
420	Pervious Bituminous Pavement System
460	Bituminous Tack Coat
470	Bituminous Seal Coat
471	Bituminous Seal Coat using Precoated Aggregate
480	Bituminous Surface Treatment

NECEPT

23

**Sections of Publication**  
**Containing Asphalt Specifications (2016, Chg. 7)**

481	Bituminous Surface Treatment using Precoated Aggregate
482	Slurry Seal
483	Polymer-Modified Emulsified Asphalt Paving System (Micro Surfacing)
489	Ultra-Thin Bonded Wearing Course
496	Asphalt Concrete Pavement, 60-month Warranty

NECEPT

24

## Section 106: Control of Materials

NECEPT 25

25

## 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...

NECEPT 26

26

## 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)

NECEPT 27


27

NECEPT 28

28

## 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)



NECEPT 29

29

## 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

NECEPT 30

30

### 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, ...)

NECEPT 31

31

### 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)

NECEPT 32

32

### 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

NECEPT 33

33

### Calculate Average of Measurements

	4.2
• The average, or $\bar{X}$ ("x-bar"), for a lot is calculated by summing all values and dividing by the number of measurements (# of sublots)	4.9
	5.1
	6.3
	7.1
	27.6

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

NECEPT 34

34

### Production Variability

Assume Normal Distribution or Gaussian Distribution

Variability represented by standard deviation  $S$

5.5

50%      50%

Total Area Under Curve = 100%

NECEPT 35

35

### Normal Distribution Curve

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

NECEPT 36

36

### 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
- |                      |             |
|----------------------|-------------|
| $(4.2-5.5)^2 = 1.69$ |             |
| $(4.9-5.5)^2 = 0.36$ |             |
| $(5.1-5.5)^2 = 0.16$ |             |
| $(6.3-5.5)^2 = 0.64$ |             |
| $(7.1-5.5)^2 = 2.56$ |             |
|                      | <b>5.41</b> |



$$5.41 / (5-1) = 1.35$$

$$\sqrt{1.35} = 1.1630$$

NECEPT

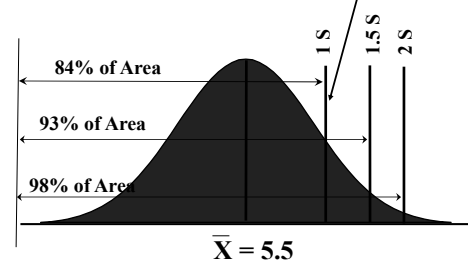
37

37

### Building Confidence Intervals

S = 1.1630

Moving One Std. Dev. From Avg.



NECEPT

38

38

### 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%**

NECEPT

39

39

### Calculation of Quality Index

**Upper quality index:**

$$Q_U = (U - \bar{X}) / s$$

$$= (6.1 - 5.5) / 1.1630$$

$$= 0.5159$$

**Lower quality index:**

$$Q_L = (\bar{X} - L) / s$$

$$= (5.5 - 5.3) / 1.1630$$

$$= 0.1720$$

NECEPT

40

40

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

NECEPT

41

41

### 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!

NECEPT

42

42

**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, ...

NECEPT 43

43

**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

NECEPT 44

44

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

**106.03 (b) 3: Certification**

Certificate of Compliance - Form CS-4171 (to certify material is in compliance with the Bulletin materials)

- Certification file (retain CS-4171 forms for no less than 3 years)
- Certification Documents
  - TR-465 – Daily Bituminous Certification (Supplied the next day)
  - Bill of Lading
  - Approved Job Mix Formula

NECEPT 45

45

**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 for Each Producer based on Producer’s ability to comply with the materials specifications

NECEPT 46

46

**106.03 (b) 3.e: Levels of Certification**

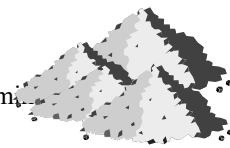
Level of Certification for Bulletin 15 Producers	Producer Material Shipment Procedure	Producer Additional Requirements
Level 1 Standard Certification	Ship on Certification with Form CS-4171*	None
Level 2 Standard Certification - Reduced	Ship on Certification with Form CS-4171*	See Section 106.03(b)3.e.2
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.	

NECEPT 47

47

**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



NECEPT 48

48

### **Section 309: Superpave Asphalt Mixture Design, HMA Base Course**

NECEPT

49

49

### **Section 309.1 Description**

- This work is the standard construction of plant mixed Hot-Mix Asphalt (HMA) base course on a prepared surface using a volumetric mixture design developed with the Superpave Gyrotory Compactor.

NECEPT

50

50

### **Section 309.3(a)7.a General Requirements**

- If 25.0 mm HMA 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 HMA base is specified at > 8” compacted, place in two or more ≈ equal lifts, none less than 4 inches or more than 8” compacted.

NECEPT

51

51

### **Section 360: Asphalt Treated Permeable Base Course**

NECEPT

52

52

### **Section 360.1 Description**

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

NECEPT

53

53

### **Section 360.2 Materials**

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

NECEPT

54

54

### 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.

NECEPT

55

55

### Section 360.2 Materials (continued)

#### e) Composition of Mixtures.

TABLE A

Passing Sieve	Percent Passing
37.5 mm (1 1/2")	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*

NECEPT

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

56

56

### Section 360.3 Construction

- a) Weather Limitations. Do not place if unstable, frozen or temperature of surface or air is < 35°F.
- b) Bituminous Mixing plant.
  1. Preparation of Mixture. Do not exceed 325°F
- c) Density Acceptance. Delete this section.

NECEPT

57

57

### 409–Superpave Asphalt Mixture Design HMA Wearing Course, Standard, RPS

- 409.1 Description
- 409.2 Materials
- 409.3 Construction
- 409.4 Measurement & Payment

*Where most changes have occurred in Specs.*

NECEPT

58

58

### Section 409.2: 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 HMA mixtures and smaller	± 0.7%	± 0.4%
25.0 mm HMA mixtures and larger	± 0.8%	± 0.5%

NECEPT

59

### Section 409.2: MATERIALS

TABLE A (Cont'd)

JMF – TEMPERATURE OF MIXTURE, °F

Class of Material	Type of Material	Minimum	Maximum
PG 58-28	Asphalt Cement	260	310
PG 64-22	Asphalt Cement	265	320
PG 76-22	Asphalt Cement	285	330
All other PG Binders	Asphalt Cement	As specified in Bulletin 25 (Specifications for Bit. Materials)	

NECEPT

60

**Section 409.2: Materials**  
**TABLE B**

JMF - VOLUMETRIC TOLERANCE REQUIREMENTS

Nominal Max Agg. Size (mm)	Each Specimen	Multiple Specimens
Air Voids at $N_{des}$ ( $V_a$ )	$\pm 2\%$	$\pm 1.5\%$
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 37.5 mm mixes	11.0	-

NECEPT

61

**Section 409.2(f).1: MATERIALS**  
**TABLE C**

MIXTURE ACCEPTANCE

Acceptance Level	Acceptance Method
Certification Acceptance	Producer Certification of Mixture Section 409.2 (f) 2
Lot Acceptance	Mixture Acceptance Sample Testing Section 409.3(h) 2

NECEPT

62

**Section 409.3: 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

NECEPT

63

**Section 409.4: Measurement & Payment**

- **TABLE H - Mixture Acceptance by Certification**
- **Asphalt Content**

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

64

64

**Section 409.4: Measurement & Payment**

- **TABLE H - Mixture Acceptance by Certification**
- **Gradation**

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

65

65

**Section 409.4: Measurement & Payment**

- **Mixture Acceptance by Lots**

**TABLE I**

– **Asphalt Content**

- Single and Multiple Samples as per Table A PF = 100
- If any Single out or Lot Average out for Multiple Samples then Table K

– **Gradation (No. 200)**

- Single and Multiple Samples as per Table A PF = 100
- If any Single out or Lot Average out for Multiple Samples then Table K

66

66



**Section 409.4: Measurement & Payment**

- **Mixture Acceptance by Lots**

**TABLE I**

- **Density**
- Non- Movement or Optimum Rolling Pattern PF = 100
- RPS Wearing and Binder Courses
  - See Table I
- Standard Wearing and Binder Courses
  - See Table I
- 25 mm and 37.5 mm Base Courses
  - See Table I

67

67

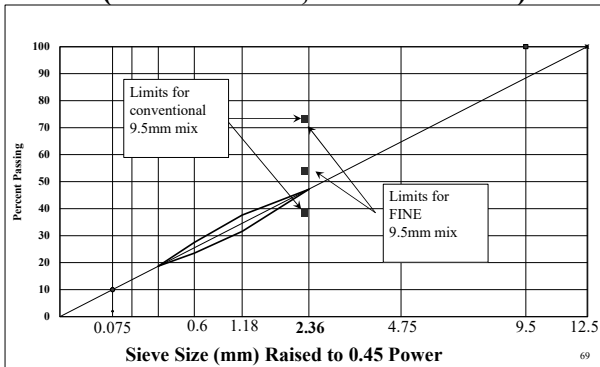
**Section 409.4: Measurement & Payment**

- **TABLE J**
  - **Upper & Lower Limits for Calculating PWL**
- **TABLE K**
  - **Payment Factor Based on PWL**

68

68

**Section 410: 9.5 mm Fine Graded Mixes  
(Pub 408/2011, Initial Edition)**



69

69

**Section 410: 9.5 mm Fine Graded Mixes**

Mixture	Minimum Depth
9.5 mm Fine Grade Wearing Course	30 mm (1 in.)

Compare with typical 9.5 mm mix at 1.5 inches of depth  
(See Table G in Section 409)

70

70

N  
E  
C  
E  
P  
T



**PennState**

Thank You!



**pennsylvania**  
DEPARTMENT OF TRANSPORTATION

71

71

# Plant Technician Certification Program

## Module 9

### Pennsylvania/AASHTO Test Methods



**Plant Technician  
Certification Program**

**Module 9**

**Pennsylvania/AASHTO Test Methods**



NECEPT

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 Max. Sp. Gr.

7

7

### AASHTO Test Methods and Practices

- AASHTO R 30-02 (2015)
  - 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 312-15
  - Standard Method of Test for Preparing and Determining the Density of HMA Specimens by Means of the SGC
- AASHTO T 283-14
  - Standard Method of Test for Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage

NECEPT

8

8

### PA Test Method No. 1:

### Method of Test for PROBABILITY SAMPLING

9

### Summary

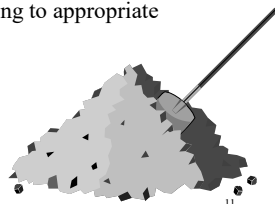
- Selecting sampling sites using probability methods
- Proper sampling is essential to good QC/QA
- Sample divided into lots and sublots
- Sample location determined by values in random number table

10

10

### 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



11

### 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, subplot size, and number of sublots per lot specified by *PTM*

12

12

### 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
.	.	.
.	.	.

13

13

### 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 subplot
- For roadway sampling, values in X and Y columns give coordinates of sample
- Otherwise, use only values in X column, as stated in PTM

14

14

AAHSTO T 40 – 02 (2012)

### Method of Test for SAMPLING BITUMINOUS MATERIALS

15

### 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

17

17

### 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

16

16

### Sample Handling

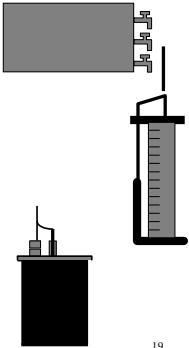
- Use only clean, new containers
- Tightly seal immediately after sampling
- Do not clean container after filling with excessive amounts of solvent
- Keep emulsion samples from freezing in cold weather
- Clearly mark all samples for identification, on the body container and not on the lid

18

18

### 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

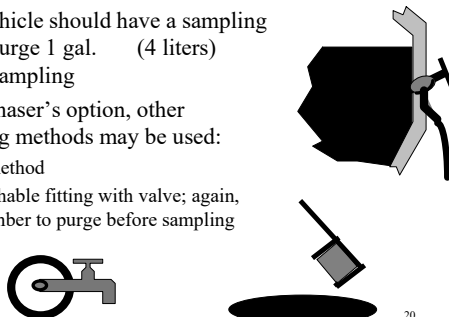


19

19

### 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



20

20

### 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

21

21

### 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

22

22

### 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

23

23

### 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



24

24

**PA Test Method No. 746**

**Method of Test for  
SAMPLING BITUMINOUS  
PAVING MIXTURES**

25

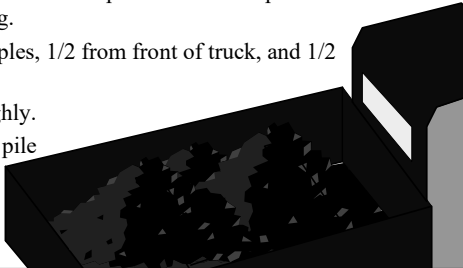
**Purpose of PTM 746**

- 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

26

**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



27

**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)

28

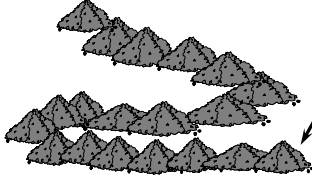
**Selecting Random Samples at Plant  
(QC Samples, based on Tonnage)**

- 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.

29

**Selecting Random Samples  
(QC Samples, based on Tonnage)**

**500 Tons = One Sublot**  
 $500 \times 0.74 = 370$  Tons  
 $370/20 = 18.5$ , so we do #19



**Each Load = 20 Ton Loads**

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

30

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

□ Example 1:

- Plant scheduled to ship 400 tons
- Sampling subplot (lot): 400 tons

Random Number	Sampling Tonnage	
	subplot	lot
0.59	$0.59 \times 400 = 236$	236

31

### 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	$0.71 \times 1,000 = 710$	710
0.26	$0.26 \times 1,000 = 260$	$1000 + 260 = 1260$
0.63	$0.63 \times 1,000 = 630$	$2000 + 630 = 2630$

32

### 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	$0.61 \times 500 = 305$	305
0.87	$0.87 \times 1000 = 870$	$500 + 870 = 1370$
0.34	$0.34 \times 300 = 102$	$1500 + 102 = 1602$

NECEPT 33

### 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 test per 1000 tons thereafter.
- Sampling sublots: 500, 1000, 1000, 1000, and 500

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

NECEPT 34

### 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.

35

### Selecting Random Samples (QA Samples, based on Time)

Conducted by Department's Representative

	X
1	0.27
2	0.39
3	0.57

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
$0.27 \times 120 \text{ min.} = 32 \text{ min.}$		8:32 am
$0.39 \times 120 \text{ min.} = 47 \text{ min.}$		10:47 am
$0.57 \times 120 \text{ min.} = 68 \text{ min.}$		1:08 pm

36



## 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

37

37

## Sampling on the Roadway

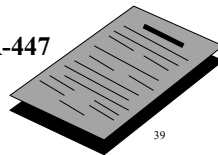
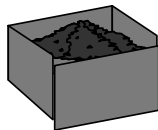
### Quality Assurance Sampling

- 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

38

## 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 19mm and smaller NMAS mixtures
- Box dimensions of 5 x 5 1/2 x 9 in. work well for 25mm and larger NMAS mixtures
- Identify all samples with **Form TR-447**



39

39

## 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.

40

40

## Asphalt Content Determination:

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

41

## Why determine asphalt content?

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

42

42

### Methods for Determining Asphalt Content

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

43

43

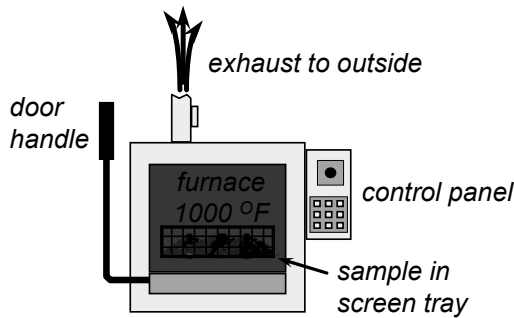
### PTM 757: Asphalt Content by Ignition Oven

- 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

44

44

### Binder Ignition System Schematic



45

45

### Asphalt Content by the Ignition Method

- Two oven types / methods
  - oven with built-in balance (method A)
  - oven without balance (method B)
- AASHTO Equivalent: T308-05
  - (notice differences)
- Must calibrate aggregate for loss during ignition

46

46

### Sample Size - Table 1 (PTM 757)

Bituminous Mixtures	Minimum Mass of Specimen, g
SP 9.5, SP 12.5, FJ'S, ID2W, ID2WHD, FB1W, FB2W, FB2W, Ralumac, Nova Chip, All Cold Mixes	1200 g
SP 19, ID3W, ID2B, ATPBC, FB1B, FB2B, FBMod, SMA	1500 g
SP 25, SP 37.5, BCBC, ID2BHD	2000 g

**Max. Mass < Min. Mass + 200 grams**

47

47

### 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

48

48

### 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

49

49

### 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

NECEPT

50

50

### 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

NECEPT

51

51

### Ignition Test Calibration Factors

- As part of JMF, Producer is to provide correction factors for
  - Percent asphalt content ( $C_f$ )
  - Percent passing the 75  $\mu\text{m}$  (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.

NECEPT

52

52

### Some Other 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

NECEPT

53

53

N  
E  
C  
E  
P  
T



**PennState**

Thank You!



**pennsylvania**  
DEPARTMENT OF TRANSPORTATION

54

**N  
E  
C  
E  
P  
T**

# **Plant Technician Certification Program**


## **Module 10**

### **PennDOT Bulletin 27**



**Plant Technician  
Certification Program**

**Module 10  
PennDOT Bulletin 27**



**NECEPT**

1

**PennDOT Bulletin 27**

**Bituminous Concrete Mixtures,  
Design Procedures, and Specifications  
For Special Bituminous Mixtures**

2

**Bulletin 27**

- Chapter 1 – Specs for HMA 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)

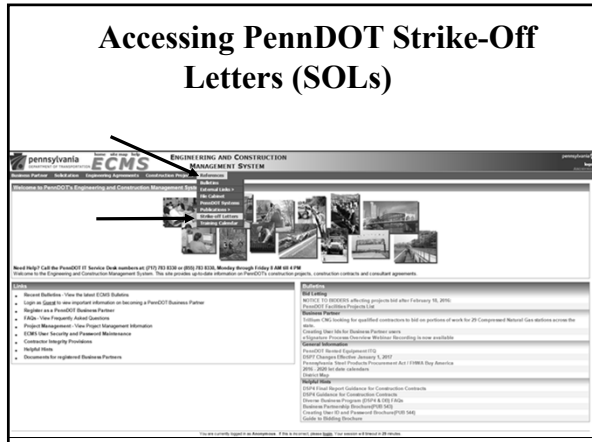
5

**Accessing PennDOT Strike-Off  
Letters (SOLs)**

- ECMS - <http://www.dot14.state.pa.us/ECMS/>



6



7

**Chapter 1**  
**SGC Calibration & Verification**

- Internal angle calibrated according to ASTM D7115
- Set to  $1.16 \pm 0.03$  degrees
- Recalibrate at least every two years or as directed.
- Specimen molds satisfy AASHTO T312
- ASTM D7115:  
Standard Test Method for Measurement of Superpave Gyratory Compactor (SGC) Internal Angel of Gyration Using Simulated Loading

8

**Chapter 1**  
**Superpave Gyratory Compactor Specific Gravities**

- Difference in Gmb from two SGC's must be  $\leq 0.03$  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

9

**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

10

**Chapter 1**  
**Plant Tolerances**

- Calibration of Drum Plants at the Beginning of the Paving Season
- Additional Calibration of Drum Plants if 3 consecutive QC tests outside limits
- Calibration of Asphalt Meter every 4 months
- Calibration of Agg. Belt Scale Bi-Weekly

11

**Chapter 1**  
**Plant Automation and Recordation/ Use of Printed Ticket**

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

12

### Chapter 2A Superpave Asphalt Mix Design

- AASHTO R 30-02 (2015)
  - Standard Practice for Mixture conditioning of HMA
- AASHTO R 35-15
  - Standard Practice for Superpave Volumetric Design for HMA
- AASHTO M 323-13
  - Standard Specification for Superpave Volumetric Design for HMA
- AASHTO T 312-15
  - Standard Method of Test for Preparing and Determining the Density of HMA Specimens by Means of the SGC
- AASHTO T 283-14
  - Standard Method of Test for Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage

13

### Chapter 2A Aggregate Gradation Control Points (Compare with AASHTO M 323)

Sieve Size	Nominal Maximum Aggregate Size-Control Points									
	37.5mm		25.0 mm		19.0 mm		12.5 mm		9.5 mm	
	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

14

### 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)

15

### Chapter 2A Materials Selection

- **Aggregates**
  - **Understanding Aggregate Requirements**
  - **Ability to perform the tests (M323-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)

16

### 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.

17

### Chapter 2A Design Binder content. (cont.)

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

18

## 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  $\leq 2\%$  at  $N_{max}$ , the pavement may be susceptible to rutting. The aggregate gradation may need to be adjusted.

19

## 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.
- 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.

20

## 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 Gyrations Levels of ESALs  $\geq 30$  Million
- Mix Conditioning Procedure for Design
- Moisture Damage Issues/Criteria

21

## 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.

22

## Chapter 2A – R 35 Modification

### Section 8: Compacting Specimens of Each Trial Gradation

- SGC Compaction Effort for
  - For Design ESAL  $> 30$  Million,  $N_{des} = 100$
  - Supported by forensic investigation & APQITF
  - Revision in Bulletin 27 required no revisions to Pub. 242 or item numbers – still specify  $> 30$  Million ESALs

23

## Chapter 2A – R 35 Modification

### Section 10: Selecting the Design Binder Content

- Mixture Conditioning must be conducted according to Bulletin 27 - Appendix I
- Evaluate Aggregate Breakdown due to Compaction
  - (Check gradation after compaction against Table A of Spec 408, Section 409)

24



### 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

25

### 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**

26

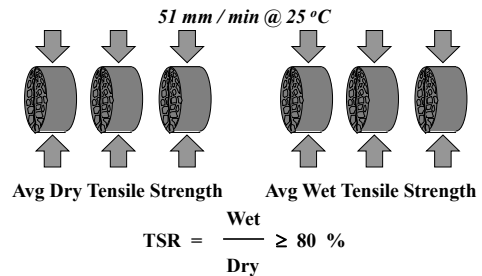
### Vacuum Application to Induce Partial Saturation

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

27

### AASHTO T 283

#### Evaluating Moisture Sensitivity



28

### Chapter 2A – R35

#### Section 11: Evaluating Moisture Sensitivity

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

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

29

### 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

30

**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

31

**Chapter 2A**

**Superpave Volumetric Mix Design (AASHTO M 323)**

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

32

**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 M323
- Evaluate Voids for conformance to PENNDOT's Specs
- If not met, Perform Additional Tests
- Report to DME before further work

33

**Chapter 2A – M 323 Modifications**

- Table 5 – Change in Aggregate Consensus Properties
- Supported by APQITF

		Fractured Faces, Coarse Aggregate Percent Minimum Depth from Surface	
		$\leq 100$ mm	$> 100$ mm
From	$>30$	100/100	100/100
To:	$>30$	95/90	95/90

34

**Chapter 2A – M 323 Modifications**

Table 6 – Superpave HMA Design Requirement

Design ESALs (Millions)	VMA Percent Minimum Nominal Maximum Aggregate Size						VFA Range % <sup>b</sup>
	37.5	25.0	19.0	12.5	9.5	4.75	
$<0.3$	11.5	12.5	13.5	14.5	15.5	16.0	70-78
0.3 to $<3$	11.5	12.5	13.5	14.5	15.5	16.0	65-78
3 to $<10$	11.5	12.5	13.5	14.5	15.5	16.0	65-75 <sup>e</sup>
10 to $<30$	11.5	12.5	13.5	14.5	15.5	16.0	65-75 <sup>e</sup>
$\geq 30$	11.5	12.5	13.5	14.5	15.5	16.0	65-75 <sup>e</sup>

35

**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

36

### 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

37

### 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 M325

AASHTO R 46: Std. Practice for Designing SMA

AASHTO M 325: Std. Specification for Designing SMA

38

### Chapter 4 - Glossary

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

39

### 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

40

### 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

41

### 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

42

### 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

43

### 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

44

### Appendix I – Mixture Conditioning

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

45

### Appendix I Maximum Specific Gravity

- Covers QC testing requirements for production
- Uses AASHTO T209 method

46

### 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  $\geq 1.5\%$ : Six Hours in Oven

47

### Appendix I Maximum Specific Gravity [Cont.]

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

48

**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  $G_{sb}$ ?*

49

**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

$$C_{fg} = (G_{se} - G_{sb})$$

Establish Offset (C<sub>fg</sub>)

$$G_{sb} \approx G_{se} - C_{fg}$$

During Production

50

**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.

51

**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.

52

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

53

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

54

**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”

55

**SOL# 481-16-04 – Appendix K  
(New)**

- Asphalt Concrete Gyratory Mix Design Naming System
  - Intended for JMF/Mix Design Number field in eCAMMS
  - Up to 10 characters
  - e.g., W95221G1

W = Type WMA  
 95 = Size 9.5 mm  
 2 = ESALS 0.3 to <3 (75 Ndes)  
 2 = Asphalt Binder PG 64-22  
 1 = RAP/RAS Tier 1  
 G = SRL-G  
 1 = Version

56

**SOL# 481-16-04 – Appendix K  
(New)**

- Asphalt Concrete Non-Gyratory Mix Design Naming System
  - Intended for JMF/Mix Design Number field in eCAMMS
  - Up to 10 characters
  - e.g., FJ12L1 \*

FJ1 = Class FJ-1  
 2 = Asphalt Material PG 64-22  
 L = SRL-L  
 1 = Version 1

57

**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

58

**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

59

**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

60

**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

61

**SOL# 481-16-06 – Chapter 2A  
Revisions**

- AASHTO R 35, Section 4.4 (Page 2A-7)
  - 1<sup>st</sup> 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)

62

**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

63

**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)

64

**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

65

**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

66

**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.

67

**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

68

**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

69

**SOL# 481-16-06 – Chapter 2B  
Revisions**

- Bulletin 27, Chapter 2B, Modifications to AASHTO R 46, Section 4. Summary of the Practice
  - Revisions (New) to Subsection 4.4 *Evaluating Moisture Susceptibility* (Page 2B-2)
    - 1st paragraph – AASHTO T 283 mixture conditioning according to Bulletin 27, Appendix I
      - i.e., 2 hours or 6 hours at 153°C (308°F)

70

**SOL# 481-16-06 – Chapter 2B  
Revisions**

- Bulletin 27, Chapter 2B, Modifications to AASHTO R 46, Section 4. Summary of the Practice
  - Revisions (New) to Subsection 4.4 *Evaluating Moisture Susceptibility* (Page 2B-2)
    - 1st paragraph – AASHTO T 283 mixture conditioning according to Bulletin 27, Appendix I
      - i.e., 2 hours or 6 hours at 153°C (308°F)
    - **DO NOT DO!**

71

**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

72



**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)

73

**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

74

**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

75

**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

76

**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

77

**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

78

**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.

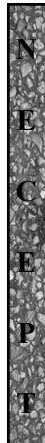
79

**Contacts**

- **Direct Questions and Comments to the Bituminous Testing Section:**


**Timothy L. Ramirez, P.E.**  
Engineer of Tests  
PA Department of Transportation  
Innovation and Support Services Division  
Laboratory Testing Section  
81 Lab Lane, Harrisburg PA 17110-2543  
Phone: 717-783-6602  
**tramirez@pa.gov**

80



**PennState**

**Thank You!**



**pennsylvania**  
DEPARTMENT OF TRANSPORTATION

81

# Plant Technician Certification Program

## Module 11 Plant Quality Control



N  
E  
C  
E  
P  
T

## Plant Technician Certification Program

### Module 11 Plant Quality Control



1


### Plant Quality/Process Control

- HMA/WMA producers must submit a quality control plan to DME annually
- According to Sections 401 and 409, contractor must submit two QC plans at the start of each project
  - material QC plan
  - paving operations QC plan
- Should also consider general good practice, and quality assurance checklists
- Specific requirements given in Sections 106, 401, 409, and 411 of Pub 408, and in Project Office Manual

2

### General Approach in Developing QC Plan

- Specific requirements for QC plans are somewhat different according to these documents
- 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



3

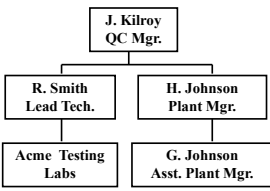
### Requirements of a “Complete” QC Plan

Component	Required by
QC Organization Chart	Contractor Material QC Plan
Testing Plan	Plant QC Plan
Equipment Cal./Ver. Procedures	Plant QC Plan / QA Checklist
Materials Storage & Handling Plan	Contractor Material QC Plan
Documentation	QA Checklist

4

### QC Organization Chart

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



5

### 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

6

### Quality Control Testing

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

7

7

### Normal Minimum Frequency of Testing

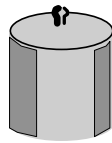
Test	PTM/AASHTO	Frequency
Aggregate stockpile gradations	T 27-14	weekly
Hot bin gradations	PTM 743	weekly
Extraction / gradation or hot-bin gradation	PTMs 702, 739/743	daily

8

8

### Density and Voids Analysis

- Perform one maximum theoretical specific gravity (AASHTO T209). If value varies more than (0.030) from JMF value run at least 3 tests the first day.
- Starting 2<sup>nd</sup> 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 normally performed three times per day, on all QC samples



9

9

### Mix Temperature

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

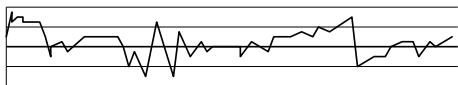


10

10

### Control Charts

- Running average of five samples for bitumen content and aggregate gradation
- Gradation determined from extracted aggregate (PTM 757) or hot-bin samples (PTM 743)

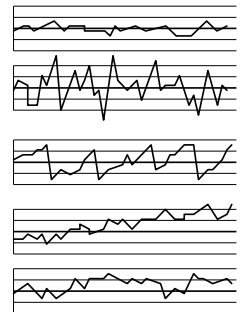


11

11

### Using Control Charts

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



12

12

### Minimum Action Limits: From 401 /409 (Standard) Job-Mix Tolerances

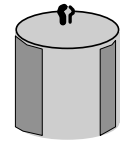
- Must be at least at job-mix tolerances specified in Section 401/409[standard] (for average of 3 to 7 samples):
  - passing 4.75 mm sieve and larger:  $\pm 6\%$
  - passing 2.36 mm to 150  $\mu\text{m}$  sieves:  $\pm 4\%$
  - passing 75  $\mu\text{m}$  sieve:  $\pm 2\%$
  - bitumen, 19.0 mm and smaller:  $\pm 0.4\%$
  - bitumen, 25.0mm and larger:  $\pm 0.5\%$
- Different tolerances for single samples

13

13

### 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 (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 %



14

14

### Action Required When Mix is Outside 401/409 Spec. 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

15

15

### For best control of plant process...

- Action limits should be set inside 401/409 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

16

16

### Comparison of Test Data

- As part of quality control plan, MTD QA/DQA 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



17

17

### 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

18

### Equipment Calibration/Verification

- Your quality control plan must also include written calibration/verification procedures when these are performed in-house

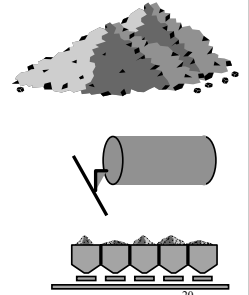


19

19

### 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



20

20

### 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

21

21

### 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!



22

NECEPT

**Thank You!**

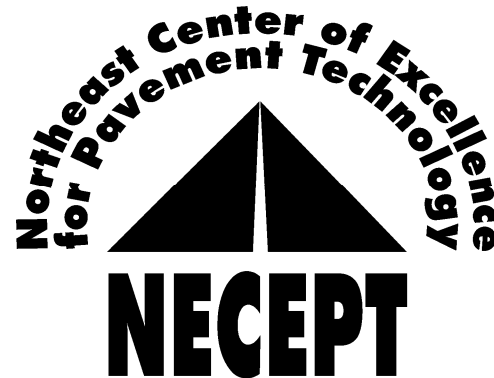
23

23

# Plant Technician Certification Program

## Module 12

### How an Asphalt Plant Works






**N  
E  
C  
E  
P  
T**

**Plant Technician  
Certification Program**

**Module 12**

**How an Asphalt Plant Works**



1



2

N  
E  
C  
E  
P  
T



# Plant Technician Certification Program


## Module 13

### Segregation in Asphalt Concrete



**Plant Technician  
Certification Program**

**Module 13  
Segregation in Asphalt Concrete**



PENNSYLVANIA STATE UNIVERSITY


1

**Module 7 - Objectives**


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

2

**What Is Segregation?**



3




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

4

**What Is the Effect of Segregation on Pavement?**

- **Premature Distress**
  - Raveling
  - Frost Damage
  - Potholes



5

**Why Do Premature Failures Occur Due To Segregation?**

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



6

## Sources Of Segregation

7

### Sources Of Segregation

<ul style="list-style-type: none"><li>• Stockpiling</li><li>• Plant Operation<ul style="list-style-type: none"><li>– Cold Feed Bins</li><li>– Hot Bins on Batch Plant</li><li>– Drum Mixer</li><li>– Surge &amp; Storage Bins</li></ul></li><li>• Truck Loading</li></ul> <p>↓</p> <p><b>Plant Technicians Responsibility</b></p>	<ul style="list-style-type: none"><li>• Truck Unloading</li><li>• Paver<ul style="list-style-type: none"><li>– Hopper</li><li>– Slat Conveyer</li><li>– Hopper gates</li><li>– Auger</li><li>– Screed</li></ul></li></ul> <p>↓</p> <p><b>Field Technicians Responsibility</b></p>
---	---

8

### How Does It Happen?

#### Stockpiling

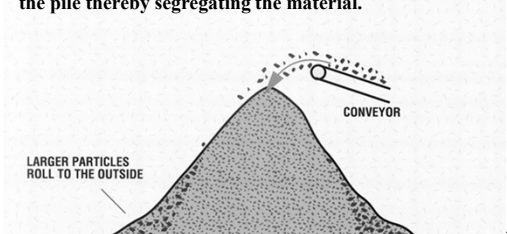
- Large Stockpiles
- Single Aggregate Blends

9

### How Does It Happen?

#### In Stock Piling

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




10

### 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.



11

### How Is It Prevented?

#### Stockpiling

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

12

### How Is It Prevented?

#### Limit Stockpile Height & Separate Sizes

**Stockpiling**

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.....

DUMP AGGREGATES IN PILES NOT LARGER THAN A TRUCKLOAD

MAKE PILES SO THEY STAY IN PLACE AND DO NOT ROLL DOWN SLOPES

13

### How Is It Prevented?

#### Build stockpiles in layers

**Stockpiling**

BUILD PROGRESSIVE HORIZONTAL LAYERS

BULLDOZER WITH CONVEYOR

BUILD PROGRESSIVE LAYERS ON SLOPE

NOT GREATER THAN 3:1 SLOPE

DO NOT DUMP DOWN SLOPE

BULLDOZER WITH TRUCK

14

### How Does It Happen?

#### In Feeding Cold Feed Bins

- Bridging

TOP VIEW RECTANGULAR OPENING

EFFECTIVE FEED AREA

DEAD AREA CAUSED BY BRIDGING

CLAM GATE

15

### How Is It Prevented?

#### In Feeding Cold Feed Bins

- Reconfigure Opening

TOP VIEW SELF-RELIEVING OPENING

EFFECTIVE FEED AREA

CLAM GATE

16

### How Does It Happen?

#### In Feeding Hot Bins on a Batch Plant

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

SCREENS

COARSE MATERIAL

DUST SLIDES DOWN SIDE OF BIN

FINE MATERIAL

HOT BIN

BATCH TOWER

17

### How Is It Prevented?

#### In Feeding Hot Bins on a Batch Plant

- Install Baffle

SCREENS

BAFFLE MINIMIZES SEGREGATION

HOT BIN

BATCH TOWER

18

### 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

19

### 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)

20

### How Does It Happen?

**In a Drum Mixer**

Gravity Discharge

21

### How Is It Prevented?

- Smaller Opening
- Deflector Plates
- Install a Plow
- Discharge at 90-degree angle

22

### How Does It Happen?

**Filling Surge and Storage Bins**

- Drag Conveyor
- Rotating Chute
- Bin Loading Batchers

23

### How Does It Happen?

**Drag Conveyors**


- Hydroplaning
- Partially Full

24

### How Is It Prevented?

**Drag Conveyors**  
Equipped with

- Floating hold downs
- Heated bottoms
- Full slats

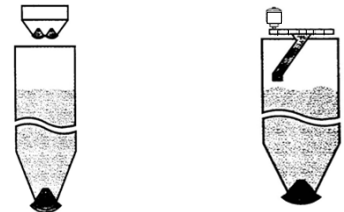


25

### How Does It Happen?

**Loading Bin**

- Batcher
- Rotating Chute

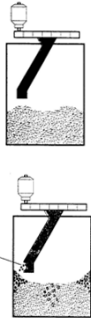


26

### How Is It Prevented?

**Rotating Chute**

- Must Rotate
- Not worn

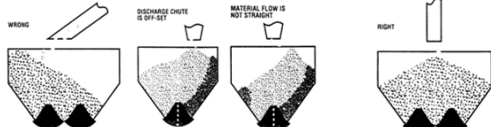


27

### How Is It Prevented?

**Batcher**

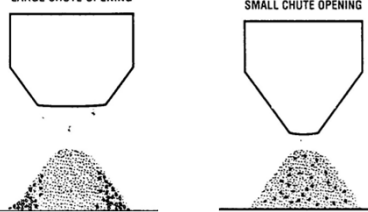
- Loaded in Center
- Filled to Capacity



28

### How Is It Prevented?

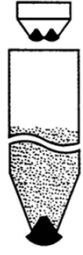
**Batcher**



29

### How Does It Happen?

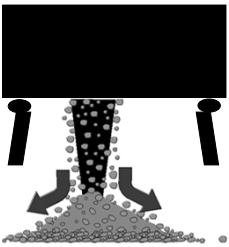
**In Loading from a Surge or Storage Bins**



30

### How Is It Prevented?

**Rapid Discharge**



31

31

### How Is It Prevented?

**Batcher Rules**

1. Batch size should be at least 5000 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.

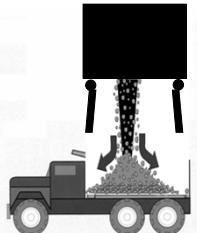
32

32

### How Does It Happen?

**In Loading the Truck**

- Dribbling the material



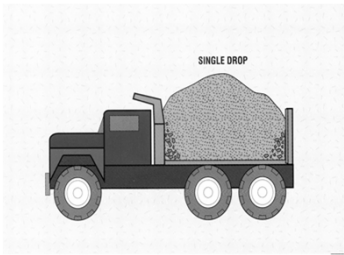
33

33

### How Does It Happen?

**In Loading the Truck**

- Single Drop



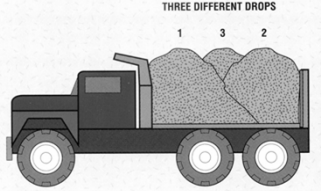
34

34

### How Is It Prevented?

**In Loading the Truck**

- Three Drops



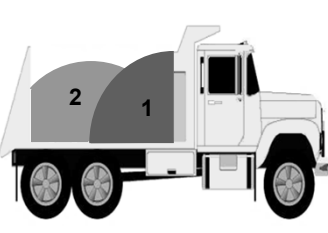
35

35

### How Is It Prevented?

**In Loading the Truck**

- Two Drops




36

36



### Segregation Trouble Shooting




- What is Wrong?

37

37

### Segregation Source And Cause



- Nothing!
- This is one beautiful mat.

38

38

### Module 6 – Review Objectives

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

39

39



## Thank You!



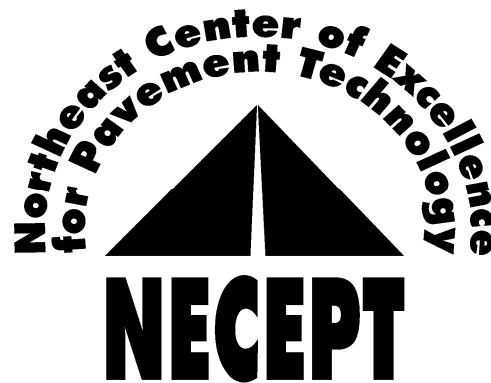
40

40

# **Plant Technician Certification Program**

## **Module 14**

### **SMA Design & Specifications**



**Plant Technician  
Certification Program**

**Module 14**

**SMA Design & Specifications**



1

1

**Outline**

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

2

2

**Background on SMA**

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

3

3

**Background on SMA**

- Used in USA in 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

4

4

**SMA Design Considerations**

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

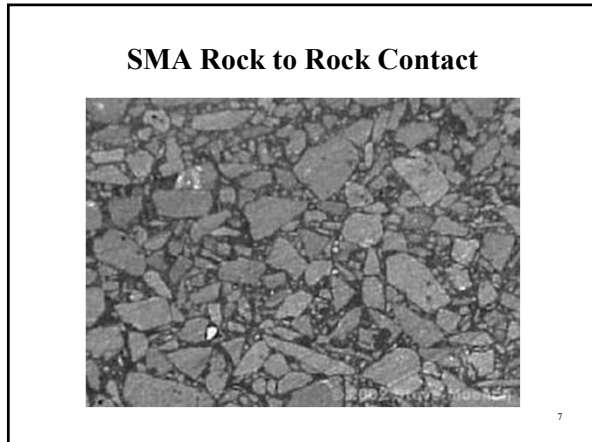
5

5

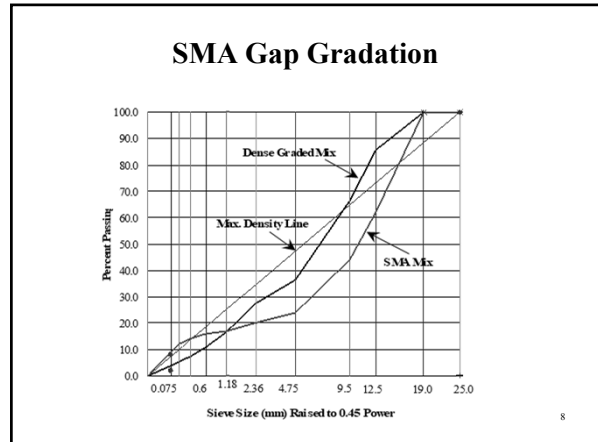
- SMA Design Considerations

6

6



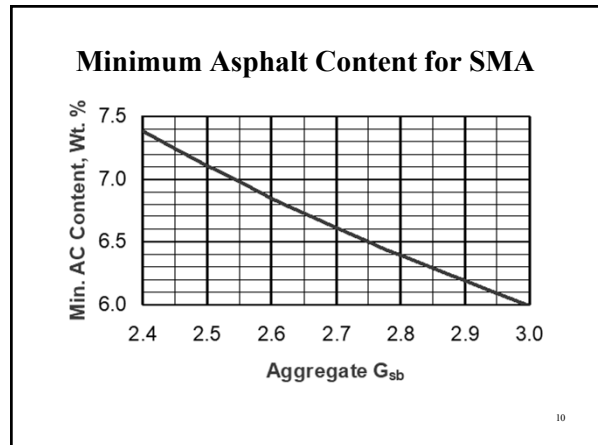
7



8

- ### 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**

9



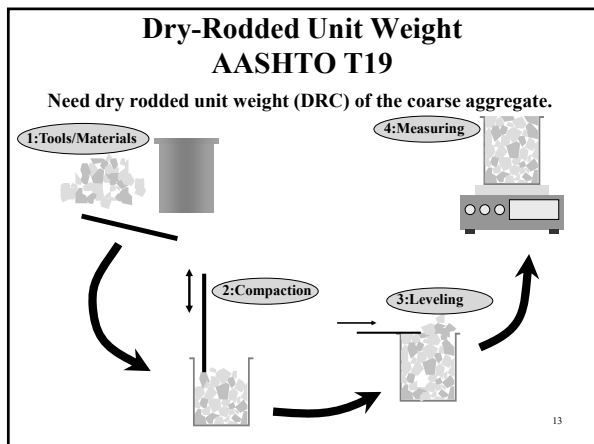
10

- ### 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):
- $$VCA_{mix} < VCA_{DRC}$$

11

- ### What is Coarse Aggregate Fraction?
- 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).
- | 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)      |

12



13

### Dry-Rodded Unit Weight Calculations

- Dry-rodded unit weight,  $\gamma_s$ , kg/m<sup>3</sup> =

$$\frac{\text{Mass of stone in bucket, kg}}{\text{Volume of bucket, m}^3}$$

14

14

### Voids in Coarse Aggregate Calculations

- Dry-rodded voids in coarse aggregate

$$VCA_{DRC} = \frac{G_{CA}\gamma_W - \gamma_S}{G_{CA}\gamma_W} \times 100 \%$$

$G_{CA}$  = coarse aggregate bulk Sp. Gr.  
 $\gamma_W$  = unit weight of water  
 (about 1,000 kg/m<sup>3</sup>)

15

15

### Calculation of $VCA_{MIX}$

- Voids in coarse aggregate in compacted mixture:

$$VCA_{MIX} = 100 \% - (G_{mb}/G_{CA}) P_{CA}$$

$G_{mb}$  = Bulk Sp. Gr. compacted mix  
 $P_{CA}$  = percentage of coarse aggregate in mix

16


16

### Check VCA

- Proper coarse aggregate structure 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

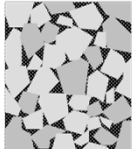


17

17

### 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:

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


18

18

### 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.

19

19

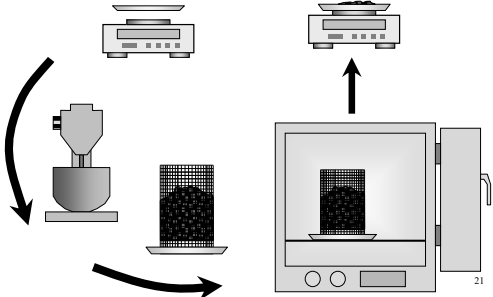
### Draindown Test

- Procedure given in *AASHTO T305*
- 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**

20

20

### Draindown Test: AASHTO T305 *Done at Expected Plant Temperature*



21

21

### What if Draindown is High?

- Increase fiber content
- Decrease mixing temperature
- Change fiber type
- Increase amount of filler
- Increase fine aggregate

22

22

### 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 fibers
  - Draindown test

23

23

- SPECIFICATIONS
  - AASHTO M 325
  - PennDOT 408/ Section 419

24

24

### SMA Related Spec & Practice

- AASHTO M325-08, Standard Specification for Designing Stone Matrix Asphalt (SMA)
- AASHTO R46, Standard Practice for Designing Stone Matrix Asphalt (SMA)
- AASHTO T305-97, Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures

25

### Pennsylvania’s SMA Spec

- VMA 18% minimum
- Design air voids 3.5 to 4.0%
- PG 76-22 only
- 9.5mm and 12.5mm NMAS
- $N_{design} = 100$  gyrations
- 0.2 to 0.4% cellulose fibers by total mix wt.
- 0.3 to 0.4% mineral fibers by total mix wt.
- Crumb Rubber: 0.3 to 1 % by total mix wt.
- Draindown: 0.3% maximum

26

### Pennsylvania’s SMA Spec

#### Coarse Aggregate Quality Requirements

Characteristic		Required Values
Abrasion, 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

27

### Fine Aggregate Requirements

- FAA requirement: 100% crushed materials
- Sand equivalent, 45% minimum— same as most Superpave wearing course mixtures
- Sodium sulfate loss 15% maximum after 5 cycles

28

### Aggregate Size and PG Grade

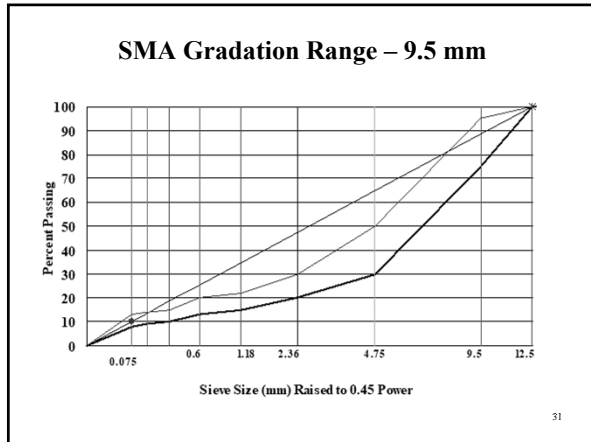
- Aggregate NMAS
  - For lift thickness of 1-1/2”, use 9.5-mm
  - For lift thickness > 1-1/2”, use 12.5-mm
- Binder grade: PG 76-22

29

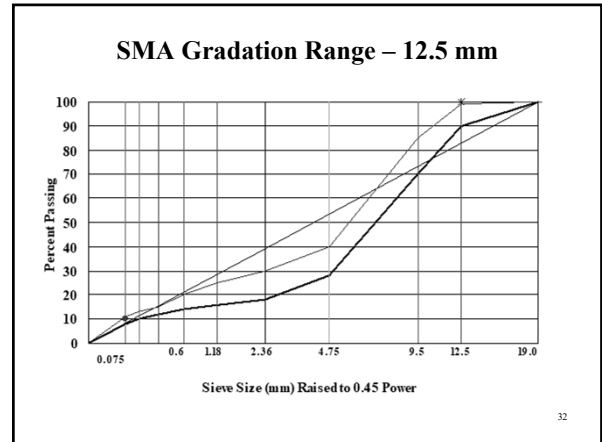
### Minimum Binder Content

Aggregate $G_s$	Minimum Binder Content
2.40	7.4%
2.50	7.1%
2.60	6.8%
2.70	6.6%
2.80	6.4%
2.90	6.2%

30



31



32

### Crumb Rubber (CR) Gradation

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

33



33

- ### 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
    - Satisfy requirements
  - Typically less expensive than mineral fiber
- 34

34

- ### Mineral Fibers for SMA
- Mesh screen analysis
    - 85 to 95% passing 250  $\mu\text{m}$  (No. 60)
    - 60 to 80% passing 63  $\mu\text{m}$  (No. 230)
  - Mainly silicate rock
- 35

35

- ### Weather Limitations
- 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  $^{\circ}\text{C}$  (50F) or lower
- 
  

- 36

36



### SMA Quality Control

- Similar to Superpave
- QC plan as required for Superpave
- Production tolerances for gradation, asphalt, voids and VMA
- Mix temperature: 285 to 330°F

37

### Quality Control Tolerances

Property	Single Sample (n = 1)	Multiple Sample (n ≥ 3)
<i>Aggregate gradation</i>	<i>Mix or hot-bin</i>	<i>Mix only</i>
Passing 9.5 mm	± 5%	± 4%
Passing 4.75 mm	± 4%	± 3%
Passing 75 µm	± 3.0%	± 2.0%
<i>Asphalt Content</i>		
Bitumen	± 0.7%	± 0.4%

38

### Quality Control Tolerances

Property	Design Value	Single Specimen (n = 1)	Multiple Specimens (n ≥ 2)
Air voids at N <sub>design</sub>	3.5 to 4.0%	± 2.0%	± 1.5%
VMA	≥ 18.0%	≥ 17.0%	---

39

### Payment

- RPS specification—similar to Superpave (Section 409)
- Payment based on testing cores
  - Asphalt content
  - Mineral filler content
  - Mat density
- Full payment or PWL
- 2,500 ton lots with 5 sublots

40

### Limits for 100 % Payment based on deviation from JMF

Property	Single Sample (n = 1)	Multiple Sample (n ≥ 3)
Asphalt content	± 0.7%	± 0.4%
Passing 75 µm	+ 4.0% - 2.0%	+ 3.0% - 1.5%

*Mat Density: all individual results for the lot must be ≥ 93% and ≤ 98% for 100% Pay*

41

### Limits for Calculating Percent Within Tolerance

Property	Lower Limit	Upper Limit
Asphalt content	- 0.4%	+ 0.4%
Passing 75 µm	- 1.5%	+ 3.0%
Mat density*	92%	98.0%

\* As percent of theoretical max. density

42

▪ Construction

43

43

**Materials Handling:  
Aggregates**

- Coarse aggregate is 72 to 80 % of blend
- Handling of coarse aggregate is very important!
- May need to feed a single aggregate through more than one cold feed bin

44

44

**Materials Handling:  
Mineral Filler**

- SMA usually about 10 % mineral filler
- Typically must add extra 5 % filler
- Addition of extra filler must be consistent and accurate

45

45

**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”

46

46

**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

47

47

**Materials Handling:  
Mixture Production**

- Similar to conventional hot-mix
- Make sure filler delivery and fines recovery systems are working properly
- Mix temperature of 285 to 330°F
- For batch plants, increase dry and wet mix times 5 to 15 seconds each
- Don't store SMA for too long

48

48

### Transport

- SMA is “sticky”
- Use approved release agent
- Clean truck beds often
- Don’t use fuel oil!
- Mix temperature:
  - 285°F (140°C) to 330°F (165°C)

49

49

### Placement

- Similar to placement methods used for conventional mix, but greater care needed
- Keep paving train moving smoothly
  - Speed dictated by compaction
  - MTV recommended
- Minimize handwork
- Keep lift thickness at about 1-1/2”

50

50

### Compaction

- More difficult to work with
- At least three 10-ton steel-wheel (Min. 10 tons)
- No pneumatic or rubber-tired rollers
- 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

51

51

### Compaction

- Watch for Fat Spots
  - Sticky mastic picked up by equipment and released.
- Roller must be equipped with watering or soapy watering system

52

52



**Thank You!**



53

**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?

2

**What is a Certified  
Bituminous Plant Technician?**



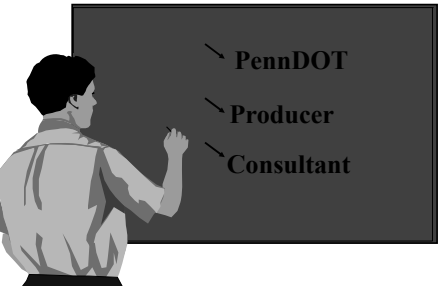
3

**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

4

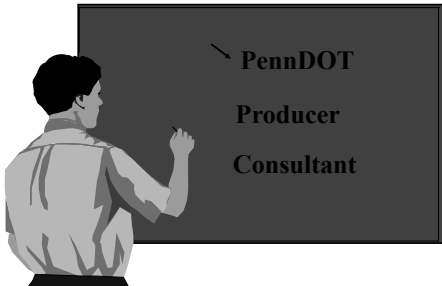
**Whom does the Technician  
Represent?**



- PennDOT
- Producer
- Consultant

5

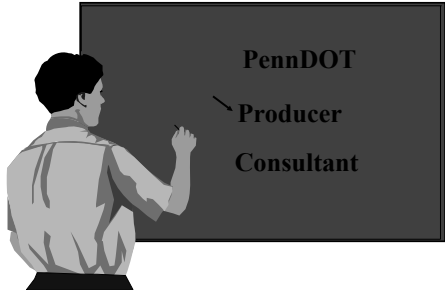
**What are my duties?  
If I work for.....**



- PennDOT
- Producer
- Consultant

6

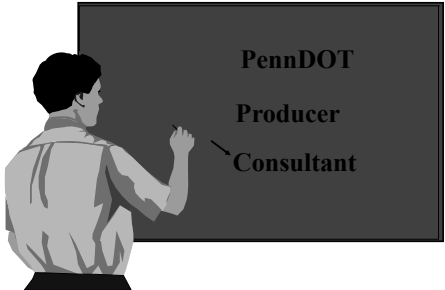
**What are my duties?  
If I work for the.....**



PennDOT  
Producer  
Consultant

7


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



PennDOT  
Producer  
Consultant

8

**What Are Your Responsibilities ?**



1. Know the specifications
2. Know the PTMs & AASHTO tests needed to insure 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

9

**What are the four principals 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.

10


**Be Familiar with  
PennDOT 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

**Published November 2018**



www.pennDOT.gov

PUB 351 (11-18)

11

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

**• MAKE THE EFFORT**

12



Commonwealth of Pennsylvania  
Department of Transportation

## Publication 408/2016

Below are links to the changes and list of effective dates. Select by clicking on the change.

Change	Effective Date
<a href="#">Initial Edition</a>	April 1, 2016
<a href="#">Change No. 1</a>	October 7, 2016
<a href="#">Change No. 2</a>	April 7, 2017
<a href="#">Change No. 3</a>	October 6, 2017
<a href="#">Change No. 4</a>	April 6, 2018
<a href="#">Change No. 5</a>	October 5, 2018
<a href="#">Change No. 6</a>	April 5, 2019
<a href="#">Change No. 7</a>	October 4, 2019

## 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 serve a permanent functional use 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 bituminous 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 bituminous material or product not produced at a source listed in Bulletin 41.
- Any bituminous 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 CMD.

Independent Assurance sampling and testing will be administered by the CMD.

## 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 Tolerance.** The percentage of each lot within the specified tolerances 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 ( $\bar{X}$ ) measurements are averaged to find  $\bar{X}$ .

$$\bar{X} = \sum_{i=1}^n \frac{X_i}{n}$$

**3.a.4** The Standard Deviation, “s,” of the lot measurements will be determined as follows:

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

**3.a.5** The Quality Index ( $Q_U$ ) is found by subtracting the average ( $\bar{X}$ ) of the measurements from the upper specification limit (U) and dividing the result by “s.”

$$Q_U = \frac{(u - \bar{X})}{s}$$

**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.”

$$Q_L = \frac{(\bar{X} - L)}{s}$$

**3.a.7** The percentage of material that will fall within the upper tolerance 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 tolerance 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) tolerance limits are concerned, the percentage of material that will fall within tolerance limits is found by adding the percent ( $P_U$ ) within the upper tolerance limit (U) to the percent ( $P_L$ ) within the lower tolerance limit (L) and subtracting 100 from the sum.

$$\text{Total percent within limits} = (P_U + P_L) - 100$$

**3.a.10** When determining the percentage within tolerance 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 tolerance will be used.
- If the calculated Q.I. is less than interpolated value, the lower listed percent within the tolerance will be used.

**TABLE A**  
**Estimating Percent of Lot Within Tolerance**  
**(Standard Deviation Method)**  
**Negative Values of  $Q_U$  or  $Q_L$**

Percent Within Tolerance	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 Tolerance**  
**(Standard Deviation Method)**  
**Negative Values of  $Q_U$  or  $Q_L$**

<b>Percent Within Tolerance</b>	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 Tolerance**  
**(Standard Deviation Method)**  
**Positive Values of  $Q_U$  or  $Q_L$**

Percent Within Tolerance	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 Tolerance**  
**(Standard Deviation Method)**  
**Positive Values of  $Q_U$  or  $Q_L$**

Percent Within Tolerance	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 BOPD.



**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-4171 that 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.

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 bituminous 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 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
<b>Level 1</b>	Standard Certification	Ship on Certification with Form CS-4171*	None
<b>Level 2</b>	Standard Certification - Reduced	Ship on Certification with Form CS-4171*	See Section 106.03(b)3.e.2
<b>Level 3</b>	Lot Approval Certification	Ship only after Material Lot Approval using Modified Certification, with Form CS-4171*	See Section 106.03(b)3.e.3
<b>Suspension or Removal</b>	In accordance with the State's Contractor Responsibility Program: <ul style="list-style-type: none"> <li>• 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.</li> <li>• Failure of Producer to advance above Certification Level 3 will result in PennDOT's initiating action for suspension or removal from Bulletin 15.</li> </ul>		

\* Certain Bulletin materials require supplemental or alternate forms of certification, refer to 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 bituminous concrete. Store aggregates on one of the following constructed according to standard practice:

- Bituminous 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 from 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 309—SUPERPAVE ASPHALT MIXTURE DESIGN, STANDARD CONSTRUCTION, HMA BASE COURSE

**309.1 DESCRIPTION**—This work is the Standard construction of a plant-mixed HMA base course on a prepared surface using a volumetric mixture design developed with the Superpave Gyrotory Compactor (SGC).

**309.2 MATERIAL**—Section 409.2

**309.3 CONSTRUCTION**—Section 409.3 as specified for Standard construction and with additions and modifications as follows:

**(b) Weather Limitations.** Section 409.3(b). Replace with the following:

Do not place base course on prepared surfaces that are wet or when the temperature of the air or the prepared surface is 35F or lower. If work is halted because of weather conditions, the Representative may allow the Contractor to place limited quantities of base course that are en route to the project.

**(h) Spreading and Finishing.** Revise as follows:

**1.b Spreading and Finishing.** Add the following:

If the indicated compacted depth of a Superpave 25.0 mm HMA base course is more than 6 inches, place the HMA base course in two or more layers of approximately equal compacted depth, with no layer less than 3 inches or more than 6 inches. If the indicated compacted depth of a Superpave 37.5 mm HMA base course is more than 8 inches, place the HMA base course in two or more layers of approximately equal compacted depth, with no layer less than 4 inches or more than 8 inches.

**(l) Surface Tolerance.** Replace the requirement for defective pavement with the following:

The pavement is defective if irregularities are more than 1/4-inch.

**(m) Tests for Depth.** Replace with the following:

Control the loose depth of each layer to construct the base course to the compacted depth indicated and within the specified tolerance. On the top lift and in the presence of the Inspector, drill full-depth cores at one random location selected by the Inspector according to PTM No. 1 in each 3,000 square yards of completed base course and at other locations the Inspector suspects are deficient.

The Inspector will measure the depth of the full-depth cores according to PTM No. 737. Pavement deficient in depth by 1/2 inch or more and that cannot be satisfactorily corrected is defective. 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 1/2 inch of the design depth.

**309.4 MEASUREMENT AND PAYMENT**—Section 409.4(a), with modifications as follows:

**(a) Bituminous Mixtures (Standard).** Revise as follows:

**1. HMA Courses.** Add the following:

**1.f Superpave Asphalt Mixture Design, HMA Base Course.** Square Yard or Ton



## SECTION 311—SUPERPAVE ASPHALT MIXTURE DESIGN, STANDARD CONSTRUCTION, WMA BASE COURSE

**311.1 DESCRIPTION**—This work is the Standard construction of a plant-mixed, dense-graded, WMA pavement base course on a prepared surface using a volumetric asphalt mixture design developed with the Superpave Gyrotory Compactor (SGC), using prescribed manufactured additives or modifiers, and/or plant process modifications.

**311.2 MATERIAL**—Section 411.2

**311.3 CONSTRUCTION**—Section 411.3 with additions and modifications as follows:

**(b) Weather Limitations.** Section 411.3(b). Replace with the following:

Do not place base course on prepared surfaces that are wet or when the temperature of the air or the prepared surface is 35F or lower. If work is halted because of weather conditions, the Representative may allow the Contractor to place limited quantities of base course that are en route to the project.

**(h) Spreading and Finishing.**

**1.b Spreading and Finishing.** Section 409.3(h)1.b. Revise the second paragraph to read as follows:

If the indicated compacted depth of a 25.0 mm WMA base course is more than 6 inches, place the WMA base course in two or more layers of approximately equal compacted depth, with no layer less than 3 inches or more than 6 inches. If the indicated compacted depth of a 37.5 mm WMA base course is more than 8 inches, place the WMA base course in two or more layers of approximately equal compacted depth, with no layer less than 4 inches or more than 8 inches.

**(l) Surface Tolerance.** Section 409.3(l). Revise the last sentence to read:

The pavement is defective if irregularities are more than 1/4-inch.

**(m) Tests for Depth.** Section 409.3(m). Revise to read as follows:

Control the loose depth of each layer to construct the base course to the compacted depth indicated and within the specified tolerance. On the top lift and in the presence of the Inspector, drill full-depth cores at one random location selected by the Inspector according to PTM No. 1 in each 3,000 square yards of completed base course and at other locations the Inspector suspects are deficient.

The Inspector will measure the depth of the full-depth cores according to PTM No. 737. Pavement deficient in depth by 1/2 inch or more and that cannot be satisfactorily corrected will be considered defective. 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 is deficient in depth at the core location and proceed longitudinally and transversely until the depth is within 1/2 inch of the design depth.

**311.4 MEASUREMENT AND PAYMENT**—Section 411.4(a) with modifications as follows:

**(a) Standard WMA Construction.**

**1. WMA Courses.** Section 411.4(a)1. Add the following:

**1.f Superpave Asphalt Mixture Design, WMA Base Course.** 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) **Bituminous Material.** Asphalt Cement, Class PG 64-22, 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 bituminous 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 bitumen content of 2.5% by weight. If necessary, adjust

the bitumen content within the range specified in Table A below to uniformly coat the aggregate and ensure the aggregate has no observable runoff of excess bitumen.

Test materials, proportions, and the mixture at the bituminous 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 bitumen content and gradation tests to verify the mixture conforms to the JMF. After the first day, perform tests for bitumen 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 bitumen content within 0.8% of the JMF (n=1). Ensure the aggregate is uniformly coated with bitumen and no runoff of excess bitumen is observed.

**4. Acceptance of the Mixture.** Obtain material certification from the material producer using the results of QC tests for bitumen 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
Bitumen 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 409.3, 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) Bituminous 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 bituminous material so that combining with aggregate produces a completed mixture. Coat the aggregate with the bituminous 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 409.3(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  $\mu\text{m}$  (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 bitumen.

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 workmanship.

#### **360.4 MEASUREMENT AND PAYMENT—Square Yard or Ton**

## SECTION 405—EVALUATION OF BITUMINOUS PAVEMENT LONGITUDINAL JOINT DENSITY AND PAYMENT OF INCENTIVE/DISINCENTIVE

**405.1 DESCRIPTION**—This work is evaluating bituminous pavement longitudinal joint samples on the surface wearing course for determining densities and the incentive/disincentive. This work also includes any necessary corrective actions required as a result of the evaluation.

### 405.3 CONSTRUCTION—

**(a) General Requirements.** Longitudinal joint density lots will be established as specified in Section 405.3(b). These incentive/disincentive lots are completely independent from lots defined in other sections of these Specifications for pavement acceptance. The Representative will determine the payment addition or deduction along with any necessary corrective actions for each longitudinal joint lot based on the test results of the density cores.

**(b) Lot Size.** A full lot is 12,500 feet of longitudinal joint and will consist of 5 sublots of 2,500 feet. The Representative will designate lots as the longitudinal joints on the project are constructed, beginning on the first day wearing course paving abuts a previously placed wearing course, forming a longitudinal joint. Joints constructed with tandem pavers will be included, unless otherwise indicated. As paving progresses and longitudinal joints are constructed, drill one core per subplot until a full lot is obtained according to Section 405.3(e). Do not include the length of excluded joints in the 12,500 feet lot. A single lot need not be contiguous and may include multiple joints throughout the project limits.

Partial lots with less than three sublots will be combined with the previous lot. Partial lots with three or more sublots will stand as a separate lot.

**(c) Quality Control Strip.** On the first day paving abuts a previously placed mat, forming a longitudinal joint eligible for evaluation, determine the effectiveness of the material placement and compaction operations as well as the mixture design on longitudinal joint density. In addition to any incentive/disincentive payment subplot cores, obtain five 6-inch diameter core samples located randomly on the longitudinal joint for QC density testing. Test the cores according to PTM No. 715 or PTM No. 716 and provide the results of the tests to the Representative within 24 hours. The Contractor may elect to make adjustments to the mixture design or placement and compaction operations to ensure adequate in place density is being achieved. If proposing changes that impact the field quality control plan or job mix formula, submit any modifications or revisions to the Department for review.

**(d) Excluded Areas.** The following joint areas are to be excluded from the longitudinal joint lots. The Representative will not obtain samples from excluded areas to determine lot incentive/disincentive payment.

- Joints where one or both sides of the pavements forming the joint were accepted for density by means other than pavement cores
- Joints where one side of the joint is formed by existing pavement not constructed under this contract
- Areas within 1 foot longitudinally of an obstruction during construction of the wearing course (manholes, inlet grates, utilities, bridge structures, pavement notches, etc.)
- Small areas, such as intersections, gore areas or transitions, or anywhere the Representative determines paving and phasing methods do not allow for consistent longitudinal joint construction. Prior to paving, submit requests in writing to the Representative for consideration of any areas to be excluded on this basis. The Representative will make the final determination.

**(e) Sampling.** The Inspector will select one location in each subplot according to PTM No. 1 and PTM No. 729. The Contractor may take one companion core per subplot for quality control purposes. For vertical joints center joint cores on the line where the joint between the two adjacent lifts abut at the surface. For notched wedge joints, center joint cores 6-inches or one half the joint taper width away from the joint line in the direction of the wedge. With the Inspector present, drill 6-inch diameter cores as soon as possible, but no later than the day following the construction of the longitudinal joint at each subplot location. 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(s) with mixture of the same JMF or with mixture used for subsequent courses and compact and seal the mixture.

Identify the samples by longitudinal joint lot and subplot number, location, dates of placement, mixture type, and as acceptance samples (Sample Class AS). Provide the daily theoretical maximum specific gravity value from Section 409.2(e)1.d.4 for the mix on each side of the longitudinal joint. The average of the two values will be used for the density calculation of each subplot in accordance with PTM No. 729. Immediately package and deliver the samples to the Inspector according to the QC Plan. Use sample containers of sufficient strength to prevent samples from being damaged during transport.

Each joint core will be comprised of portions of two lanes, with the potential for two different JMFs within each core. The Representative will only include samples within a lot having the same JMF combination on one Form TR-447 for testing at the LTS. The Representative will submit separate samples and Forms TR-447 for sublots with different JMF combinations or after work stoppages of more than 5 days.

The LTS will test the density samples according to PTM No. 715, and if necessary PTM No. 716, to determine the percent compaction.

**(f) Percent Within Tolerance (PWT).** Once all test results for a lot have been received, the Representative will compute the PWT and average in place density for each lot according to Section 106.03(a)3.a and as follows. The lower specification limit (L) will be 90%. No upper specification limit (U) for density will be factored into the PWT determination.

**(g) Corrective Action.** Seal the entire length of the longitudinal joint(s) within each lot where the average in place lot density is less than 88.0% at no additional cost to the Department. Seal the surface at the longitudinal joint(s) with hot PG 64-22 asphalt cement. Heat and maintain asphalt cement sealant between 265F and 320F. Do not place sealant when the air temperature is below 40F, unless otherwise allowed 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  $\pm$  1 inch and thickness of 1/16 inch  $\pm$  1/32 inch at specified temperature range. Center the sealant band within 1 inch of the joint. Immediately level high spots with a squeegee or wand. Remove and dispose of excess sealant at no cost to the Department. Re-seal areas of the joint that are inconsistently or not completely covered at no additional cost to the Department. Complete any required rumble strip installation at joints before sealing operations. Replace pavement markings that are marred by sealing operations at no additional cost to the Department.

#### **405.4 MEASUREMENT AND PAYMENT—Dollar**

The proposal will include an item and a predetermined amount of money for Evaluation of Bituminous Pavement Longitudinal Joint Density and Payment of Incentive/Disincentive. 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. When bituminous pavement longitudinal joint density 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.

Due to the incentive or bonus status of the payment being made the provisions of Section 110.02(d) are not applicable to this item.

Measured and paid for, under the Evaluation of Bituminous Pavement Longitudinal Joints and Payment of Incentive item as follows:

For each lot Table A will be used to determine the incentive/disincentive payment for longitudinal joint density.

The incentive/disincentive payment for a lot containing other than 5 sublots will be determined as a percentage of a full 12,500 feet lot, by the following:

- N=3 (60% of the Table A amount)
- N=4 (80% of the Table A amount)
- N=6 (120% of the Table A amount)
- N=7 (140% of the Table A amount)

For a full lot with a PWT  $\geq 81$ , the Contractor will receive a prorated positive incentive payment up to a maximum of \$5,000 calculated according to Table A. Lots with average density  $\geq 92.0\%$  will receive the maximum incentive regardless of PWT.

For a full lot with a PWT  $\leq 49$ , the Contractor will receive a prorated negative adjustment (disincentive) up to a maximum of \$10,000 for the longitudinal joint lot calculated according to Table A. Lots with PWT  $\leq 49$  and average density  $\geq 89.0\%$  will be assessed a disincentive up to a maximum of \$1,000 per subplot regardless of PWT.

Costs associated with providing joint pavement cores will not be paid for separately and will be considered incidental to the construction items for the wearing courses eligible for the longitudinal joint evaluation. Costs associated with corrective action such as traffic control or other costs will not be paid for separately.

**TABLE A**

<b>Lot by Lot Payment Schedule for Longitudinal Joint Incentive/Disincentive</b>	
<b>Lot PWT</b>	<b>Amount</b>
PWT $\geq 81$	$(\text{PWT} - 80)/20 \times \$5,000$ (Incentive)
PWT = 50 to 80	\$0
PWT $\leq 49$	$(50 - \text{PWT})/50 \times -\$10,000$ (Disincentive)



## SECTION 409—SUPERPAVE MIXTURE DESIGN, STANDARD AND RPS CONSTRUCTION OF PLANT-MIXED HMA COURSES

**409.1 DESCRIPTION**—This work is the standard and RPS construction of plant-mixed HMA on a prepared surface using a volumetric mixture design developed with the Superpave Gyrotory Compactor.

### 409.2 MATERIALS—

#### (a) Bituminous 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, AASHTO M 320, 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 bituminous material 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 cement in the RAP and, if applicable, the RAS source material. The LTS will determine the class (grade) of asphalt cement that the Contractor is required to use in the mixture.

Furnish material conforming to the requirements of Standard Specifications for Performance-Graded Asphalt Binder, AASHTO M 320, 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 bituminous material on the first day of paving and when the batch number changes.

#### (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 as specified in 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 conform to AASHTO M 323, Table 5. Determine the sand-equivalent value according to AASHTO T 176 and conform to AASHTO M 323, Table 5.

**3. Coarse Aggregate.** Type A, Section 703.2, except Table C gradation does not apply and revise the following quality requirements of Table B:

- Abrasion, Maximum Percent as specified in Bulletin 27, Chapter 2A, Table 5A
- Thin and Elongated Pieces, Maximum Percent as specified in AASHTO M 323, Table 5, for Flat and Elongated
- Crushed Fragments, Minimum Percent, as specified in AASHTO M 323, Table 5, 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 hot-mix bituminous 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 conforms to Section 409.2(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 and RAS material by shredding, screening or other methods so that 100 percent passes the 12.5 mm (1/2 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 409.2(e).

**(d) Filler.** Section 703.1(c)1. Do not use flyash 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 in proportions to produce a JMF that conforms to the material, gradation, and volumetric Superpave Asphalt Mixture Design requirements as specified in Bulletin 27, Chapter 2A, for the specified nominal maximum aggregate size (NMAS) and design ESALs.

Submit a copy of each completed JMF, signed by a certified HMA 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 HMA producer in the JMF. Provide the calibration factors ( $C_f$  and  $200 C_f$ ) required by 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.

**1.b Plant Technicians.** During mixture production, provide a certified HMA Level 1 plant technician at the plant and an on-call certified HMA Level 2 plant technician, both meeting the requirements outlined in Publication 351. Instruct and train the certified technicians to perform all tests and to control plant operation. The Department may use its own certified HMA plant technicians to verify tests and to work in close cooperation 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, as determined by 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 as specified in 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 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.

**TABLE A**  
**Job-Mix Formula**  
**Composition Tolerance Requirements of the Completed Mix**

		Single Sample (n = 1)	Multiple Samples (n ≥ 3)
<b>Gradation</b>			
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%
<b>Asphalt Content</b>			
19.0 mm HMA mixtures and smaller		±0.7%	±0.4%
25.0 mm HMA mixtures and larger		±0.8%	±0.5%
<b>Temperature of Mixture (F)</b>			
Class of Material	Type of Material	Minimum	Maximum
PG 58-28	Asphalt Cement	260	310
PG 64-22	Asphalt Cement	265	320
PG 76-22	Asphalt Cement	285	330
All other PG Binders	Asphalt Cement	As specified in Bulletin 25 (Specifications for Bituminous Materials)	

**TABLE B**  
**Job-Mix Formula**  
**Volumetric Tolerance Requirements of the Laboratory Compacted Mix**

Property	Each Specimen	Multiple Specimens
Air Voids at $N_{\text{design}}$ ( $V_a$ )	( $\pm 2\%$ )	( $\pm 1.5\%$ )
Minimum VMA % for 4.75 mm mixes	16.0	-
Minimum VMA % for 9.5 mm mixes	15.0	-
Minimum VMA % for 12.5 mm mixes	14.0	-
Minimum VMA % for 19.0 mm mixes	13.0	-
Minimum VMA % for 25.0 mm mixes	12.0	-
Minimum VMA % for 37.5 mm mixes	11.0	-

**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 2.36 mm (No. 8) sieve, the 75  $\mu\text{m}$  (No. 200) sieve, or asphalt content are not within the tolerances in Table A.
- The average of multiple samples ( $n \geq 3$ ) for percent passing any sieve or asphalt content, as determined according to Section 409.2(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 409.2(e)1 and as follows:

**2.a RAM and RAP SRL.** For HMA 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 409.2(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) 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 409.3(h)2.

**TABLE C**  
**Mixture Acceptance**

Acceptance Level	Acceptance Method
Certification Acceptance	Producer Certification of Mixture (Section 409.2(f)2)
Lot Acceptance	Mixture Acceptance Sample Testing (Section 409.3(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.
- All 4.75 mm asphalt mixture applications will be accepted by Certification Acceptance.
- Other mixtures, conditions, or applications as approved by the Representative.

**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 4.75mm asphalt mixtures)
- Percent Passing the 75  $\mu$ m (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 409.3(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.

### 409.3 CONSTRUCTION—

#### (a) **Preplacement Requirements.**

**1. Paving Operation QC Plan.** Prepare a paving operation QC Plan, as outlined on Form CS-409, for field control and evaluation of bituminous 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 bituminous concrete courses as specified in Section 409.3. Do not start paving until after the Representative reviews the QC Plan.

**2. Preplacement Meeting.** At least 2 weeks before placing bituminous paving mixtures, schedule a bituminous 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 bituminous acceptance samples.

**(b) Weather Limitations.** Do not place any bituminous paving mixtures from November 1 to March 31, unless an extension of the paving season, as specified in Section 409.3(b)1, is granted in writing by the District Executive. Do not place bituminous paving mixtures when surfaces are wet or when the air or surface temperature is 40 F 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.** An extension of the paving season from October 31 to November 20, or from April 1 to March 20, will be granted by the District Executive provided the following conditions are met:

- A written request is submitted to the District Executive for an extension. Requests to pave after October 31 must be submitted by October 15. Requests to pave prior to April 1 must be received by March 5. The request must justify the need for the extension, while also demonstrating a paving plan that is able to accomplish the desired scope of work on or before the Required Completion Date.
- The following information is submitted within 30 calendar days after the actual Notice to Proceed Date:
  - All active Department projects for which the Contractor is responsible, including project locations and applicable milestone dates;
  - Paving crew and/or paving equipment allocations;
  - A project paving plan (defining dates, hours, and production rates) to ensure continuous material delivery, placement and compaction operations.

Use Warm Mix Asphalt (WMA), in accordance with temperature restrictions specified in Section 411, Table A. If necessary, replace original contract HMA bituminous pavement items with WMA bituminous pavement items provided each WMA item is added to the contract at a unit price that is less than or equal to the unit price for the HMA contract item it is to replace.

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.

A Final Acceptance Certificate will not be issued for work completed under the paving season extension in November prior to the following May 1.

An extension of the paving season will not be granted for the month of March on projects with an actual Notice to Proceed date in April of that calendar year.

An extension of the paving season will not be granted for the month of November on projects with paving scheduled to continue into the next paving season, except when doing so would enable the Department to facilitate

roadway use and the convenience of traffic.

**2. Wearing Courses.** Do not place wearing courses specified with design ESALs of 10 million or greater or wearing courses specified with PG 76-22 from October 1 to March 31 in Districts 1-0, 2-0, 3-0, 4-0, 5-0 (Monroe and Carbon Counties), 9-0 (Cambria and Somerset Counties), and 10-0; and from October 16 to March 31 in Districts 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 directed in writing by the District Executive.

**(c) Bituminous Mixing Plant.** Obtain bituminous mixtures from a plant fully automated and recorded 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. 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. Ensure that virgin aggregate is free of unburned fuel oil 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 within the temperatures specified in Table A for the class and type of material used.

**(d) Hauling Equipment.** Haul the mixtures in tightly sealed vehicles that do not contain petroleum oils, solvents, or other materials that adversely affect bituminous concrete. Provide covers of sufficient size and quality to protect the entire load under all conditions. Maintain the proper and uniform placement temperature specified in Section 409.3(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 50 °F from October 1 to April 30.

**(e) Paving Equipment**

**1. Bituminous 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. 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. Bituminous 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 or allowed 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 bituminous 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 bituminous mixtures with a uniform coating of bituminous material, Class E-6 (AASHTO SS-1 or CSS-1), E-8 (AASHTO SS-1h or CSS-1h), Class AET applied in two or more applications, or of the class and type designated for the bituminous course.

Before overlaying existing surfaces, apply a tack coat as specified in Section 460 unless otherwise indicated. Apply a tack coat to previously placed courses if the Representative determines a tack coat is necessary to ensure bonding between the two courses.

**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 of the wearing course in accordance with the Standard Drawing RC-28M, or as otherwise indicated. Perform milling as specified in Section 491.

**(h) Spreading and Finishing.****1. General Requirements.**

**1.a Placing.** Unless otherwise allowed, deliver, place, and compact bituminous 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.

Utilize a Material Transfer Vehicle (MTV) as specified in Section 108.05(c)5 for RPS pavements unless otherwise approved by the Representative.

**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 bituminous 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 a bituminous gutter. Seal the mixture surface with a hot bituminous material of the class and type listed in Table A. Evenly apply the bituminous material a minimum width of 12 inches from the curb. The Contractor may use Class AET, Class E-6 (AASHTO SS-1 or CSS-1), or E-8 (AASHTO SS-1h or CSS-1h) emulsified asphalt instead of hot bituminous 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 Field Technician.** Provide a certified HMA field technician, with the qualifications outlined in Publication 351, to control the placement of bituminous mixtures. Instruct and train the certified HMA field technician to control the paving operation so that the completed paving work complies with the specified requirements. A certified HMA field technician must be onsite and carry a valid certification card during placement of all HMA mixtures.

**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. Each lot consists of five equal sublots (n=5). A completed sublot has a mixture acceptance box sample as specified in Section 409.3(h)2.b and either a core collected according to PTM No. 1 or other density acceptance as specified in Section 409.3(j).

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 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 days. If a lot is terminated due to a stoppage of 5 days or more, adjust the lot size and number of sublots as specified in Table D. If work stoppages exceed 5 days, a new lot will be established.

**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  $\mu$ m (No. 200) sieve, mixture acceptance samples will be evaluated individually using Section 409.2(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  $\mu$ m (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 percent of the contract unit

price. If samples tested for asphalt content and percent passing the 75  $\mu\text{m}$  (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 percent below the minimum or no more than 2 percent above the maximum limits of Table E, payment will be 90 percent of the contract unit price. If samples for density are more than 2 percent below the minimum or more than 2 percent 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	$\geq 92$ and $\leq 97$
All Standard 9.5 mm, 12.5 mm, 19 mm, and 25 mm Wearing or Binder Courses	$\geq 90$ and $\leq 97$
All 25 mm and 37.5 mm Base Courses	$\geq 90$ and $< 100$

**2.a.2 For JMF's placed in quantities less than 2,500 tons.** For JMF's 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 may be considered a lot if density acceptance is by pavement cores, however mixture acceptance will be by certification. The lot will be divided into three equal sublots.

**2.b Mixture Acceptance Samples.** The Inspector will select different sample locations in each subplot according to PTM No. 1 and PTM No. 746. In the presence of the Inspector, obtain one loose mixture sample for each subplot directly from the uncompacted mixture placed by the paving equipment specified in Section 409.3(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 Inspector, identify the samples by ECMS project number, lot and subplot 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 Inspector.

For quality control purposes, a maximum of one loose sample per subplot 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.

**2.c Mixture Acceptance 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, if previously identified problematic aggregates are used in the mixture, to determine asphalt content and the percent passing the 75  $\mu\text{m}$  (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 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 409.3(h)2.a.1. The Department will accept lots with three or more test results as specified in Section 409.4(a)4 or Section 409.4(b).

If the asphalt content or the percent passing the 75  $\mu\text{m}$  (No. 200) sieve is not within the single sample ( $n=1$ ) or multiple sample ( $n\geq 3$ ) 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.

**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 his or her own risk while he or she immediately and continually adjusts 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 409.3(h)3.c.

**3.b Test Section.** If the macrotexture tests identify unacceptable pattern segregation, then:

- Immediately suspend placing the bituminous 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 bituminous 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 409.3(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, 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  $\mu\text{m}$  (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 309.3(1)12 or Section 409.3(1).

**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 its own risk while it immediately and continually adjusts 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 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 409.3(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 bituminous 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 409.3(j)2 and 409.3(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 409.3(j)4. The Department will accept mat density of all 4.75 mm asphalt material 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, and other miscellaneous applications determined by the Representative. Shoulders where density is critical will be accepted by pavement cores as specified in Section 409.3(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, 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 409.3(j)4.a.
- Mixtures placed at less than the minimum compacted depths in Table G.

With the Representative and the Contractor's certified HMA 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 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	1 1/2 in.
19 mm Binder Course	2 1/2 in.
25 mm Binder Course	3 in.

#### 4.b Lots and Sublots. Section 409.3(h)2.a.

**4.c Density Acceptance Samples.** The Inspector will select different sample locations in each subplot 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. 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 subplot 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 from Section 409.2(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 average of the daily theoretical maximum specific gravity values from the days the lot was placed will be used to calculate the density. 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 subplot 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.

#### 4.d Acceptance Sample Testing. These procedures apply to standard and RPS construction.

**4.d.1 LTS Acceptance Testing.** The LTS will test the density acceptance samples according to PTM No. 715, and if necessary PTM No. 716, to determine the percent compaction. The Department will determine acceptance, with respect to density, as specified in Section 409.4(a)4 or Section 409.4(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 bituminous material, the PG-Binder used in the pavement course or PG 64-22. 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 409.3(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 6 to 12 inches from the joint for the first pass forward. 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.

### **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 NMAAS 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 according to Standard Drawing RC-28M.
- If the joint is next to opposing traffic, place the abutting lane within 1 working day after placing the mixture. If the joint is next to traffic in the same direction, place the abutting lane 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 bituminous material, the PG-Binder used in the pavement course or PG 64-22, 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 bituminous 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 a Class AET, Class E-6 (AASHTO SS-1 or CSS-1) or E-8 (AASHTO SS-1h or CSS-1h) emulsified asphalt instead of hot bituminous 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 bituminous 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 10-foot straightedge at areas the Representative determines may be deficient or irregular, and at transverse joints 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 subplot 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 using PTM No. 1. For courses with density acceptance by lots, the inspector will measure the depth of each subplot 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 140 F 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 140 F 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 409.3(h)3, for flushing as specified in Section 409.3(h)4, surface tolerance as specified in Section 409.3(l) or Section 309.3(l) and depth as specified in Section 409.3(m), or Section 309.3(m). Remove and replace pavement defective for percent within tolerance or Payment Factor Percentages as specified in Tables H and I.

#### 409.4 MEASUREMENT AND PAYMENT—

**(a) Standard HMA Construction.**

**1. HMA Courses.**

**1.a Superpave Asphalt Mixture Design, HMA Wearing Course.** Square Yard or Ton

**1.b Superpave Asphalt Mixture Design, HMA Wearing Course (Scratch).** Ton

**1.c Superpave Asphalt Mixture Design, HMA Wearing Course (Leveling).** Ton

**1.d Superpave Asphalt Mixture Design, HMA Binder Course.** Square Yard or Ton

**1.e Superpave Asphalt Mixture Design, HMA Binder Course (Leveling).** Ton

**2. Bituminous 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 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  $\mu$ m (No. 200) sieve, and percent passing the 2.36 mm (No. 8) sieve (No. 8 sieve not applicable for 4.75 mm asphalt mixtures) are all 85%. For pavements with density acceptance by cores, the pavement will be considered defective if the pavement density cores result in a percent within tolerance less than 64.

**TABLE H**  
**Contract Unit Price Adjustments - Mixture Acceptance by Certification**

Mixture NMAS	Test Criteria	Test Value		Payment Factor Percentage
<b>Asphalt Content</b>				
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 $\geq$ 2)	
		$\pm 0.7\%$	$\pm 0.5\%$	100
		$\pm 0.8\%$ to 1.0%	$\pm 0.6\%$	85
		$> \pm 1.0\%$	$\geq \pm 0.7\%$	*
25.0 mm and larger	QC Sample Testing**	$\pm 0.8\%$	$\pm 0.6\%$	100
		$\pm 0.9\%$ to $\pm 1.2\%$	$\pm 0.7\%$	85
		$> \pm 1.2\%$	$\geq \pm 0.8\%$	*
<b>Gradation</b>				
		Single Sample (n=1)	Multiple Samples (n $\geq$ 2)	
All sizes	QC Sample Testing for % Passing 75 $\mu$ m (No. 200) Sieve**	$\pm 3.0\%$	$\pm 2.1\%$	100
		$\pm 3.1\%$ to $\pm 4.0\%$	$\pm 2.2\%$ to $\pm 2.7\%$	85
		$> \pm 4.0\%$	$\geq \pm 2.8\%$	*
All sizes	QC Sample Testing for % Passing 2.36 mm (No. 8) Sieve**	$\pm 6\%$	$\pm 4\%$	100
		$\pm 7\%$ to $\pm 8\%$	$\pm 5\%$	85
		$> \pm 8\%$	$\geq \pm 6\%$	*
<b>Mat Density</b>				
All sizes	Non-Movement	Section 409.3(j)2.		100
	Optimum-Rolling Pattern	Section 409.3(j)3.		100

Sizes from Table I	Acceptance Sample Testing of Pavement Cores	Table I	Table I
* Defective pavement. Remove and replace or, when permitted by the District Executive in writing, leave in place and the Department will pay 50% 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 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 Payment Factor Percentages as specified in Table I. 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 J.

**TABLE I**  
**Contract Unit Price Adjustments - Mixture Acceptance by Lots**

Mixture NMAAS	Test Criteria	Test Value	Payment Factor Percentage
<b>Asphalt Content</b>			
All sizes	Acceptance Sample Testing	All individual subplot acceptance sample test results for the lot are within the $n=1$ tolerances in Table A and the lot average is within the $n\geq 3$ tolerances in Table A*	100
		Percent Within Tolerance if any individual subplot acceptance sample test result for the lot is not within the $n=1$ tolerances in Table A or the lot average is not within the $n\geq 3$ tolerances in Table A	Table K
<b>Gradation</b>			
All sizes	Acceptance Sample Testing for % Passing 75 $\mu$ m (No. 200) Sieve	All individual subplot acceptance sample test results for the lot are within the $n=1$ tolerances in Table A and the lot average is within the $n\geq 3$ tolerances in Table A*	100
		Percent Within Tolerance, if any individual subplot acceptance sample test result for the lot is not within the $n=1$ tolerances in Table A or the lot average is not within the $n\geq 3$ tolerances in Table A	Table K
<b>Mat Density</b>			
All sizes	Non-Movement	Section 409.3(j)2.	100
	Optimum-Rolling Pattern	Section 409.3(j)3.	100
All RPS 9.5 mm, 12.5 mm, 19 mm and 25 mm Wearing or Binder Courses	Acceptance Sample Testing of Pavement Cores	All individual subplot test results for the lot are $\geq 92\%$ and $\leq 97\%$ of maximum theoretical density	100
		Percent Within Tolerance if any individual subplot test result for the lot is not $\geq 92\%$ and $\leq 97\%$ of maximum theoretical density	Table K
All Standard 9.5 mm, 12.5 mm, 19 mm and	Acceptance Sample Testing of Pavement Cores	All individual subplot test results are $\geq 90\%$ and $\leq 97\%$ and the lot average is $\geq 92\%$ and $\leq 97\%$ of the maximum theoretical density	100

25 mm Wearing or Binder Courses		Percent Within Tolerance if any individual subplot test result is not $\geq 90\%$ and $\leq 97\%$ or if the lot average is not $\geq 92\%$ and $\leq 97\%$ of the maximum theoretical density	Table K
All 25 mm and 37.5 mm Base Courses	Acceptance Sample Testing of Pavement Cores	All individual subplot test results are $\geq 90\%$ and $< 100\%$ of the maximum theoretical density	100
		Percent Within Tolerance if any individual subplot test result is not $\geq 90\%$ and $< 100\%$ of the maximum theoretical density	Table K
<p>* The Department may elect to randomly select and test only one subplot mixture acceptance sample from each lot to verify conformance to the specifications. If only one subplot mixture acceptance sample is tested, tighter tolerances than those in Table A will be used to verify conformance to the specifications for the entire lot. If the one subplot is within <math>\pm 0.2\%</math> of the JMF for asphalt content and within <math>\pm 1.0\%</math> of the JMF for percent passing the 75 <math>\mu\text{m}</math> (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 subplot fails to meet the tighter tolerances, all mixture acceptance samples from the lot will be tested to determine the payment factor percentage according to this table.</p>			

**TABLE J  
Upper and Lower Specification Limits for Calculating Percent Within Tolerance**

Mixture NMAS	Testing Criteria	
	Lower Specification Limit (L)	Upper Specification Limit (U)
	<b>Asphalt Content from JMF Value, %</b>	
9.5 mm, 12.5 mm, and 19 mm	-0.4	+0.4
25 mm and 37.5 mm	-0.5	+0.5
	<b>Percent Passing the 75 <math>\mu\text{m}</math> (No. 200) sieve from JMF Value, %</b>	
All sizes	-2.0	+2.0
	<b>Mat Density*</b>	
9.5 mm, 12.5 mm, 19 mm, and 25 mm Wearing and Binder Courses	0.91T	0.98T
25 mm and 37.5 mm Base Courses	0.89T	1.00T

\* Where T = Current Maximum Theoretical Density, lbs./cu. ft.

**TABLE K  
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 50% 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  $\mu\text{m}$  (No. 200) sieve

**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) 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. 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  $\mu\text{m}$  (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 subplot, 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. 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 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 cores will be rinsed with water before testing. 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.

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. Upon completing the retesting of the original density acceptance cores, the LTS will evaluate testing repeatability using both the original density test values and the 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	Mixture Acceptance Retest Cost if Retest Results Indicate
	100% Pay Factor(s)	<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 Repeatabile
PTM No. 715	\$200	\$750

**(b) HMA RPS Construction.** Square Yard or Ton

**1. Mixture Acceptance by Lot and Density Acceptance by Pavement Cores.** Section 409.4(a)4, except for RPS, the Department will determine mat density by pavement cores only.

## SECTION 410 – SUPERPAVE MIXTURE DESIGN, STANDARD AND RPS CONSTRUCTION OF PLANT-MIXED HMA FINE-GRADED COURSES

**410.1 DESCRIPTION**— This work is the standard and RPS construction of a plant-mixed HMA 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 409.2 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 409.3 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 in accordance with the requirements of Section 409.4 for a 9.5 mm Wearing Course.

## SECTION 411—SUPERPAVE MIXTURE DESIGN, STANDARD AND RPS CONSTRUCTION OF PLANT-MIXED WMA COURSES

**411.1 DESCRIPTION**—This work is the Standard and RPS construction of a plant-mixed, dense-graded, WMA pavement course on a prepared surface using a volumetric asphalt mixture design developed with the Superpave Gyrotory Compactor (SGC), using prescribed manufactured additives or modifiers, and/or plant process modifications.

**411.2 MATERIAL**—Section 409.2 with additions and modifications as follows:

(a) **Bituminous Material.** Section 409.2(a). Add the following subsections:

**3. WMA Technology Additives or Modifiers Blended at the Bituminous Material Supplier’s Refinery or Terminal.** Provide refinery or terminal blended bituminous material blended with a WMA Technology additive or modifier from an approved manufacturer and source listed in Bulletin 15. Include in the bituminous 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 bituminous material modified with the WMA Technology additive or modifier meets the requirements of Section 409.2(a)1 or Section 409.2(a)2 for the specified grade.

**4. WMA Technology Additives or Modifiers Blended at the Bituminous Mixture Producer’s Plant.** Provide a blended bituminous 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 bituminous material of the specified grade conforming to the requirements of Standard Specifications for Performance-Graded Asphalt Binder, AASHTO M 320, 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 409.2(e)1.a and the additional Producer QC Plan requirements within this specification. Provide certification that the bituminous material blended with the WMA Technology additive or modifier at the bituminous mixture production plant meets the requirements of Section 409.2(a)1 or Section 409.2(a)2 for the specified grade.

(e) **Mixture Composition for Standard and RPS Construction.**

**1. Virgin Material Mixtures.** Section 409.2(e)1. Replace the first paragraph with the following:

Size, uniformly grade, and combine aggregate fractions, bituminous material, 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 as specified in Bulletin 27, Chapter 2A, 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 WMA mixtures and 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. Develop a Hot Mix Asphalt (HMA) JMF and incorporate the WMA Technology additive, modifier, or process into that JMF during production. Do not develop a volumetric WMA JMF based on incorporating the WMA Technology additive, modifier or process during the volumetric asphalt mixture design process. For tracking purposes, create a separate WMA JMF cover sheet (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 WMA moisture sensitivity testing.

**1.a.2. Testing Plan with Action Points.** Section 409.2(e)1.a.2. Add the following additional bullets:

- Blended bituminous material lot size/quantity and lot designation method.
- List of all tests to be performed on the blended bituminous material.



- Testing and certification of the blended bituminous material and WMA Technology additive or modifier for conformance to Section 409.2(a)1 or Section 409.2(a)2.
- Frequency of testing of the blended bituminous material.
- List action points to initiate corrective procedures for the blended bituminous material.
- Recording method to document corrective procedures for the blended bituminous material.
- Handling and disposition of blended bituminous material failing to meet the bituminous material specification requirements.

**1.a.3. Materials Storage and Handling.** Section 409.2(e)1.a.3. Add the following additional bullets:

- 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 prior to 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 bituminous material and method of automation, recordation and print outs.
- Storage and handling of the blended bituminous material with the WMA Technology additive or modifier.
- WMA production temperature range for normal paving and any specific temperature ranges for special conditions or situations.
- WMA laboratory compaction temperature for QC volumetric analysis. Determine the SGC compaction temperature for the mix design which yields the same target air voids as the related HMA mixture.

**1.c. Annual JMF Verification.** Section 409.2(e)1.c. Add the following:

Perform annual verification of the WMA mixture JMF even if the equivalent HMA mixture JMF was previously annually verified.

**1.d. Production.** Section 409.2(e)1.d. Add the following:

Prepare and test WMA mixtures, including SGC specimens for quality control using the same test methods, procedures and frequencies as specified for HMA, except as modified by the Producer QC Plan. Maintain records of the testing of WMA and make available for review by the Representative when requested.

**1.d.6 Degree of Particle Coating.** For all WMA mixtures, sample the mixture according to PTM No. 1 and at the frequency in the Producer QC Plan. Examine the completed WMA mixture for particle coating. Produce a WMA mixture with fully coated particles. Increase the plant mixing time or make other plant adjustments if particle coating is deficient. Produce a WMA mixture capable of being handled, placed, and compacted without stripping the bituminous material from the aggregate.

**Table A  
Job-Mix Formula**

**Composition Tolerance Requirements of the Completed Mix**

Section 409.2(e), Table A. Revise the Temperature of Mixture (F) requirements as follows:

Temperature of Mixture (F)				
Class of Material	Type of Material	Chemical, Organic, Foaming Additives Minimum*	Mechanical Foaming Equipment/Process Minimum*	Maximum*
PG 58-28	Asphalt Cement	215	230	310
PG 64-22	Asphalt Cement	220	240	320
PG 76-22	Asphalt Cement	240	255	330
All other Binders	Asphalt Cement	The higher of 215 or the minimum temp. specified in Bulletin 25 minus 45	The higher of 230 or the minimum temp. specified in Bulletin 25 minus 30	As specified in Bulletin 25
* Outline in the Producer QC Plan and follow any additional temperature requirements provided by the Technical Representative for production and placement of the mixture. Determine the SGC compaction temperature for the mix design which yields the same target air voids as the related HMA mixture. 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.				

**(g) WMA Technologies (Additive(s), Modifier(s), or Processes) and WMA Manufacturers.** Produce the WMA 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 bituminous material, provide bituminous material blended with the WMA additive or modifier according to Section 411.2(a)3 or Section 411.2(a)4. For WMA Technology additives or modifiers blended with the bituminous mixture at the bituminous 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 bituminous material. Do not start blending until the DME/DMM reviews the QC Plan.

**(h) Anti-Strip Additives.** Incorporate a liquid anti-strip additive at the same dosage rate as the dosage rate for the HMA JMF for which the WMA JMF is based. If the WMA Technology includes an anti-strip additive as part of its WMA Technology, additional liquid anti-strip additive is not required in mixtures where the moisture sensitivity analysis cannot be performed as specified in Section 411.2(e)1. If the WMA Technology includes an anti-strip additive as part of its WMA Technology and moisture sensitivity analysis can be performed according to Section 411.2(e)1 add additional anti-strip additive or make other adjustments to the JMF and meet the specified moisture sensitivity requirements. Use either a compatible, heat stable, amine-based liquid anti-strip or a compatible alternate anti-strip additive.

**(i) WMA Technology Manufacturer Technical Representative (Technical Representative).** Identify and provide a Technical Representative that is knowledgeable in how the WMA Technology will affect the storage, handling, blending, mixture production, mixture QC testing, placement, and compaction requirements of the mix. Either have the Technical Representative present during the initial production of the WMA and subsequently at the project location during the initial placement operations or, if not required to be on site, on-call and capable of being in direct, verbal contact with the Producer, Contractor, and/or Department Representative within 2 hours after initial contact. Have the Technical Representative review and sign the Producer's QC Plan and include their current direct contact telephone numbers (office and mobile) in the Producer's QC Plan. If unable to sign the QC Plan, have the Technical Representative submit documentation that supports all of the data outlined in Sections 411.2(e)1.a.2 and 411.2(e)1.a.3.

If the WMA Producer is using a fully approved (not provisionally or conditionally approved) WMA Technology listed in Bulletin 15 and the WMA Producer has previously produced WMA mixture using the WMA Technology to the satisfaction of the DME/DMM responsible for the production plant, a Technical Representative is not required to be present during the production and placement of the WMA material. During all WMA production and placement operations, have the Technical Representative identified in the Producer's QC Plan remain on-call for technical support.

If the WMA 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, have a Technical Representative present at the

plant during initial production and subsequently at the project location during initial placement of the specified WMA pavement course. Have the Technical Representative present at the project location until at least 1 lane mile of the specified pavement course has been placed and compacted. If there are no apparent technical issues, request that the Department Representative agree to release the Technical Representative from being present on-site. The Department may direct that a Technical Representative is not required to be present on-site during initial production and placement operations for provisionally or conditionally approved WMA Technologies. If the Department directs a Technical Representative is not required to be present on-site, have the Technical Representative identified in the Producer's QC Plan remain on-call for technical support.

**(j) WMA Mixture Production, Delivery and Placing Temperatures When Placing Over Membrane Systems 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 WMA on top of the membrane at elevated mixture temperatures as per the membrane manufacturer's recommendation. Ensure proper adhesion between the asphalt pavement overlay and the underlying membrane.

**411.3 CONSTRUCTION**—Section 409.3 with additions and modifications as follows:

**(a) Preplacement Requirements.**

**1. Paving Operation QC Plan:** Section 409.3(a)1. Add the following:

Prepare and submit additional information specifically related to all aspects of the field control of WMA concrete paving operations to the Representative as part of the paving operation QC Plan that addresses all recommendations and direction from the Technical Representative. Do not incorporate any material delivered outside the temperature limits specified in Table A. Describe the construction equipment and methods necessary to control the WMA paving operations including the testing, delivery, placement, compaction, and protection of the WMA concrete courses for all placement applications including handwork as specified in Section 409.3.

**(c) Bituminous Mixing Plant.** Section 409.3(c). Add the following:

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 a WMA mixture meeting these specifications.

**1. Batch Plant.** Section 409.3(c)1. Replace the last sentence with the following:

Dry the aggregate according to the specific recommendations and direction from the Technical Representative and heat to a suitable temperature so that the resulting completed mixture temperature is within the mixture temperature recommended by the Technical Representative or manufacturer and Table A. Ensure that the aggregate is free of unburned fuel oil and excess moisture as defined in Section 409.2(e)1.d.1 when delivered to the pug mill.

**2. Drum Mixer Plant.** Section 409.3(c)2. Replace the last sentence with the following:

Produce a completed mixture that is within the mixture temperature range recommended by the Technical Representative or manufacturer and Table A. Ensure that the aggregate and completed mixture is free of unburned fuel oil and excess moisture as defined in Section 409.2(e)1.d.1.

**411.4 MEASUREMENT AND PAYMENT**—Section 409.4 with modifications as follows:

**(a) Standard WMA Construction.**

**1. WMA Courses.** Section 409.4(a)1. Replace with the following:

**1.a Superpave Asphalt Mixture Design, WMA Wearing Course.** Square Yard or Ton

**1.b Superpave Asphalt Mixture Design, WMA Wearing Course (Scratch).** Ton

**1.c Superpave Asphalt Mixture Design, WMA Wearing Course (Leveling).** Ton

**1.d Superpave Asphalt Mixture Design, WMA Binder Course.** Square Yard or Ton

**1.e Superpave Asphalt Mixture Design, WMA Binder Course (Leveling).** Ton

**(b) WMA RPS Construction.** Square Yard or Ton

## SECTION 419—STONE MATRIX ASPHALT MIXTURE DESIGN, RPS CONSTRUCTION OF PLANT-MIXED HMA/WMA 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 either HMA or WMA as indicated, with the WMA produced using an approved WMA technology.

### 419.2 MATERIALS—

#### (a) Bituminous Material

**1. Virgin Mix.** Furnish material conforming to the requirements of Standard Specifications for Performance-Graded Asphalt Binder, AASHTO M 320, 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 bituminous 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 Bituminous Material Supplier's Refinery or Terminal.** Provide refinery or terminal blended bituminous material blended with a WMA Technology additive or modifier from an approved manufacturer and source listed in Bulletin 15. Include in the bituminous 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 bituminous material modified with the WMA Technology additive or modifier meets the requirements for the specified grade.

**1.b WMA Technology Additives or Modifiers Blended at the Bituminous Mixture Producer's Plant.** Provide a blended bituminous 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 bituminous material of the specified grade conforming to the requirements of Standard Specifications for Performance-Graded Asphalt Binder, AASHTO M 320, 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 409.2(e)1.a and the additional Producer QC Plan requirements within this specification. Provide certification that the bituminous material blended with the WMA Technology additive or modifier at the bituminous mixture production plant meets the requirements for the specified grade.

#### (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 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 in accordance with 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 in accordance with 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**

419 – 1  
Change No. 4

Characteristic	Required Values
Abrasion, Max. %	35
Flat and Elongated Particles, Max % ASTM D4791 (measured by mass, on material retained on and above the 4.75 mm (No.4) sieve)	
3 to 1	20
5 to 1	5
Absorption, Max % AASHTO T 85	2.0
Crushed Fragments, Min. %	100 for one fracture face 90 for two fracture faces

(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 as indicated in 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 0.25 inch average diameter. Pellets may contain binder ingredients such as asphalt cement, 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 cement. 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 $\mu$ m (No. 60)	85 - 95
63 $\mu$ m (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 $\mu$ m (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  $50 \pm \text{g}$  ( $1.76 \pm 0.004$  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 in accordance with the requirements of Bulletin 27, Chapter 2B. Size, uniformly grade, and combine aggregate fractions, bituminous material, and an approved WMA Technology when WMA is indicated in such proportions that the total aggregate and bitumen in the JMF conform to the material, gradation, and volumetric requirements for the SMA mixture specified in Tables B and C. Do not use RAP in the mix.

For WMA mixtures, 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. When WMA is indicated, develop a HMA JMF and incorporate the WMA Technology additive, modifier, or process into that JMF during production. Do not develop a volumetric WMA JMF based on incorporating the WMA Technology additive, modifier or process during the volumetric asphalt mixture design process. For all WMA 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. For tracking purposes, create a separate WMA JMF cover sheet (TR-448A) for approval containing the WMA Technology used, WMA Technology dosage rate, material code, and the AASHTO T 283 (TSR) data from the WMA moisture susceptibility testing.

**TABLE B**  
**Mix Design Requirements for SMA Mixtures**

<b>AGGREGATE GRADATION REQUIREMENTS, PERCENT PASSING</b>		
<b>Sieve Size</b>	<b>9.5-mm Mixture</b>	<b>12.5-mm Mixture</b>
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 $\mu\text{m}$ (No. 30)	-	-
300 $\mu\text{m}$ (No. 50)	-	-
150 $\mu\text{m}$ (No. 100)	-	-
75 $\mu\text{m}$ (No. 200)	8 – 13	8 – 11
<b>VOLUMETRIC DESIGN REQUIREMENTS</b>		
<b>Design Gyration (<math>N_{\text{design}}</math>)</b>	100	
<b>Voids in Mineral Aggregate</b>	18.0 % Minimum	
<b>Voids in Course Aggregate (VCA)</b>	$VCA_{\text{mix}} < VCA_{\text{dry rodded}}$	
<b>Design air voids</b>	3.5 - 4.0 %	
<b>Minimum asphalt binder content</b>	Table C	
<b>Binder grade</b>	PG 76-22	
<b>Stabilizer content</b>	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	
<b>Draindown</b>	0.3 % maximum	

**TABLE C**  
**Minimum Asphalt Binder Requirements for SMA Mixtures**

<b>Combined Aggregate</b>	<b>Minimum Asphalt Content,</b>
---------------------------	---------------------------------

Bulk Specific Gravity	% by Total Mix Weight
2.40	7.4
2.45	7.2
2.50	7.1
2.55	7.0
2.60	6.8
2.65	6.7
2.70	6.6
2.75	6.5
2.80	6.4
2.85	6.3
2.90	6.2
2.95	6.1
3.00	6.0

Perform draindown testing according to AASHTO T 305 using a 1 hour reading. Design a mix meeting the tolerances outlined in Table B.

Design each SMA mix within the job-mix tolerances specified in Tables B and C. Test the materials, proportions, and the mixture at the HMA plant laboratory.

Submit a copy of each completed JMF, signed by a certified HMA 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 HMA producer in the JMF. Provide the calibration factors ( $C_f$  and  $200 C_f$ ) required by 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 409.2(e)1.a for HMA and Section 411.2(e)1.a for WMA, except RAP/RAS/RAM is not allowed in the mixture.

**1.b Plant Technicians.** Section 409.2(e)1.b

**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 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 WMA mixture JMF even if the equivalent HMA mixture JMF was previously annually verified.

**1.d Production.** Section 409.2(e)1.d, except as follows :

When producing WMA, produce and test mixtures, including Superpave Gyratory Compactor (SGC) specimens for quality control using the same test methods, procedures and frequencies as specified for HMA, except as modified by the Producer QC Plan. Maintain records of the testing of WMA and make available for review by the Representative when requested.

**1.d.3 Gradation.** Section 409.2(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 of 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 Drindown.** Sample the completed mixture according to PTM No. 1 a minimum of once daily. Perform drindown 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 WMA 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 WMA mixture according to AASHTO T 195. Produce a WMA mixture with percent coated particles  $\geq 95.0\%$ . Increase the plant mixing time or make other plant adjustments if the required percent of coated particles is not met. Produce a WMA mixture capable of being handled, placed, and compacted without stripping the bituminous material from the aggregate.

**TABLE D**  
**Composition Tolerance Requirements of the Completed Mix**

		<b>Single Sample (n = 1)</b>	<b>Multiple Samples (n <math>\geq</math> 3)</b>
<b>Gradation</b>			
Passing 9.5 mm (3/8 inch) and Larger Sieves		$\pm 5\%$	$\pm 4\%$
Passing 4.75 mm (No. 4) to 150 $\mu\text{m}$ (No. 100) Sieves (Inclusive)		$\pm 4\%$	$\pm 3\%$
Passing 75 $\mu\text{m}$ (No. 200) Sieve		$\pm 3.0\%$	$\pm 2.0\%$
<b>Asphalt Content</b>			
% Asphalt by Weight		$\pm 0.7\%$	$\pm 0.4\%$
<b>Drindown</b>			
% by Weight		0.3 % maximum	
<b>Temperature of Mixture (F)</b>			
<b>Class of Material</b>	<b>Type of Material</b>	<b>Minimum</b>	<b>Maximum</b>
PG 76-22	Asphalt Cement (HMA)	285	330
PG 76-22	Asphalt Cement (WMA)	260	330

**TABLE E**  
**Volumetric Tolerance Requirements of the Laboratory Compacted Mix**

	<b>Single Specimen (n = 1)</b>	<b>Multiple Specimens (n <math>\geq</math> 2)</b>
Air Voids at $N_{\text{design}}$ ( $V_a$ )	$\pm 2.0\%$ from JMF	$\pm 1.5\%$ 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  $\mu\text{m}$  (No. 200) sieve, or asphalt content are not within the tolerances in Table D.
- The average of multiple samples (n $\geq$  3) for percent passing any sieve or asphalt content, as determined according to Section 419.2(e)1.d, are not within the tolerances in Table D.
- QC test results on a single specimen (n=1) or on multiple specimens (n $\geq$  2) are not within the tolerances in Table E.
- Drindown test result(s) are not within the tolerances in 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.
2. **Certification.** SMA material will not be accepted by certification

**(g) WMA Technologies (Additive(s), Modifier(s), or Processes) and WMA Manufacturers.** For WMA mixtures, Section 411.2(g)

**(h) Anti-Strip Additives.** For WMA mixtures, Section 411.2(h)

**(i) WMA Technology Manufacturer Technical Representative (Technical Representative).** For WMA mixtures, Section 411.2(i)

**(j) Mixture Production, Delivery and Placing Temperatures When Placing Over Membrane Systems 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, SMA that is to be placed on top of the membrane must be produced and placed at mixture temperatures as per the membrane manufacturer's recommendations except not to exceed the minimum and maximum limits in Table D. Ensure proper adhesion between the asphalt pavement overlay and the underlying membrane. For WMA mixtures, have the Technical Representative indicate that producing and placing mixture at the membrane manufacturer's recommended temperatures is an acceptable practice for their specific WMA Technology.

### 419.3 CONSTRUCTION—

**(a) Preplacement Requirements.** Provide HMA or WMA as indicated for the entire project unless approved by the Department in writing to use both.

1. **Paving Operation QC Plan.** Prepare a paving operation QC Plan, as outlined on Form CS-409, for field control and evaluation of bituminous 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 bituminous concrete courses as specified in Section 419.3. For WMA mixes, 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 bituminous paving mixtures, schedule a bituminous 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 bituminous 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 bituminous 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) Bituminous Mixing Plant.** Section 409.3(c), except the following requirements are for SMA mixes.

Obtain bituminous mixtures from a plant fully automated and recorded 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 defined in Section 409.2(e)1.d.1.

For WMA 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 a WMA 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  $\pm 10\%$  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 cement into the mixture. When a drum plant is used, do not allow the fibers to become entangled in 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 1 hour of plant mixing. Stored SMA material that does not consistently meet the same quality as material discharged directly into hauling vehicles will be rejected.

**(d) Hauling Equipment.** Section 409.3(d)

**(e) Bituminous Pavers.** Section 409.3(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.

This work is incidental to the wearing course. If vibratory rolling is proposed, demonstrate to the satisfaction of the Inspector-in-Charge that no breaking of aggregate or flushing of asphalt binder results from the vibration.

**(h) Preparation of Existing Surface.** Section 409.3(g)

**(i) Spreading and Finishing.**

**1. General Requirements.**

**1.a Placing.** Unless otherwise allowed, 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 409.3(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 409.3(h)1.c

**2. Mixture and Density Lot Acceptance (RPS Construction).** Lot acceptance is required for RPS construction.

**2.a Lots and Sublots.** Section 409.3(h)2.a except as follows: A completed subplot has either three core samples collected according to PTM No. 1 or two core samples collected according to PTM No. 1 and one loose mixture sample as specified in 419.3(i)2.b.

**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. If a lot is terminated before a sample point is reached, obtain one sample for mixture acceptance and one sample for mat density acceptance as specified in 419.3(i)2.a at a location provided by the Representative. For asphalt content and percent passing the 75  $\mu\text{m}$  (No. 200) sieve, mixture acceptance samples will be evaluated individually using Section 419.4(a), Table G (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  $\mu\text{m}$  (No. 200) sieve meet the n=1 criteria of Table G, and samples tested for density meet the criteria in Table F, payment will be 100 percent of the contract unit price. If samples tested for asphalt content and percent passing the 75  $\mu\text{m}$  (No. 200) sieve do not meet the n=1 criteria of Table G, the material will be considered defective work. If samples tested for density are no more than 2.0 percent below the minimum or no more than 2.0 percent above the maximum limits of Table F, payment will be 90 percent of the contract unit price. If samples for density are more than 2.0 percent below the minimum or more than 2.0 percent 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	$\geq 93.0$ and $\leq 98.0$

**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 419.3(i)2.a.

**2.b Mixture Acceptance and Theoretical Maximum Specific Gravity (Gmm) Verification Samples.** The Inspector will select different sample locations in each subplot according to PTM No. 1, PTM No. 729, and PTM No. 746. In the presence of the Inspector, obtain two core samples (One for acceptance and one for Gmm verification), or one core sample (for acceptance) and one loose mixture sample (for Gmm verification) for each subplot at each sample location and immediately package. If the contractor elects to obtain a loose mixture sample for the Gmm verification sample, obtain the sample from uncompacted placed mixture or from the paver screed. One core sample at each location will be used to determine the mixture acceptance and the second core sample or the 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 TR-447 sample identification forms.

Package individual loose mixture samples in 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. Package individual core samples in plastic 6 inch diameter concrete cylinder molds.

Immediately after packaging and in the presence of the Inspector, identify the samples by ECMS project number, lot and subplot 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 or cylinder mold free of any writing or marking for LTS use in testing the samples.

Immediately after identifying, submit the samples to the Inspector.

For quality control purposes, a maximum of one loose sample per subplot 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.c Mixture and Density Acceptance Sample Testing.** LTS Testing will be utilized unless otherwise indicated in the contract.

**2.c.1 LTS Testing.** The LTS will test the density acceptance samples according to PTM No. 715, and if necessary PTM No. 716, to determine the percent compaction. 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 419.3(i)2.a.1.

The LTS will then randomly select one of the Gmm verification cores or loose mixture samples obtained as specified in Section 419.3(i)2.b from the lot according to PTM No. 1. The LTS will test the randomly selected Gmm verification core or 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.

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  $\pm 0.030$ , 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  $\pm 0.030$ , 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 averaged 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 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  $\mu\text{m}$  (No. 200) sieve. For PTM No. 757, the LTS will use the calibration factors ( $C_f$  and 200  $C_p$ ) provided with the JMF. 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 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 ( $n\geq 3$ ) tolerances in Table D for two consecutive lots or a total of three lots
- the percent passing the 75  $\mu\text{m}$  (No. 200) sieve is not within the single sample ( $n=1$ ) or multiple sample ( $n\geq 3$ ) 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.** 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.

The Inspector will select different sample locations in each subplot 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 ( $G_{mb}$ ) 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 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 subplot 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 from 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 described in Section 419.3(i)2.c.1. Immediately deliver the samples to the Inspector 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 quality control purposes, a maximum of one pavement core per subplot 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

**(l) Joints.** Section 409.3(k).

(m) **Surface Tolerance.** Section 409.3(l)

(n) **Tests for Depth.** Section 409.3(m)

(o) **Protection of Courses.** Section 409.3(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 409.3(l) and depth as specified in Section 409.3(m). Remove and replace pavement defective for percent within tolerance or Payment Factor Percentage as specified in Table F.

**419.4 MEASUREMENT AND PAYMENT—**

(a) **SMA RPS Construction.**

1. **SMA Wearing Course RPS.** Square Yard or Ton

2. **Bituminous 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 G. 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 H.

3.a **Payment.** Section 409.4(a)4.a

**TABLE G  
Contract Price Adjustments**

Test Criteria	Test Value	Payment Factor Percentage
<b>Asphalt Content</b>		
Acceptance Sample testing of % Asphalt	All acceptance sample test results are within $\pm 0.7\%$ for $n=1$ and $\pm 0.4\%$ for $n \geq 3$ of the JMF	100
	Percent Within Tolerance if all acceptance sample test results are not within $\pm 0.7\%$ for $n=1$ and $\pm 0.4\%$ for $n \geq 3$ of the JMF	Section 409.4(a) Table K
<b>Gradation</b>		
Acceptance Sample Testing of % Passing 75 $\mu$ m (No. 200) Sieve	All acceptance sample test results are within +4.0% and -2.0% for $n=1$ , and +3.0% and -1.5% for $n \geq 3$ of the JMF	100
	Percent Within Tolerance if all acceptance sample test results are not within +4.0% and -2.0% for $n=1$ , and +3.0% and -1.5% for $n \geq 3$ of the JMF	Section 409.4(a) Table K
<b>Mat Density</b>		
Acceptance Sample Testing of Pavement Cores	All individual results for the lot are $\geq 93.0\%$ and $\leq 98.0\%$ of the maximum theoretical density	100

	Percent Within Tolerance if any individual subplot test result for the lot is not $\geq 93.0\%$ and $\leq 98.0\%$ of the maximum theoretical density.	Section 409.4(a) Table K
--	---	-----------------------------

**TABLE H**  
**Upper and Lower Specification Limits for Calculating Percent Within Tolerance**

Testing Criteria	
Lower Specification Limit (L)	Upper Specification Limit (U)
<b>Asphalt Content from JMF Value, %</b>	
-0.4	+0.4
<b>Percent Passing the 75 <math>\mu\text{m}</math> (No. 200) sieve from JMF Value, %</b>	
-1.5	+3.0
<b>Mat Density*</b>	
92.0	98.0
* The Percent of Theoretical Maximum Density	

**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. 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  $\mu\text{m}$  (No. 200) sieve, the Inspector will identify the locations where the original mixture acceptance 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 subplot, 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 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  $\mu\text{m}$  (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 according to Section 409.3(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 409.3(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  $\geq 1.5\%$  as indicated on the JMF and then only when the calculated percent of theoretical maximum density indicates any one individual failing subplot 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 subplot 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 I:

**TABLE I**  
**Dispute Resolution Retest Cost Table**

Test Method	Mixture Acceptance Retest Cost if Retest Results Indicate	Mixture Acceptance Retest Cost if Retest Results Indicate
	100% Pay Factor(s)	<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 Repeatability
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 409.3(j)4.d.1	\$1,100	\$4,000

## SECTION 702—BITUMINOUS MATERIAL

**702.1 GENERAL**—Obtain bituminous material conforming to the requirements of Bulletin 25 from a producer listed in Bulletin 15.

(a) **QC.** Prepare a QC Plan as specified in Section 106.03(a)2. Submit the QC Plan to the LTS for review before shipping material to the project and at least annually. For PG-Binder suppliers, the QC Plan shall conform to AASHTO R 26 as supplemented by Bulletin 25.

**(b) Certification.**

**1. General.**

- Obtain a verification sample from each batch and test according to Bulletin 25. A batch is a tank completely filled, partially filled, or refilled with a blend of residual and new material. Test one-half of each sample and forward the results and remaining one-half of each sample to the LTS. The LTS will evaluate QC on the basis of verification samples.
- Provide a certificate of compliance signed by a responsible company official that lists the type of material, tank number, and company lot number for cross-referencing to the bill of lading.
- The Department's QA Teams will periodically review the QC Plan, inspect production and testing facilities, and take QA samples of material either at the plant or the point where the material will be incorporated into the project.

**2. Levels of Certification.** Section 106.03.(b)3.e

(c) **Handling and Transportation.** Section 106.06 and as follows:

For each shipment to the project or bituminous concrete producer, submit one copy of the vendor's bill of lading on a form acceptable to the LTS that contains the following information:

- Statement that the material has been tested and conforms to Bulletin 25.
- Statement that the shipment container was free of contamination before loading.
- Class of material.
- Tank number.
- Company batch number.
- Date of shipment.
- Producer's name and location.
- Consignee's name and location (Bituminous Concrete Plant or Maintenance District).
- For cutback asphalts and emulsified asphalts, minimum and maximum mix or application temperature requirements, handling and storage requirements for proper usage, percent bitumen residue by weight, and statement that material is compatible with job aggregate.
- For non-polymer-modified PG-Binders, a temperature-viscosity chart (Figure 1, Bulletin 25) for each lot or batch of material to be shipped based on the rotational viscosities in either Pascal-seconds (Pa-s) or centipoises at 275F and 329F. Instead of plotted data, provide minimum and maximum laboratory

mixing and compaction temperatures based on Figure 1, Bulletin 25. The bituminous mixture placement temperatures for the type and class of PG-Binder used are listed in Section 409 or Section 411, Table A and Bulletin 25.

- For polymer-modified PG-Binders, any specific handling and storage requirements and minimum and maximum laboratory mixing and compaction temperatures. The bituminous mixture placement temperatures for the type and class of PG-Binder used are listed in, Section 409 or Section 411, Table A and Bulletin 25.
- Specific gravity at 60F.
- Quantity of material.

## 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 that are present in amounts large enough to cause inconsistent performance in the properties of bituminous 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 conforming 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. The Department will accept manufactured sand only if it is the primary product of the crushing operation and sized by a sand classifier. However, for fine aggregate used in bituminous concrete mixtures, a sand classifier is not required.

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 bituminous 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. 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 two 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 as required in 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 that 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  $\pm 0.20$  from the average fineness modulus of the consecutive test samples. Determine the fineness modulus according to PTM No. 501.

For bituminous mixtures:

- If directed, vary the gradations within the limits listed in 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 of Table A and use cement, cement dust, fly ash, or fines from the crushing of stone, gravel, or slag that are reasonably free of clay.

**2. Material Finer than the 75  $\mu\text{m}$  (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 requirements of 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**

Sieve Size	Cement Concrete Sand	Bituminous Concrete Sand Type B			Mortar Sand
	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 $\mu\text{m}$ (No. 30)	25-65	20-65	20-65	100	—
300 $\mu\text{m}$ (No. 50)	10-30	7-40	7-40	95-100	—
150 $\mu\text{m}$ (No. 100)	0-10	2-20	2-20	90-100	0-25
75 $\mu\text{m}$ (No. 200)	—	0-10	0-10	70-100	0-10
Material Finer Than 75 $\mu\text{m}$ (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 that are present in amounts large enough to cause inconsistent performance in the properties of bituminous 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 that 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 bituminous 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. 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. 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.

**4. Steel Slag.** By-product of a steel making process. Tough, hard, and durable pieces of steel slag reasonably uniform in density and quality. 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 two additional months before resampling and retesting.

Aggregate manufactured from steel slag is not acceptable for pipe or structure backfill or in cement concrete. Steel slag may be used for subbase, selected granular material, shoulders, selected material surfacing, and in bituminous surface courses.

**5. Granulated Slag.** By-product of an iron-making process. Granulated blast furnace slag is the granular glassy material formed when molten slag from iron-making is rapidly quenched by immersion in water and contains not more than 3% total iron reported as  $Fe_2O_3$ . 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  $\mu$ m (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 as specified in 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 that 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<sup>(8)</sup>**

	<b>Type A</b>	<b>Type B</b>	<b>Type C</b>	<b>Type S</b>
Soundness, Max. %	10	12	20	16
Abrasion, Max. %	45 <sup>(6)</sup>	45 <sup>(6)</sup>	55 <sup>(6)</sup>	55 <sup>(6)</sup>
Freeze-Thaw Loss, Max %	—	—	—	7.0 <sup>(7)</sup>
Thin and Elongated Pieces, Max. %	15	20	—	—
Material Finer Than 75 µm (No. 200) Sieve, Max. %	— <sup>(1)</sup>	— <sup>(1)</sup>	10	10
Crushed Fragments, Min. %	55 <sup>(2)</sup>	55 <sup>(2)</sup>	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 <sup>(3)</sup>	4 or 10 <sup>(3)</sup>	—	—
Iron, Max. %	3 <sup>(5)</sup>	3 <sup>(5)</sup>	3 <sup>(5)</sup>	3 <sup>(5)</sup>
Absorption, Max. %	3.0 <sup>(4)</sup>	3.5 <sup>(4)</sup>	—	2 <sup>(4)</sup>
Total of Deleterious Shale, Clay Lumps, Friable Particles, Coal, or Coke Allowed, Max. %	2	2	15	15
Notes:				
(1) See Section 703.2(c)4.				
(2) See Section 703.2(c)5.				
(3) See Section 703.2(c)9.				
(4) Gravel only for Types A and B. See Section 703.2(c)2. All natural aggregates for Type S.				
(5) See Section 703.2(c)10.				
(6) Blast Furnace Slag excluded. See Section 703.2(a)3.				
(7) 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.

- (8) Test methods to determine the quality requirements of Table B are indicated 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 aggregate in subbase only. Other recycled concrete may be used in subbase if the concrete was made using materials approved by the Department. Provide recycled concrete conforming to Table B and Table C, except soundness testing is not required.

**(b) Production Testing.**

**1. Personnel and Equipment.** Provide and assign to the work a PennDOT Certified Aggregate Technician who will test coarse 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 as required in 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 that 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. Measuring 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 bituminous mixtures.

\*\* PennDOT Number – Only Type C 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, provided that not 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 bituminous concrete; however, the aggregate is required to be clean and free of fines that would adversely affect the coating of the aggregate with bituminous 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 bituminous 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 when aggregate with metallic iron is used in bituminous 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 AASHTO T 27:

- Passing 50 mm (2-inch) sieve—100%
- Passing 4.75 mm (No. 4) sieve—15% to 60%
- Passing 150  $\mu$ m (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 that may be 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 bituminous coal mine waste, and within the maximum limits of the individual deleterious and total deleterious materials as specified in Section 703.2(a), 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 ASMT D 5821.
- 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.** Conforming 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%, then the total percent passing the 75 µm (NO. 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 T 2 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 any additional materials from the stockpile(s) until test results from source verification samples have  $PWL \geq 90$ .

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 for compliance with Tables A, B, C, and D, as applicable. If the test results verify that 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 according to 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 that 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 that 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**

<b>Aggregate Quantities</b>	<b>Number of Samples (<math>n=3</math>)</b>
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 when 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 that 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 with

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 of 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.

- When 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 that 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  $\geq 90$ PWL. Once five consecutive lots are accepted at  $\geq 90$  PWL, acceptance may again be by producer certification and verification testing will begin again at the frequency in 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 according to Section 106.03(a)3. If results indicate a  $PWL \geq 90$ , 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 any sieve size 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 shown in 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 in Table G and Table H. The total DNC will be used to adjust the payment represented by the non-conforming lot as shown in Table I.

**TABLE G**  
**Multiplication Factors for DNC**

<b>Sieve Size</b>	<b>Multiplication Factor</b>
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**

<b>% Maximum</b>	<b>Upper Limit To Calculate DNC</b>	<b>Multiplication Factor</b>
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**

<b>Total Sum of DNC</b>	<b>Percent of Contract Unit Price Reduction</b>
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 that 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 PWT 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 PWT for the material. If results indicate a PWT 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 with Section 107.23(b). Designate a licensed weigh person(s) to act as the Contractor's agent. Ensure that 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 that they were implemented.

#### **703.6 CERTIFICATION OF AGGREGATES AT BITUMINOUS AND CEMENT CONCRETE PLANTS—**

**(a) Certification.** Certify aggregate at bituminous and cement concrete plants yearly for quality requirements as specified in Section 106.03(b)3 using Form CS-4171 or another acceptable form.

## 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 his 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 5 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 subplot 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.

This page left intentionally blank

## 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 on 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 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:

- M-92, Wire-Cloth Sieves for Testing Purposes
- R-16, Regulatory Information for Chemicals Used in AASHTO Tests
- T-27, Sieve Analysis of Fine and Coarse Aggregate

##### 2.2 ASTM Standards:

- C 670, Practice for Preparing Precision Statements for Test Methods for Construction Materials
- E 100, Specification for ASTM Hydrometers

### 3. APPARATUS

3.1 Sieves- With square openings of the following sizes conforming to AASHTO M-92, for sieving the samples in accordance with Sections 5, 6, and 8:

4.75 mm	(No. 4)	63 mm	(2½")
4.00 mm	(No. 5)	50 mm	(2")
2.36 mm	(No. 8)	37.5 mm	(1½")
1.18 mm	(No. 16)	31.5 mm	(1¼")
600 µm	(No. 30)	25.0 mm	(1")
300 µm	(No. 50)	19.0 mm	(¾")
150 µm	(No. 100)	16.0 mm	(⅝")
		12.5 mm	(½")
		9.5 mm	(⅜")
		8.0 mm	(5/16")

3.2 Mechanical Sieving Device- A mechanical sieving device shall provide the motion specified in PTM 616, Sieve Analysis of Coarse and Fine Aggregate (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"), 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 (4⅞") in diameter and not less than 76 mm (3") deep are satisfactory containers for the samples.

3.3.2 For Coarse Aggregates- Stainless steel or aluminum pans, approximately 203 mm (8") in diameter and not less than 76 mm (3") 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 (0.2°F).

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  $110 \pm 5^{\circ}\text{C}$  ( $230 \pm 9^{\circ}\text{F}$ ) 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  $21 \pm 2^{\circ}\text{C}$  ( $70 \pm 3^{\circ}\text{F}$ ), 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  $\pm 0.001$ .

#### 4. SODIUM SULFATE SOLUTION

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 the salt in water (Note 4) at a temperature of  $25^{\circ}\text{C}$  ( $77^{\circ}\text{F}$ ) minimum. Add sufficient salt (Note 3) of the anhydrous ( $\text{Na}_2\text{SO}_4$ ) form to ensure not only saturation but also the presence of excess crystals when the solution is ready for use in the tests. 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  $20.3$  to  $21.9^{\circ}\text{C}$  ( $68.5$  to  $71.5^{\circ}\text{F}$ ). Again stir, and allow the solution to remain at the designated temperature 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 3- 215 g of anhydrous salt per liter of water is sufficient for saturation of the sodium sulfate solution at  $22^{\circ}\text{C}$  ( $71.6^{\circ}\text{F}$ ). 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 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<sub>2</sub> 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") 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 (3/8")	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 sample contain less than 5 percent 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.

Table 1 - Coarse Aggregate Sample

Sieve Size	Mass, g
63 mm to 37.5 mm (2½" to 1½")	5000 ± 300
Consisting of:	
50 mm to 37.5 mm (2" to 1½") material	2000 ± 200
63 mm to 50 mm (2½" to 2") material	3000 ± 300
37.5 mm to 19.0 mm (1½" to ¾")	1500 ± 50
Consisting of:	
25.0 mm to 19.0 mm (1" to ¾") material	500 ± 30
37.5 mm to 25.0 mm (1½" to 1") material	1000 ± 50
19.0 mm to 9.5 mm (¾" to ⅜")	1000 ± 10
Consisting of:	
12.5 mm to 9.5 mm (½" to ⅜") material	330 ± 5
19.0 mm to 12.5 mm (¾" to ½") material	670 ± 10
9.5 mm to 4.75 mm (⅜" to No. 4)	300 ± 5

NOTE 5- The sample size for AASHTO No. 8's shall be  $300 \pm 5$  g passing the 3/8" sieve retained on the No. 4 sieve only.

5.2.1 Should the sample contain less than 5 percent 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 percent of the sample, 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 to 19.0 mm (1½ to ¾") and 63 to 37.5 mm (2½ to 1½") 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") sieve.

5.2.4 When the finished aggregate material will contain particles coarser than 63 mm (2½"), such as aggregate for use in mass concrete, crush the material coarser than 63 mm (2½") and distribute the material among that in the range of 63 mm (2½") 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  $110 \pm 5^\circ\text{C}$  ( $230 \pm 9^\circ\text{F}$ ), 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). Do not use fine aggregate sticking in the meshes of the sieves in preparing the samples. Weigh samples consisting of  $100 \pm 0.1$  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  $110 \pm 5^\circ\text{C}$  ( $230 \pm 9^\circ\text{F}$ ) and separate it into the different sizes shown in Section 5.2 by sieving to refusal. 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 (¾"), 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 <sup>a</sup>	0.45	
Totals		100			5.33	
Soundness Test of Coarse Aggregate						
63 mm to 50 mm	2825 g	63 to 37.5 mm	20	4783	4.80	0.96
50 mm to 37.5 mm	1958 g					
37.5 mm to 25.0 mm	1012 g	37.5 to 19.0 mm	45	1525	8.00	3.60
25.0 mm to 19.0 mm	513 g					
19.0 mm to 12.5 mm	675 g	19.0 to 9.5 mm	23	1008	9.60	2.21
12.5 mm to 9.5 mm	333 g					
9.5 mm to 4.75 mm			12	298	11.20	1.34
Totals			100			8.11

<sup>a</sup> The percentage loss (11.20 percent) of the next smaller size is used as the percentage loss for this size, since this size contains less than 5 percent 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 2A, OGS, #57, #67, the standard grading is as follows:

Table 3 - AASHTO 2A OGS, #57, #67 Gradation

Sieve Size		Standard Grading %
Passing	Ret. On	
7.5 mm (1½")	19.0 mm (¾")	36.8
9.0 mm (¾")	9.5 mm (⅜")	36.9
9.5 mm (⅜")	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"), 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 to 21.9°C (68.5 to 71.5°F) 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 ± 5°C (230 ± 9°F). 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 percent of sample mass in 4 hours of drying. After constant mass has been achieved, allow the samples to cool to 20 to 25°C (68 to 77°F) (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 21.1°C (70.0°F) may change the temperature of the solution temporarily, thereby causing a change in salt saturation even though the solution returns to 21.1°C (70.0°F) 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  $43 \pm 6^\circ\text{C}$  ( $110 \pm 10^\circ\text{F}$ ) 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 checked 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, dry each fraction of the sample to constant mass at  $110 \pm 5^\circ\text{C}$  ( $230 \pm 9^\circ\text{F}$ ). 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")	31.5 mm (1¼")
37.5 mm to 19.0 mm (1½ to ¾")	16.0 mm (⅝")
19.0 mm to 9.5 mm (¾ to ⅜")	8.0 mm (5/16")
9.5 mm to 4.75 mm (⅜" 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 (¾") 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 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 (¾") 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 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 aggregates sizes finer than the 300 µm (No. 50) sieve they shall be assumed to have 0 percent 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 percent 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") sieve, assume such sizes to have the same percentage loss as the 63 to 37.5 mm (2½ to 1½") 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 (¾") sieve before the test: (1) count the number of particles in each fraction before the test, and (2) count the number of particles affected, classified as to number disintegrating, splitting, crumbling, cracking, flaking, etc., as shown in Table 4.

Table 4 - Suggested Form for Qualitative Examination (with Illustrative Test Values)

Qualitative Examination of Coarse Sizes									
Sieve Size	Particles Exhibiting Distress								Total No. of Particles Before Test
	Splitting		Crumbling		Cracking		Flaking		
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	
63 mm to 37.5 mm (2½ to 1½")	2	7			2	7			29
37.5 mm to 19.0 mm (1½ to ¾")	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 ranges of 6 to 16 percent for sodium sulfate, the precision indexes are as indicated, in Table 5 (Note 12).

Table 5 - Precision Indexes

	Coefficient of Variation (1S%), Percent <sup>a</sup>	Difference Between Two Tests (D2S%), Percent of Average <sup>a</sup>
Multilaboratory:		
Sodium sulfate	41	116
Single-Operator:		
Sodium sulfate	24	68

<sup>a</sup> These numbers represent, respectively, the (1S%) and (D2S%) limits as described in ASTM C 670.

NOTE 12- The values in the precision statement are based on testing according to this method prior to revision in 1991. The revisions in 1991 are believed to improve the precision of the method.

This page left intentionally blank

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](http://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  $110 \pm 5^{\circ}\text{C}$  ( $230 \pm 9^{\circ}\text{F}$ ). 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.

This page left intentionally blank

## LABORATORY TESTING SECTION

### Method of Test for

## QUANTITATIVE EXTRACTION OF BITUMEN FROM BITUMINOUS PAVING MIXTURES

### 1. 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 ( $\pm 0.1$  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  $163 \pm 5^{\circ}\text{C}$  ( $325 \pm 9^{\circ}\text{F}$ ).
- 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  $(\text{NH}_4)_2\text{CO}_3$ .
- 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  $163 \pm 5$  °C ( $325 \pm 9$  °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  $163 \pm 5$  °C ( $325 \pm 9$  °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  $163 \pm 1.5$  °C ( $325 \pm 9$  °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  $88 \pm 5.5$  °C ( $190 \pm 10$ °F). Also, the extracted aggregate shall be dried to a constant mass at  $88 \pm 5.5$  °C ( $190 \pm 10$ ° 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, 1-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 ( $\pm 0.1$  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 as possible and add the mineral matter to the aggregate in the bowl. Dry the ring to constant mass in an oven at  $163 \pm 5$  °C ( $325 \pm 9$  °F). Dry the contents of the bowl to a constant mass in an oven at  $163 \pm 5$  °C ( $325 \pm 9$  °F).

NOTE 10- The sample shall be dried until further drying at  $163 \pm 5$  °C ( $325 \pm 9$  °F) 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 °C), cool, and add 5 mL of saturated ammonium carbonate solution  $(\text{NH}_4)_2\text{CO}_3$  per gram of ash. Digest at room temperature for one hour. Dry the ash in an oven at  $110 \pm 5$  °C ( $230 \pm 9$  °F) 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:

$$\text{grams total ash} = G \times \frac{V + 100}{100}$$

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:

$$\% \text{ Bitumen content of a dry sample} = [(W_1 - W_2) - (W_3 + W_4 + W_5)] \times \frac{100}{(W_1 - W_2)}$$

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  $\mu\text{m}$  openings (No.185 mesh), shaped to cover completely the inside of the basket.

10.1.4 Thermometer-, Accurate to 0.1 °C (0.2° F), covering a temperature range of 19 to 27 °C (66 to 80 °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  $163 \pm 5$  °C ( $325 \pm 9$  °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 °C (0.2° F), covering a temperature range of 19 to 27 °C (66 to 80 °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 °C (325 °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  $163 \pm 5$  °C ( $325 \pm 9$  °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 °C (80 °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 °C (77.0 °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 °C (0.2 °F) at the time of weighing.

NOTE 15 – A correction can be applied for extract temperatures differing from 25 °C (77.0 °F), between 23 and 27 °C (74 and 80 °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 °C above 25 °C (0.7 g per degree above 77 °F), and subtract 1.23 grams from the weight for each degree below 25 °C (0.7 g per degree below 77 °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

$$\% \text{ bitumen} = [G_2 / (W_1(G_3 - G_2))] \times [G_3(V_1 - ((W_2 + W_3 - W_1) / G_1)) + W_3 - W_1] \times 100$$

Where:

$G_1$  = Specific gravity of the solvent at 25 °C (77.0 °F)  
(within 0.001)

$G_2$  = Specific gravity of the bitumen at 25 °C (77.0 °F)  
(within 0.01)

$G_3$  = Specific gravity of the aggregate fines at 25 °C (77.0° F) (within 0.1)

$V_1$  = Volume of the bitumenometer at 25 °C (77.0° 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  $\pm 0.1$  percent for the following variations in the measurements of specific gravities:

specific gravity of the solvent  $\pm 0.001$   
 specific gravity of the bitumen  $\pm 0.01$

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:

$$W_4 = (G_3 / (G_3 - G_2)) \times [W_1 - W_3 - G_2(V_1 - ((W_2 - W_1 + W_3) / G_1))]$$

Where:

$W_4$  = Mass of the fines in the extract

## PROCEDURE 2

### Percent Bitumen Calculation

Specific Gravity of Bitumen ( $\pm 0.01$ ) at 25 C (77.0 F)	$G_2 =$
Specific Gravity of Aggregate Fines ( $\pm 0.1$ ) at 25 C (77.0 F)	$G_3 =$
Specific Gravity of Solvent ( $\pm 0.001$ ) 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	$W_d = W_2 - W_c$
<u>Weight of Solvent (<math>W_d</math>) ( ) = Volume of Solvent (<math>V_a</math>)</u>	
Sp. Gr. Of Solvent ( $G_1$ ) ( ) in the Bitumenometer	
Volume of Bitumenometer	$V_1 =$
- Volume of Solvent	$V_a =$
Volume of Extraction Loss or Volume of Bitumen & Fines:	
	$V_b = V_1 - V_a$
Volume of Extraction Loss	$V_b =$
<u>x Sp. Gr. Of Aggregate Fines</u>	$G_3 =$
Algebraic Term (Weight of Extraction Loss)	$a_1 = V_b \times G_3 =$
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)	$a_3 = G_3 - G_2 =$
<u>Algebraic Term (Weight of Bitumen) (<math>a_2</math>) ( ) =</u>	Volume of Bitumen
Algebraic Term (Sp. Gr. Of Bitumen) ( $a_3$ ) ( )	in Sample ( $V_c$ )
Volume of Bitumen in Sample	$V_c =$
<u>x Specific Gravity of Bitumen</u>	$G_2 =$
Weight of Bitumen in Sample	$W_e = V_c \times G_2 =$
<u>Weight of Bitumen in Sample (<math>W_e</math>) ( ) x 100 =</u>	% of Bitumen
Weight of Original Sample ( $W_1$ ) ( )	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  $163 \pm 5^{\circ}\text{C}$  ( $325 \pm 9^{\circ}\text{F}$ ) 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.

<b>Superpave or SMA Mixture Nominal Maximum Aggregate Size (NMAS), mm</b>	<b>Other Asphalt Mixtures or Material Classes</b>	<b>Minimum Mass of Test Sample, g</b>
12.5 or smaller	FJ-1, FJ-1C, FJ-4, FB-1W, FB-2W, FB-3 Modified, Micro-Surfacing, Ultra-Thin Friction Course, Cold Patch	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  $700 \pm 50$  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  $163^{\circ}\text{C} \pm 5^{\circ}\text{C}$  ( $325^{\circ}\text{F} \pm 9^{\circ}\text{F}$ ) 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  $27^{\circ}\text{C}$  ( $80^{\circ}\text{F}$ ). 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  $163\text{ C} \pm 5^{\circ}\text{C}$  ( $325\text{ F} \pm 9^{\circ}\text{F}$ ). 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

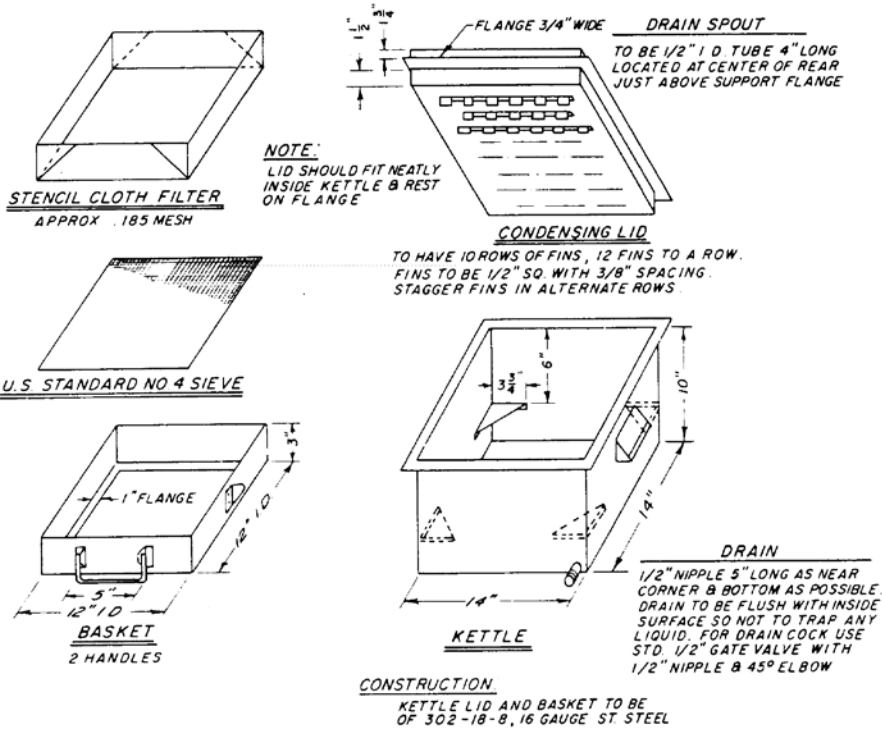
NOTE 20- The precision statement is derived from 10 laboratories testing 4 samples with 3 replicates per test.

28. REFERENCE

AASHTO Method T-164      ASTM Method D 2172

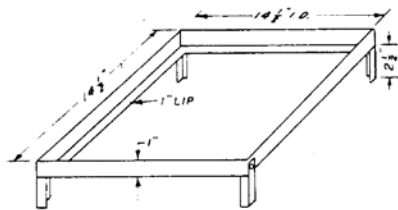
Attachments: Figures 1 thru 4; Table 1.





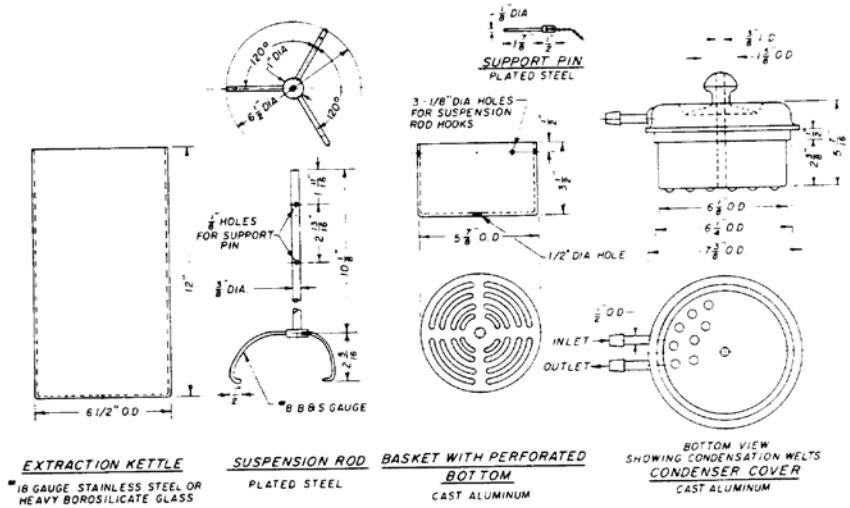
STAND MADE FROM 1" x 1" x 1/8" ANGLE IRON

See Table 1 for metric equivalents.



FRONT LEGS FIXED WITH SINGLE PIN  
 TO ALLOW LEGS TO FOLD BACK WHEN  
 DRAINING THE EXTRACTOR.

FIG. 2



NOTE—See Table 1 for metric equivalents.

FIG. 3

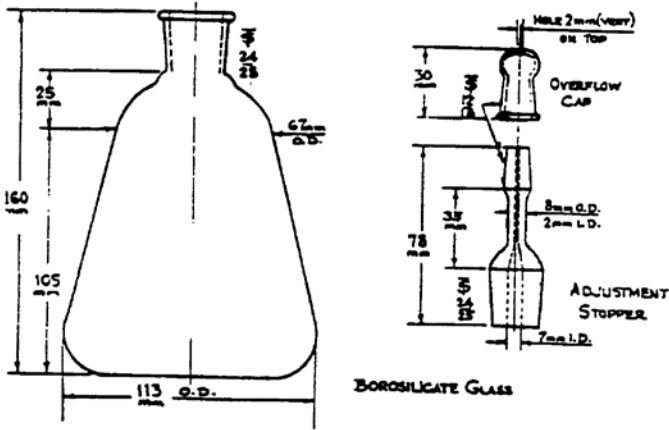


Figure 4 - Bitumenometer, 750ml Capacity



**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 1/16	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 3/4	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 5/8	257
1 3/16	30.2	4 1/4	108	12	305
1 1/2	35.7	5	127	14	355
1 1/2	38.0	5 7/16	138	14 1/2	370
1 5/8	41.0				

This page left intentionally blank

## 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):

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

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 1, 2 and 3 in the paving mixture

$G_1, G_2, G_3$  = bulk specific gravities of aggregates 1, 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:

<u>Constituent Material</u>	<u>Value</u>	<u>Bulk Sp. Gr Test Method</u>	<u>Percent by Weight Total Mix</u>
Coarse aggregate	2.604 (G <sub>1</sub> )	AASHTO T 85	51.4 (P <sub>1</sub> )
Fine aggregate #1	2.827 (G <sub>2</sub> )	AASHTO T 84	18.7 (P <sub>2</sub> )
Fine aggregate #2	2.619 (G <sub>3</sub> )	AASHTO T 84	22.9 (P <sub>3</sub> )
Asphalt cement	1.010 (G <sub>b</sub> )	AASHTO T 228	7.0 (P <sub>b</sub> )
TOTAL:			100.0

Maximum Sp. Gr. of Mix (AASHTO T 209) = 2.439 (G<sub>mm</sub>)

Calculate the Effective Asphalt Content in the above mixture as follows:

(a) Bulk Sp. Gr. of the Total Aggregate (G<sub>sb</sub>)

$$\begin{aligned}
 G_{sb} &= \frac{P_1 + P_2 + P_3}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \frac{P_3}{G_3}} \\
 &= \frac{51.4 + 18.7 + 22.9}{\frac{51.4}{2.604} + \frac{18.7}{2.827} + \frac{22.9}{2.619}} \\
 &= \frac{93.0}{19.739 + 6.615 + 8.744} \\
 &= \frac{93.0}{35.098} = 2.650
 \end{aligned}$$



(b) Effective Sp. Gr. of the Total Aggregate ( $G_{se}$ ):

$$\begin{aligned} G_{se} &= \frac{G_{mm} (100 - P_b)}{100 - \frac{G_{mm} \times P_b}{G_b}} \\ &= \frac{2.439 (100 - 7.0)}{100 - \frac{2.439 \times 7.0}{1.010}} \\ &= \frac{226.827}{100 - 16.904} \\ &= \frac{226.827}{83.096} = 2.730 \end{aligned}$$

(c) Percent Asphalt Absorbed by the Aggregate ( $P_{ba}$ ):

$$\begin{aligned} P_{ba} &= \frac{G_{se} - G_{sb}}{G_{se} \times G_{sb}} \times G_b \times 100 \\ &= \frac{2.730 - 2.650}{2.730 \times 2.650} \times 1.010 \times 100 \\ &= \frac{0.080}{7.234} \times 101.0 = 1.117 \end{aligned}$$

(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)	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**

<b>SAMPLE NO.</b>	1					
<b>SPECIFICATION</b>	ID-2W					
<b>AGGREGATE</b>	Gravel					
<b>% ASPHALT (Total) P<sub>b</sub></b>	7.0					
<b>MASS SAMPLE + H<sub>2</sub>O</b>	1826.9					
<b>- MASS S.S.D. SAMP.</b>	1229.3					
<b>= VOL WATER</b>	597.6					
<b>VOL VOLUMETER</b>	1122.8					
<b>- VOL WATER</b>	597.6					
<b>= VOL SAMPLE</b>	525.2					
<b>MASS SAMPLE</b>	1228.8					
<b>÷ VOL SAMPLE</b>	2.439					
<b>= SP GR SAMPLE</b>	503.8					
<b>MASS SAMPLE</b>	1228.8					
<b>÷ THEOR. SP GR (Gmm)</b>	2.439					
<b>= THEOR. VOL.</b>	503.8					
<b>VOL. SAMPLE</b>	525.2					
<b>- THEOR. VOL.</b>	503.8					
<b>= VOL. VOIDS</b>	21.4					
<b>÷ VOL. SAMPLE</b>	525.2					
<b>= % VOIDS</b>	4.1					
<b>MASS SAMPLE</b>	1228.8					
<b>x % ASPHALT (Effective) P<sub>be</sub></b>	6.0					
<b>= MASS ASPHALT</b>	73.7					
<b>÷ SP GR A.C.</b>	1.010					
<b>= VOL. A.C.</b>	73.0					
<b>+ VOL. VOIDS</b>	21.4					
<b>= VOL. V.M.A.</b>	94.4					
<b>÷ VOL. SAMPLE</b>	525.2					
<b>= % V.M.A.</b>	18.0					
<b>VOL. ASPHALT</b>	73.0					
<b>÷ VOL. V.M.A.</b>	94.4					
<b>= % V.F.A.</b>	77.3					
<b>MASS S.S.D. SAMP.</b>						
<b>- DRY MASS</b>						
<b>= MASS ABSORB.</b>						
<b>÷ VOL. SAMPLE</b>						
<b>= % ABSORB (VOL.)</b>						
<b>STABILITY</b>						
<b>FLOW</b>						
<b>AVG. SP. GR.</b>						
<b>AVG. % VOIDS</b>						
<b>AVG. % VMA</b>						
<b>AVG. % VFA</b>						
<b>AVG. STABILITY</b>						
<b>AVG. FLOW</b>						

TR-4265 (9-77)  
 M (1/96)



MARSHALL SPECIMEN WORK SHEET

<b>SAMPLE NO.</b>						
SPECIFICATION						
AGGREGATE						
% ASPHALT						
<b>MASS SAMPLE + H<sub>2</sub>O</b>						
- MASS S.S.D. SAMP.						
= VOL WATER						
<b>VOL VOLUMETER</b>						
- VOL WATER						
= VOL SAMPLE						
<b>MASS SAMPLE</b>						
÷ VOL SAMPLE						
= SP GR SAMPLE						
<b>MASS SAMPLE</b>						
÷ THEOR. SP GR						
= THEOR. VOL.						
<b>VOL. SAMPLE</b>						
- THEOR. VOL.						
= VOL. VOIDS						
÷ VOL. SAMPLE						
= % VOIDS						
<b>MASS SAMPLE</b>						
x % ASPHALT ( <i>Effective</i> )						
= MASS ASPHALT						
÷ SP GR A.C.						
= VOL. A.C.						
+ VOL. VOIDS						
= VOL. V.M.A.						
÷ VOL. SAMPLE						
= % V.M.A.						
<b>VOL. ASPHALT</b>						
÷ VOL. V.M.A.						
= % V.F.A.						
<b>MASS S.S.D. SAMP.</b>						
- 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, $P_{be}$ )	



## 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  $25 \pm 0.5^{\circ}\text{C}$  ( $77 \pm 0.9^{\circ}\text{F}$ )

3.3 Thermometer- ASTM 17C (17F), having a range of  $19$  to  $27^{\circ}\text{C}$  ( $66$  to  $80^{\circ}\text{F}$ ), graduated in  $0.1^{\circ}\text{C}$  ( $0.2^{\circ}\text{F}$ ) subdivisions

3.4 Volumeter<sup>1</sup> - 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  $25 \pm 1^{\circ}\text{C}$  ( $77 \pm 1.8^{\circ}\text{F}$ ). Place the saturated specimen into the volumeter. Bring the temperature of the water in the volumeter to  $25 \pm 1^{\circ}\text{C}$  ( $77 \pm 1.8^{\circ}\text{F}$ ), 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  $52 \pm 3^{\circ}\text{C}$  ( $125 \pm 5^{\circ}\text{F}$ ) does not alter the mass by more than 0.05 percent. Samples saturated with water shall initially be dried overnight at  $52 \pm 3^{\circ}\text{C}$  ( $125 \pm 5^{\circ}\text{F}$ ), 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.

<sup>1</sup>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  $52 \pm 3^{\circ}\text{C}$  ( $125 \pm 5^{\circ}\text{F}$ ) 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):

$$G_{Sm} = \frac{W_{Sm}}{(0.997 \text{ g/mL}) \times [V_{Vo} - (1.003 \text{ mL/g}) \times (W_T - W_{Sa} - W_{Vo})]}$$

Where:

$G_{Sm}$  = bulk specific gravity of the specimen at  $25.0^{\circ}\text{C}$  ( $77^{\circ}\text{F}$ )

$W_{Sm}$  = mass in grams of the dry specimen

$V_{Vo}$  = volume in mL of the volumeter at  $25.0^{\circ}\text{C}$  ( $77^{\circ}\text{F}$ ) to the nearest tenth of a milliliter

$W_T$  = total mass in grams of the volumeter, saturated specimen, and water in the volumeter at  $25.0^{\circ}\text{C}$  ( $77^{\circ}\text{F}$ )

$W_{Sa}$  = mass in grams of the saturated specimen

$W_{Vo}$  = 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):

$$\text{Percent Water Absorbed} = \frac{\text{WSa} - \text{WSm}}{(0.997 \text{ g/mL}) \times [\text{VVo} - (1.003 \text{ mL/g}) \times (\text{WT} - \text{WSa} - \text{WVo})]} \times 100$$

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  $52 \pm 3^{\circ}\text{C}$  ( $125 \pm 5^{\circ}\text{F}$ ) does not alter the mass by more than 0.05 percent. Samples saturated with water shall initially be dried overnight at  $52 \pm 3^{\circ}\text{C}$  ( $125 \pm 5^{\circ}\text{F}$ ), 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

This page left intentionally blank

## 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  $25 \pm 0.5^{\circ}\text{C}$  ( $77 \pm 0.9^{\circ}\text{F}$ )

3.3 Thermometer- An ASTM 17 C (17 F), having a range of  $19$  to  $27^{\circ}\text{C}$  ( $66$  to  $80^{\circ}\text{F}$ ), graduated in  $0.1^{\circ}\text{C}$  ( $0.2^{\circ}\text{F}$ ) subdivisions

3.4 Volumeter<sup>1</sup> – Calibrated, 1.2 L or an appropriate capacity depending on the size of the test sample

<sup>1</sup>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  $52 \pm 3^{\circ}\text{C}$  ( $125 \pm 5^{\circ}\text{F}$ ) 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  $4.5^{\circ}\text{C}$  ( $40^{\circ}\text{F}$ ) for 30 min. and then dipping the specimen in warm paraffin at  $5.5^{\circ}\text{C}$  ( $10^{\circ}\text{F}$ ) 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  $25^{\circ}\text{C}$  ( $77^{\circ}\text{F}$ ). 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  $25 \pm 1^{\circ}\text{C}$  ( $77 \text{ F} \pm 2^{\circ}\text{F}$ ), 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:

$$G_{Sm} = \frac{W_{Sm}}{V_{Vo} - [(P_{W_{Sm}} + W_{Wa}) - P_{W_{Sm}}] + \frac{(P_{W_{Sm}} - W_{Sm})}{GP}}$$

Where:

$G_{Sm}$  = Specific gravity of the specimen at 25.0°C (77°F)

$W_{Sm}$  = Mass in grams of the uncoated specimen in air at 25.0°C (77°F)

$V_{Vo}$  = Volume in cc of the volumeter at 25.0 °C (77°F)

$P_{W_{Sm}}$  = Mass in grams of the paraffin coated specimen in air at 25.0 °C (77°F)

$(P_{W_{Sm}} + W_{Wa})$  = Mass in grams of the paraffin coated specimen and water in the volumeter at 25.0°C (77°F)

$GP$  = Specific gravity of the paraffin at 25.0°C (77°F)

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<sup>3</sup> (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  $25 \pm 1^{\circ}\text{C}$  ( $77 \pm 2^{\circ}\text{F}$ ).

### 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  $25 \pm 1^{\circ}\text{C}$  ( $77 \pm 2^{\circ}\text{F}$ ). Designate this as mass E.

7.4 Determine the specific gravity of the paraffin at  $25^{\circ}\text{C}$  ( $77^{\circ}\text{F}$ ), 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 25°C (77°F)

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.

This page left intentionally blank

## 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  $2,500 \times (\text{sieve opening in mm}) \times (\text{sieving surface area in m}^2)$ . For the 2.36 mm (No.8) sieve, the mass retained shall not exceed  $9 \text{ kg/m}^2$  ( $6\text{g/in.}^2$ ), 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  $6 \text{ kg/m}^2$  ( $4\text{g/in.}^2$ ), 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  $\mu\text{m}$  (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  $\mu\text{m}$  (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  $\mu\text{m}$  (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

This page left intentionally blank



## 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  $538\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$  ( $1000\text{F} \pm 9\text{F}$ ) 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**

<b>Bituminous Mixture</b>	<b>Minimum Mass of Specimen, g</b>
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  $163\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$  ( $325\text{F} \pm 9\text{F}$ ) 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 75 $\mu$ m (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  $\mu$ m (No. 200) sieve of the burnt samples minus the percent passing the 75  $\mu$ m (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:

$$\text{Actual asphalt \%} = [(\% \text{RAP}/100) \times \text{Pbr}] + \% \text{ Virgin Asphalt Added}$$

$$\text{Pbr} = \text{Corrected Percent Asphalt in 100\% RAP}$$

$$\% \text{ Virgin Asphalt Added} = \% \text{ of new asphalt by total mix weight}$$

EXAMPLE: If THE JMF INDICATES 20% RAP Material:

6.2% Avg. Total Loss

$$\text{Pbr} = 6.2\% - 0.5\% = 5.7\%$$

4.3% new asphalt added

THEN:  $\text{Actual Asphalt \%} = [(20/100) \times 5.7] + 4.3\%$   
 $\text{Actual Asphalt \%} = 1.14\% + 4.3\% = 5.44\%$

$$\text{Cf} = \frac{[(D1 - P1) + (D2 - P2)]}{2}$$

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  $163\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$  ( $325\text{F} \pm 9\text{F}$ ) 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  $163\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$  ( $325\text{F} \pm 9\text{F}$ ) 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  $163\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$  ( $325\text{F} \pm 9\text{F}$ ) 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  $578\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$  ( $1072\text{F} \pm 9\text{F}$ ), 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  $\mu\text{m}$  (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  $163\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$  ( $325\text{F} \pm 9\text{F}$ )

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  $650\text{ }^{\circ}\text{C}$  ( $1202^{\circ}\text{F}$ ), 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  $538\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$  ( $1000\text{F} \pm 9\text{F}$ ). 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  $\pm 5$  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  $578\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$  ( $1072\text{F} \pm 9\text{F}$ ). 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  $\mu\text{m}$  (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  $163\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$  ( $325\text{F} \pm 9\text{F}$ )

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  $650\text{ }^{\circ}\text{C}$  ( $1202\text{F}$ ), 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  $538\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$  ( $1000\text{F} \pm 9\text{F}$ ).

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<sub>a</sub> = the total weight of the aggregate remaining after ignition  
W<sub>s</sub> = 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<sup>2</sup> (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

<b>A</b>	Mass of Aggregate before wash	=	1143.0
<b>B</b>	Mass of Aggregate after wash	=	1085.4
<b>C</b>	Mass Loss on wash	=	57.6
<b>D</b>	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	
600 $\mu$ m (No. 30)	126	+	57.6	=	183.6	16	
300 $\mu$ m (No. 50)	61	+	57.6	=	118.6	10	
150 $\mu$ m (No. 100)	23	+	57.6	=	80.6	7	
<b>75<math>\mu</math>m (No. 200)</b>	<b>1.3</b>	<b>+</b>	<b>57.6</b>	<b>=</b>	<b>58.9</b>	<b>5.2</b>	<b>- 0.5 = 4.7</b>

## **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.**

OS-299 (7-08)



## 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:**

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.

**ADDITIONAL COPIES ARE AVAILABLE FROM:**

- PennDOT SALES STORE  
(717) 787-6746 phone  
(717) 787-8779 fax  
ra-penndotsalesstore@state.pa.us
- PennDOT website - [www.dot.state.pa.us](http://www.dot.state.pa.us)  
*Click on Forms, Publications & Maps*
- DGS warehouse (PennDOT employees ONLY)

**APPROVED FOR ISSUANCE BY:**

R. SCOTT CHRISTIE BY:

Rebecca S. Burns \s\

Rebecca S. Burns, P.E.  
Acting Director, Bureau of Construction and  
Materials, Highway Administration

## Chapter 2A

### Design and Control of Hot-Mix Asphalt (HMA) Mixtures Using the Superpave Asphalt Mixture Design and Analysis System

#### 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. Superpave (Superior Performing Asphalt Pavements) is the end result of the Strategic Highway Research Program's (SHRP) \$50 million investment in asphalt-related research. Unlike the empirical Marshall mix design system, Superpave is a comprehensive method, based on performance characterizations tailored specifically to project traffic, environment, and structural section. Since 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:*

3.13 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.

3.14 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.

3.15 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  $\mu\text{m}$  (No. 200) sieve fraction.

3.16 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 which polish rapidly and repeatedly produce low friction numbers 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.

3.17 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.

3.18 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 compactive effort in the field.

3.19 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 pavements 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.

3.20 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  $N_{max}$  insures 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 3:***

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 4:***

Also, other recognized procedures may be used to select trial blends or recommend a design aggregate structure. One such method is the "Baily Method for Gradation Selection in Hot-Mix Asphalt Mixture Design," by W.R. Vavrik, G. Huber, W.S. Pine, S.H. Carpenter and R. Baily. 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](mailto:TRBSales@nas.edu). This publication is also available on the Internet at <http://www.trb.org> and following the links for "Online Documents" and "E-Circulars" and then locating E-Circular 44.

##### ***Revise Subsection 4.4 as follows:***

In the first sentence, change the reference for how the mixture is conditioned from "mixture conditioning for the volumetric mixture design procedure in R 30" to "the revised mixture conditioning for volumetric mixture design and production quality control testing time (Appendix I herein) plus an additional 2 hours"

##### ***Also, add the following to the end:***

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 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 mixtures susceptibility, the recommended approach is to consider the mix moisture susceptible.

##### ***Revise Section 4 by adding a new Subsection as follows:***

4.5 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 (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 409 in addition to the criteria specified herein.

Whenever the Contractor's gradations and calculations do not check, the DMM/DME shall 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 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 320, 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 MTD.

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 4 and Department Revisions to Note 4 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 5A** - M 323, Table 3 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 3.10. (See Department Revisions to AASHTO M 323, Section 6.1.2 Table 3). Also see Note 4.

***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 6 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 7 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 Row for Design ESALs  $\geq 30$  Million and Columns for Compaction Parameters as follows:*

**Table 1** – Superpave Gyratory Compaction Effort

Design ESALs <sup>a</sup> (Millions)	Compaction Parameters		
	$N_{initial}$	$N_{design}$	$N_{max}$
$\geq 30$	8	100	160

*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 to the end:*

In the event a discrepancy occurs between lab test data, PTM No. 715, Method A will be the referee method. Notes 9 and 10 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 8) 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.

$$\%G_{mm\ design} = 100 \frac{G_{mb}}{G_{mm}} \quad (15A)$$

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 409, 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 409, 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 409, 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 17A** - 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.

**Note 17B** – If multiple mix designs use the same aggregate combination and the same PG binder but differ in optimal asphalt content, the DMM/DME 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 409, Table A.

*Revise Subsections 11.1 and 11.2 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  $7 \pm 0.5$  percent air voids in accordance with T 312.

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 17C).
- (b) Delete T 283, Sections 10.3.5 and 10.3.6

**Note 17C** – 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.

***Revise Subsection 11.3 by adding the following:***

If the average dry strength for mixtures containing PG 64-22 or PG 76-22 is less than 80 psi (552 kPa) or the average dry strength for mixtures containing PG 58-28 is less than 65 psi (448 kPa), the mix is unacceptable. Any mixture containing PG 58-28, PG 64-22 or PG 76-22 with average wet/freeze strength less than 50 psi (345 kPa) is unacceptable.

**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 4. 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:

12.4.1. 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  $\mu$ m (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 75 $\mu$ m (No. 200) sieve content is high, a reduction in this fraction will increase the aggregate voids.

12.4.2. 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 6, or voids that are outside of the Department's production specifications (Publication 408, Section 409) 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.

12.4.3. 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  $\mu$ m (No. 100) sieve. This condition is most critical when occurring near the 600  $\mu$ m (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.

12.4.4. 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  $\mu\text{m}$  (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  $\mu\text{m}$  (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 MTD. The MTD will make the final determination if problematic aggregates exist. The MTD, 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 and 2. 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 3 as follows:*

Table 3 - Aggregate Gradation Control Points

Sieve Size	Nominal Maximum Aggregate Size - Control Point (Percent Passing)									
	37.5 mm		25.0 mm		19.0 mm		12.5 mm		9.5 mm	
	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 the Table 3 in AASHTO M 323 to better conform with the written definition of the nominal maximum aggregate size provided in AASHTO R 35 Section 3.10. (Refer to Department Revisions to AASHTO R 35, Subsection 6.8, Note 5A)

**Delete Subsection 6.1.3 completely.**

**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 5A. The percentage of weight loss will be determined in accordance with AASHTO T 96.

**Table 5A - 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 5 Row for Design ESALs ≥30 Million and Columns for Fractured Faces, Coarse Aggregate, Percent Minimum as follows:**

**Table 5 – Superpave Aggregate Consensus Property Requirements**

Design ESALs <sup>a</sup> (Million)	Fractured Faces, Coarse Aggregate, <sup>c</sup> Percent Minimum	
	Depth from Surface	
	≤ 100 mm	> 100 mm
≥30	95/90	95/90

**AASHTO M 323, Section 7. HMA Design Requirements**

**Revise Subsection 7.1 by adding the following to the end:**

“and as modified herein.”

**Revise the Subsection 7.2, Table 6 Rows for All Design ESALs and Columns for Voids in the Mineral Aggregate (VMA) Percent Minimum and Columns for Voids Filled with Asphalt (VFA) and Revise and Add Table Footnotes as follows:**

**Table 6 – Superpave HMA Design Requirements**

Design ESALs <sup>a</sup> (Million)	Voids in the Mineral Aggregate (VMA), Percent Minimum						Voids Filled with Asphalt (VFA) Range, <sup>b</sup> Percent
	Nominal Maximum Aggregate Size, mm						
	37.5	25.0	19.0	12.5	9.5	4.75	
<0.3	11.5	12.5	13.5	14.5	15.5	16.0	70-78
0.3 to <3	11.5	12.5	13.5	14.5	15.5	16.0	65-78
3 to <10	11.5	12.5	13.5	14.5	15.5	16.0	65-75 <sup>e</sup>
10 to <30	11.5	12.5	13.5	14.5	15.5	16.0	65-75 <sup>e</sup>
≥30	11.5	12.5	13.5	14.5	15.5	16.0	65-75 <sup>e</sup>

<sup>b</sup> For 37.5-mm nominal maximum aggregate size mixtures, the specified lower limit of the VFA range shall be 64 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 66 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 69 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 71 percent for all design traffic levels.

<sup>d</sup> Delete this footnote.

<sup>e</sup> For design traffic levels > 3 million ESALs, 9.5-mm nominal maximum aggregate size mixtures, the specified VFA range shall be 73 to 76 percent and for 4.75-mm nominal maximum aggregate size mixtures shall be 75 to 78 percent.

**Revise Section 7 by adding the following new Subsections to the end:**

7.4 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 409. This design, when verified and proven in production by the process described in Publication 408, Section 409.2 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:

7.4.1 Statistical Evaluation of JMF Production

- (a) 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.
- (b) Evaluate the mix composition (gradation and asphalt binder content) for conformance to Publication 408, Section 409.2, Table A. Using the procedure described in Publication 408, Section 106.03, calculate a PWL for asphalt binder content (P<sub>b</sub>), percent passing the 2.36 mm (No. 8) sieve,

and percent passing the 75  $\mu\text{m}$  (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.

- (c) Evaluate the mixture 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 6 and voids for conformance to the Department's production specifications.
- (d) 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 DMM/DME for review prior to performing any work with such a design.

7.5 Quality Control Requirements for Mix Designs During Production - Prepare and Submit a QC Plan to the DMM/DME for review and approval as specified in Chapter 1, Section 2.1 and Publication 408, Section 409.2. 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.

- 7.5.1 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  $\mu\text{m}$  (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 MTD suspend testing of samples that have arrived at the MTD 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 bituminous testing efficiency and testing turnaround time at the MTD.

After reviewing the supporting data, the DMM/DME 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 MTD Bituminous Lab Manager to stop testing on pending samples for the particular JMF Year and Number. MTD 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 MTD Bituminous Lab Manager.

7.5.2 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 MTD to suspend testing of samples that have arrived at the MTD 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 bituminous testing efficiency and testing turnaround time at the MTD.

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 MTD. The request must include all supporting data to justify the request for a change in test method. The MTD will make the final determination if problematic aggregates exist. The MTD, 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 MTD. The request must include all supporting data to justify the request for a change in test method. The MTD will make the final determination if problematic aggregates cease to exist. The MTD, at its discretion, may request samples of the problematic aggregates for verification testing.

## 7.6 Quality Control Requirements for P.G. Binder Supply and Handling During Production

7.6.1 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 76-22 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).



7.6.2 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.

7.6.3 If the storage tank is not dedicated to a specific grade, producers of bituminous mixtures are to maintain a log of shipments or notify the respective DMM/DME when receiving and storing a PG-Binder of a different grade or different modifier.

7.6.4 When a supply change occurs during production, evaluate the mixtures using same grade PG-Binders supplied from a different primary supplier (i.e., Citgo vs. Chevron) for moisture susceptibility in accordance with ASTM D 3625 (Boiling Water Test) as a screening test. When asphalt binder coating is less than 95%, as determined by ASTM D 3625, 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 D 3625 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 recommend best practice is to conduct testing according to Section 11 as soon as time permits using the new primary PG Binder Supplier.

7.6.5 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 insure that valves were set correctly and that this asphalt grade was added to the HMA mix.

7.6.6 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.

[This page intentionally left blank.]

## 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 Gyration ( $N_{des}$ ) – 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  $6 \pm 1.0$  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.

<b>Table J-1</b>			
<b>Material</b>	<b>Test Method</b>	<b>Minimum Number of Tests to Determine the Producer Average Aggregate Gsb Value</b>	<b>Maximum Difference Between Producer and MTD Average Aggregate Gsb Values</b>
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  $\leq$  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  $\leq 0.015$  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.

**Existing Mix Design – Submittal Process:**

**B.  $\geq 5$  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  $\leq 0.015$  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  $\geq 90$ ,
- c. averages for asphalt content and gradation of all sieves meet the  $n \geq 3$  tolerances in Pub. 408, Section 409, Table A, and
- d. gradation (for all sieves) and asphalt content PWL are all  $\geq 90\%$ ,

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  $n \geq 3$  tolerances in Pub. 408, Section 409, Table A, and
  - c. gradation (of all sieves) and asphalt content PWL are all  $\geq 90\%$ ,

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  $\geq 90$
  - c. average asphalt content or average gradation of any sieve does NOT meet the  $n \geq 3$  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  $n \geq 3$  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  $\geq 5$  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.

<b>Table J-2</b>		
<b>Acceptable Ranges of Air Voids (Va) for Laboratory Mixed, Laboratory Compacted Specimens for Evaluating JMFs from the Previous Calendar Year.</b>		
<b>Condition</b>	<b>Range of Air Voids (Va) for each Single (n=1) Laboratory Mixed, Laboratory Compacted Specimen, %</b>	<b>Range of Air Voids (Va) for the Average of Multiple (n≥2) Laboratory Mixed, Laboratory Compacted Specimens, %</b>
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.

[This page intentionally left blank.]

**WORKSHOP**  
**AGGEGATE GRADATION ANALYSIS**

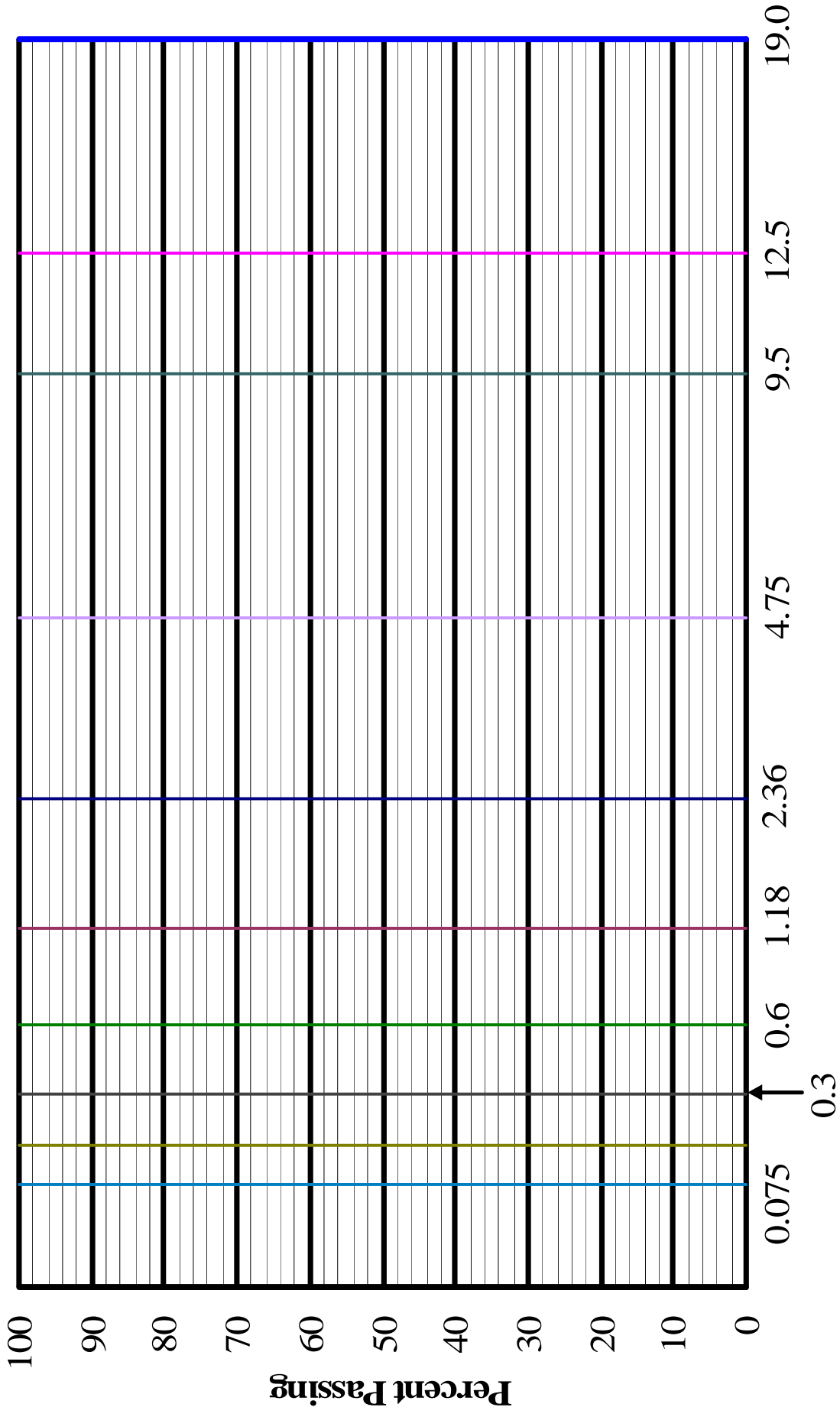
A sample of No. 8 aggregate is taken from the plant stockpile. It is quartered to a sample size of 5013.2 grams. The sample is then sieved to give the following weight passing each sieve:

Sieve Size (mm)	Sieve Size English	Cumulative Mass Retained (g)	Mass Passing (g)	Percent Passing Each Sieve
12.5	1/2"	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?

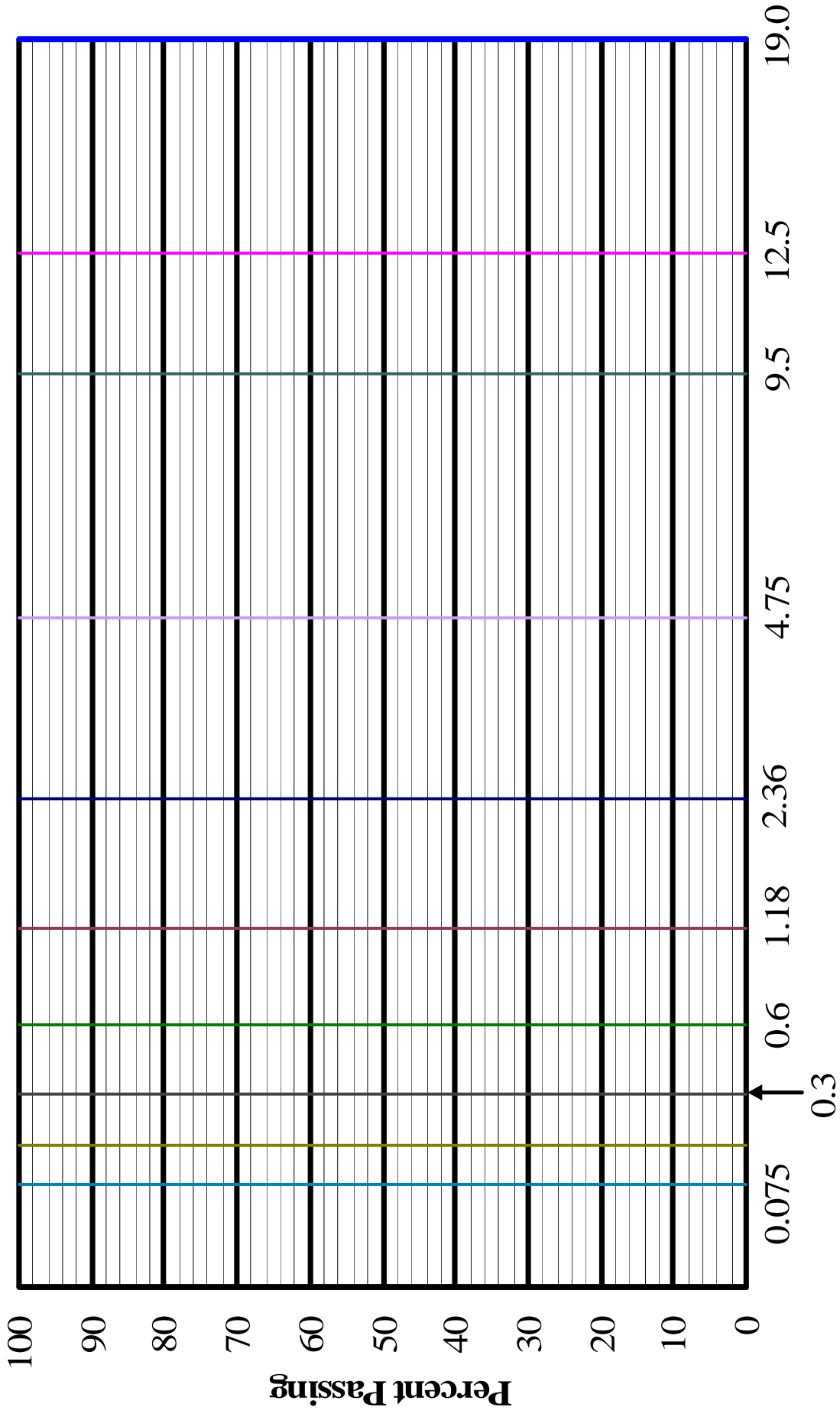


# Gradation Chart



**Sieve Size (mm) Raised to 0.45 Power**

# Gradation Chart



**Sieve Size (mm) Raised to 0.45 Power**

## Aggregate Blending Workshop Problem

The gradations of two aggregates are as follows:

Sieve Size	F.A. #1	C.A
75 $\mu\text{m}$	2.2	0.2
150 $\mu\text{m}$	3.0	0.3
300 $\mu\text{m}$	14.2	0.5
600 $\mu\text{m}$	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 =

■  $P_{FA} = (X / Y) \times 100$  % .....

■  $P_{CA} = 100 - P_{FA}$  .....

**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
Sum U				

Diagonal Products									
12.5mm	↘	↘	↘						
2.36mm	↘	↘	↘						
Diagonal Products									
								Sum L	D=L-U

Sieve Size	% Passing Target	% Passing Agg. B	% Passing Agg. C	% Passing Target
Sum Ua				

Diagonal Products									
12.5mm	↘	↘	↘						
2.36mm	↘	↘	↘						
Diagonal Products									
								Sum La	Da=La-Ua

Sieve Size	% Passing Agg. A	% Passing Target	% Passing Agg. C	% Passing Agg. A
Sum Ub				

Diagonal Products									
12.5mm	↘	↘	↘						
2.36mm	↘	↘	↘						
Diagonal Products									
								Sum Lb	Db=Lb-Ub

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Target	% Passing Agg. A
Sum Uc				

Diagonal Products									
12.5mm	↘	↘	↘						
2.36mm	↘	↘	↘						
Diagonal Products									
								Sum Lc	Dc=Lc-Uc

$P_a = \% \text{ Agg. A} = \frac{D_a}{D} \times 100\% =$

$P_b = \% \text{ Agg. B} = \frac{D_b}{D} \times 100\% =$

$P_c = \% \text{ Agg. C} = \frac{D_c}{D} \times 100\% =$

SUM

**Check:**

	Target1=(PaXPPa1+PbXPPb1+PcXPPc1)/100=
	Target2=(PaXPPa2+PbXPPb2+PcXPPc2)/100=
	<b>NOTE: PP is Percent Passing for a Specific Aggregate</b>



# 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		
2.36mm	8.0	80.0	0.0	8.0		
Diagonal Products			8000.0	0.0	0.0	8000.0

D=L-U

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		
2.36mm	45.0	80.0	0.0	45.0		
Diagonal Products			8000.0	0.0	0.0	8000.0

Da=La-Ua

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		
2.36mm	8.0	45.0	0.0	8.0		
Diagonal Products			4500.0	0.0	0.0	4500.0

Db=Lb-Ub

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		
2.36mm	8.0	80.0	45.0	8.0		
Diagonal Products			8000.0	4500.0	800.0	13300.0

Dc=Lc-Uc

**Check:**

$P_a = \% \text{ Agg. A} = D_a/D \times 100\% =$

$P_b = \% \text{ Agg. B} = D_b/D \times 100\% =$

$P_c = \% \text{ Agg. C} = D_c/D \times 100\% =$

SUM

	Target1=(PaXPPa1+PbXPPb1+PcXPPc1)/100=	
	Target2=(PaXPPa2+PbXPPb2+PcXPPc2)/100=	
	<b>NOTE: PP is Percent Passing for a Specific Aggregate</b>	

# 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		
2.36mm	8.0	80.0	0.0	8.0		
Diagonal Products			8000.0	0.0	0.0	8000.0

D=L-U

7200.0
--------

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		
2.36mm	45.0	80.0	0.0	45.0		
Diagonal Products			8000.0	0.0	0.0	8000.0

Da=La-Ua

3500.0
--------

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		
2.36mm	8.0	45.0	0.0	8.0		
Diagonal Products			4500.0	0.0	0.0	4500.0

Db=Lb-Ub

3700.0
--------

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		
2.36mm	8.0	80.0	45.0	8.0		
Diagonal Products			8000.0	4500.0	800.0	13300.0

Dc=Lc-Uc

0.0
-----

**Check:**

$P_a = \% \text{ Agg. A} = D_a/D \times 100\% =$

$P_b = \% \text{ Agg. B} = D_b/D \times 100\% =$

$P_c = \% \text{ Agg. C} = D_c/D \times 100\% =$

SUM

48.6	Target1=(PaXPPa1+PbXPPb1+PcXPPc1)/100=	100
51.4	Target2=(PaXPPa2+PbXPPb2+PcXPPc2)/100=	45.0
0.0	<b>NOTE: PP is Percent Passing for a Specific Aggregate</b>	
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

Sum U

Diagonal Products					
12.5mm					
2.36mm					
Diagonal Products					

D=L-U

Sum L

Sieve Size	% Passing Target	% Passing Agg. B	% Passing Agg. C	% Passing Target

Sum Ua

Diagonal Products					
12.5mm					
2.36mm					
Diagonal Products					

Da=La-Ua

Sum La

Sieve Size	% Passing Agg. A	% Passing Target	% Passing Agg. C	% Passing Agg. A

Sum Ub

Diagonal Products					
12.5mm					
2.36mm					
Diagonal Products					

Db=Lb-Ub

Sum Lb

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Target	% Passing Agg. A

Sum Uc

Diagonal Products					
12.5mm					
2.36mm					
Diagonal Products					

Dc=Lc-Uc

Sum Lc

$P_a = \% \text{ Agg. A} = \frac{D_a}{D} \times 100\% =$   
 $P_b = \% \text{ Agg. B} = \frac{D_b}{D} \times 100\% =$   
 $P_c = \% \text{ Agg. C} = \frac{D_c}{D} \times 100\% =$   
**SUM**

**Check:**

	Target1=(PaXPPa1+PbXPPb1+PcXPPc1)/100=
	Target2=(PaXPPa2+PbXPPb2+PcXPPc2)/100=
	<b>NOTE: PP is Percent Passing for a Specific Aggregate</b>

# 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	<del>47.0</del>	<del>90.5</del>	<del>100.0</del>	<del>47.0</del>		
2.36mm	<del>0.2</del>	<del>11.4</del>	<del>48.0</del>	<del>0.2</del>		
Diagonal Products			535.8	4344.0	20.0	4899.8

D=L-U

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	<del>82.2</del>	<del>90.5</del>	<del>100.0</del>	<del>82.2</del>		
2.36mm	<del>27.5</del>	<del>11.4</del>	<del>48.0</del>	<del>27.5</del>		
Diagonal Products			937.1	4344.0	2750.0	8031.1

Da=La-Ua

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	<del>47.0</del>	<del>82.2</del>	<del>100.0</del>	<del>47.0</del>		
2.36mm	<del>0.2</del>	<del>27.5</del>	<del>48.0</del>	<del>0.2</del>		
Diagonal Products			1292.5	3945.6	20.0	5258.1

Db=Lb-Ub

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	<del>47.0</del>	<del>90.5</del>	<del>82.2</del>	<del>47.0</del>		
2.36mm	<del>0.2</del>	<del>11.4</del>	<del>27.5</del>	<del>0.2</del>		
Diagonal Products			535.8	2488.8	16.4	3041.0

Dc=Lc-Uc

**Check:**

$P_a = \% \text{ Agg. A} = D_a/D \times 100\% =$

$P_b = \% \text{ Agg. B} = D_b/D \times 100\% =$

$P_c = \% \text{ Agg. C} = D_c/D \times 100\% =$

SUM

	Target1=(PaXPPa1+PbXPPb1+PcXPPc1)/100=	<input style="width: 50%; height: 20px;" type="text"/>
	Target2=(PaXPPa2+PbXPPb2+PcXPPc2)/100=	<input style="width: 50%; height: 20px;" type="text"/>
	<b>NOTE: PP is Percent Passing for a Specific Aggregate</b>	

# 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	<del>47.0</del>	<del>90.5</del>	<del>100.0</del>	<del>47.0</del>		
2.36mm	<del>0.2</del>	<del>11.4</del>	<del>48.0</del>	<del>0.2</del>		
Diagonal Products			535.8	4344.0	20.0	4899.8

D=L-U

1485.7

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	<del>82.2</del>	<del>90.5</del>	<del>100.0</del>	<del>82.2</del>		
2.36mm	<del>27.5</del>	<del>11.4</del>	<del>48.0</del>	<del>27.5</del>		
Diagonal Products			937.1	4344.0	2750.0	8031.1

Da=La-Ua

456.7

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	<del>47.0</del>	<del>82.2</del>	<del>100.0</del>	<del>47.0</del>		
2.36mm	<del>0.2</del>	<del>27.5</del>	<del>48.0</del>	<del>0.2</del>		
Diagonal Products			1292.5	3945.6	20.0	5258.1

Db=Lb-Ub

235.7

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	<del>47.0</del>	<del>90.5</del>	<del>82.2</del>	<del>47.0</del>		
2.36mm	<del>0.2</del>	<del>11.4</del>	<del>27.5</del>	<del>0.2</del>		
Diagonal Products			535.8	2488.8	16.4	3041.0

Dc=Lc-Uc

793.3

**Check:**

$P_a = \% \text{ Agg. A} = D_a/D \times 100\% =$

$P_b = \% \text{ Agg. B} = D_b/D \times 100\% =$

$P_c = \% \text{ Agg. C} = D_c/D \times 100\% =$

SUM

30.7	Target1=(PaXPPa1+PbXPPb1+PcXPPc1)/100=	82.2
15.9	Target2=(PaXPPa2+PbXPPb2+PcXPPc2)/100=	27.5
53.4	NOTE: PP is Percent Passing for a Specific Aggregate	
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

Sum U

<b>Diagonal Products</b>					
<b>Diagonal Products</b>					

D=L-U

Sum L

Sieve Size	% Passing Target	% Passing Agg. B	% Passing Agg. C	% Passing Target

Sum Ua

<b>Diagonal Products</b>					
<b>Diagonal Products</b>					

Da=La-Ua

Sum La

Sieve Size	% Passing Agg. A	% Passing Target	% Passing Agg. C	% Passing Agg. A

Sum Ub

<b>Diagonal Products</b>					
<b>Diagonal Products</b>					

Db=Lb-Ub

Sum Lb

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Target.	% Passing Agg. A

Sum Uc

<b>Diagonal Products</b>					
<b>Diagonal Products</b>					

Dc=Lc-Uc

Sum Lc

Pa=% Agg. A = Da/D X 100%=  
 Pb=% Agg. B = Db/D X 100%=  
 Pc=% Agg. C = Dc/D X 100%=  
 SUM

**Check:**

	Target <sub>1</sub> =(P <sub>aX</sub> PP <sub>a</sub> )+P <sub>bX</sub> PP <sub>b1</sub> +P <sub>cX</sub> PP <sub>c1</sub> )/100=	
	Target <sub>2</sub> =(P <sub>aX</sub> PP <sub>a2</sub> +P <sub>bX</sub> PP <sub>b2</sub> +P <sub>cX</sub> PP <sub>c2</sub> )/100=	
	<b>NOTE: PP is Percent Passing for a Specific Aggregate</b>	



# 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

<b>Diagonal Products</b>					
	→	→	→	→	
	→	→	→	→	
<b>Diagonal Products</b>					

D=L-U

Sum L

Sieve Size	% Passing Target	% Passing Agg. B	% Passing Agg. C	% Passing Target

Sum Ua

<b>Diagonal Products</b>					
	→	→	→	→	
	→	→	→	→	
<b>Diagonal Products</b>					

Da=La-Ua

Sum La

Sieve Size	% Passing Agg. A	% Passing Target	% Passing Agg. C	% Passing Agg. A

Sum Ub

<b>Diagonal Products</b>					
	→	→	→	→	
	→	→	→	→	
<b>Diagonal Products</b>					

Db=Lb-Ub

Sum Lb

Sieve Size	% Passing Agg. A	% Passing Agg. B	% Passing Target.	% Passing Agg. A

Sum Uc

<b>Diagonal Products</b>					
	→	→	→	→	
	→	→	→	→	
<b>Diagonal Products</b>					

Dc=Lc-Uc

Sum Lc

$P_a = \% \text{ Agg. A} = \frac{D_a}{D} \times 100\% =$   
 $P_b = \% \text{ Agg. B} = \frac{D_b}{D} \times 100\% =$   
 $P_c = \% \text{ Agg. C} = \frac{D_c}{D} \times 100\% =$   
**SUM**

**Check:**

	$\text{Target}_1 = (P_{aX}PP_a) + P_{bX}PP_{b1} + P_{cX}PP_{c1})/100 =$	
	$\text{Target}_2 = (P_{aX}PP_{a2} + P_{bX}PP_{b2} + P_{cX}PP_{c2})/100 =$	
	<b>NOTE: PP is Percent Passing for a Specific Aggregate</b>	

## **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**

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

$$G_{sa} = \frac{A}{(A + B - C)}$$

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

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**

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

$$G_a = \frac{A}{(A - C)}$$

$$Absorption(\%) = \frac{B - A}{A} \times 100$$

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**
- **volume of volumeter: 1118.2 cm<sup>3</sup>**

#### **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

$$G_{sb} = \frac{100}{\frac{P_1}{G_{sb1}} + \frac{P_2}{G_{sb2}} + \dots + \frac{P_n}{G_{sbn}}} \quad [1]$$

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}} \quad [2]$$

$$G_{mm} = \frac{100}{\frac{P_s}{G_{se}} + \frac{P_b}{G_b}} \quad [3]$$

$$P_{ba} = 100 \times \frac{G_{se} - G_{sb}}{G_{se} \times G_{sb}} \times G_b \quad [4]$$

$$P_{be} = P_b - \left( \frac{P_{ba}}{100} \times P_s \right) \quad [5]$$

$$VMA = 100 - \frac{G_{mb} \times P_s}{G_{sb}} \quad [6]$$

$$V_a = 100 \times \frac{G_{mm} - G_{mb}}{G_{mm}} \quad [7]$$

$$VFA = \left( \frac{VMA - V_a}{VMA} \right) \times 100 \quad [8]$$

$$\% \text{Density} : \quad \% G_{mm} = \left( \frac{G_{mb}}{G_{mm}} \right) \times 100 \quad [9]$$



**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 subplot if the generated random number for this subplot 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 408 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](http://www.transportation.org))
2. ADT: Average Daily Traffic
3. AET: Asphalt Emulsion Tack
4. AI: Asphalt Institute ([www.asphaltinstitute.org](http://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](http://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](http://www.asphaltpavement.org))
21. NECEPT: Northeast Center of Excellence for Paving Technology ([www.superpave.psu.edu](http://www.superpave.psu.edu))
22. NMAS: Nominal Maximum Aggregate Size
23. OSHA: Occupational Safety and Health Administration ([www.osha.gov](http://www.osha.gov))
24. PAPA: Pennsylvania Asphalt Pavement Association ([www.pahotmix.org](http://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](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 Gyrotory 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



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	
					X	X	X							X					Bleeding
				X				X	X										Brown, Dead Appearance
					X	X	X							X			X		Rich or Fat Spots
		X	X			X	X			X	X	X			X	X	X	X	Poor Surface Texture
X	X	X				X	X			X	X	X			X	X	X	X	Rough Uneven Surface
			X	X		X	X			X	X	X			X	X	X		Honeycomb or Raveling
			X							X	X	X			X	X	X		Uneven Joints
				X	X	X				X						X			Roller Marks
X	X		X	X	X	X	X				X	X			X				Pushing or Waves
			X	X		X							X						Cracking (Many Fine Cracks)
													X						Cracking (Large Long Cracks)
		X				X				X	X	X							Rocks Broken by Roller
		X		X		X			X	X	X	X					X	X	Tearing of Surface During Laying
X	X		X	X	X		X		X			X	X						Surface Slipping on Base

*Types of Pavement Imperfections  
That May Be Encountered In  
Laying Plant Mix  
Paving Mixtures.*

**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	
		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	A	B	B	BA								B	B	B	C	B		A	Aggregate Gradation Does Not Check Job Mix Formula	
A	A						B	B	B	A	A	A	B	B	B	A							B	B			C	B		A	Excessive Fines in Mix	
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	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			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		Mixture Steams in Truck	
			A	A	A													A										A	A		Mixture Appears Dull in Truck	

Types of Deficiencies That May Be Encountered in Producing Plant-Mix Paving Mixtures.

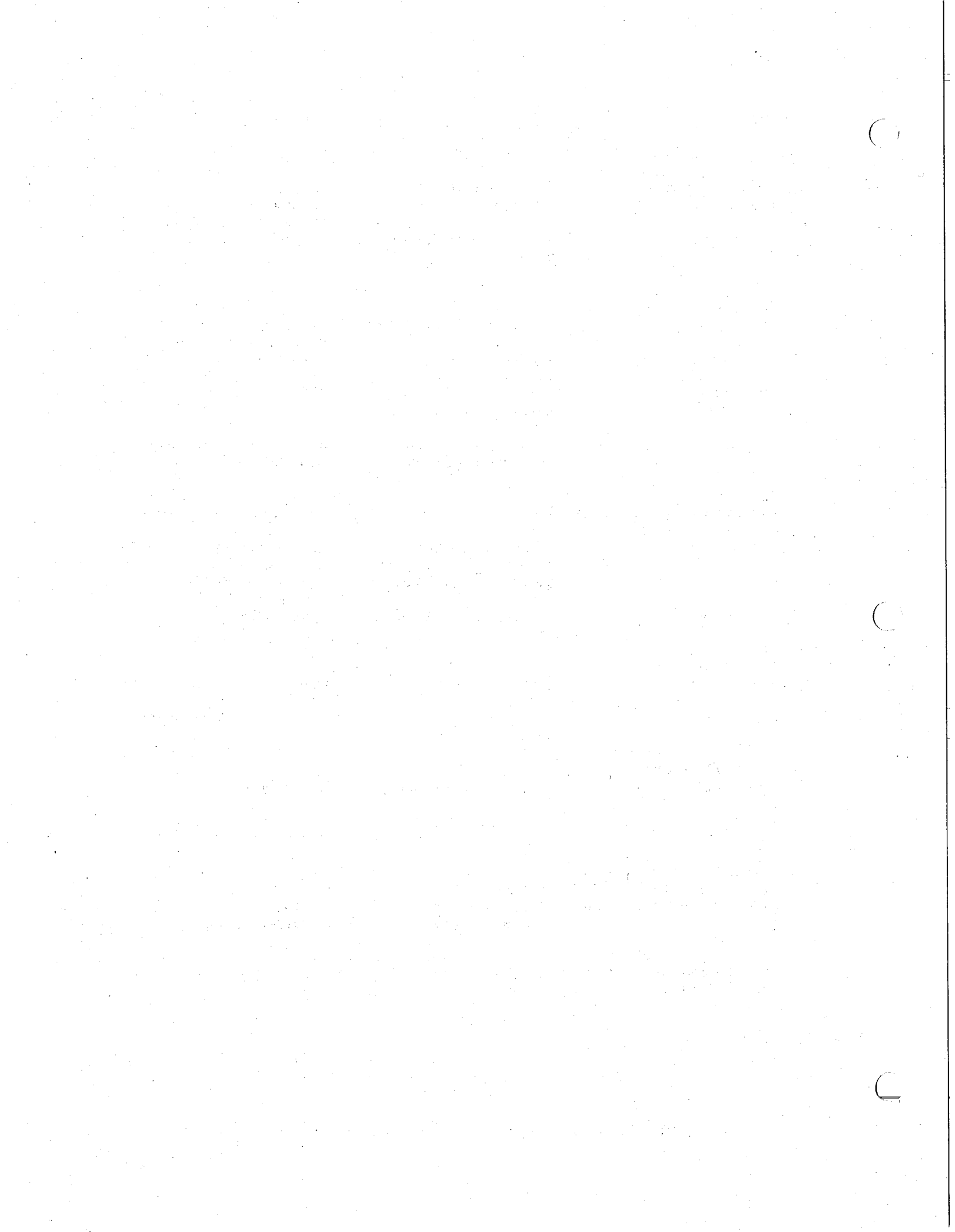
FIGURE 4.23—Possible Causes of Deficiencies in Hot Plant-Mix Paving Mixtures. A—Applies to Batch and Drum Mix Plants; B—Applies to Batch Plants; C—Applies to Drum Mix Plants.



ITEM	EFFECT	CORRECTIONS*
<b>Aggregate</b>		
• 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
<b>Asphalt</b>		
• 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
<b>Mix</b>		
• 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
<b>Mix temperature</b>		
• High	Difficult to compact—mix lacks cohesion	Decrease mixing temperature
• Low	Difficult to compact—mix too stiff	Increase mixing temperature
<b>Course Thickness</b>		
• 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
<b>Weather Conditions</b>		
• 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/](http://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.**