Hot-Mix Asphalt
Level I
Technician Course

LAKE LAND
COLLEGE

2023-2024

Illinois Department of Transportation
Central Bureau of Materials

HOT-MIX ASPHALT LEVEL I TECHNICIAN COURSE OUTLINE

***All times are approximate and subject to change, to better fit class need.**

MONDAY - DAY 1

8:00 a.m. to 9:00 a.m.

Registration, Orientation and Introduction

9:00 a.m. to 12:00 p.m.

Chapter 1 - Specifications

12:00 p.m. to 1:00 p.m.

Lunch on own

1:00 p.m. to 1:45 p.m.

Videos on Plants, Sampling & Jobsite Sampling

1:45 p.m. to 4:30 p.m.

Chapter 2 - Plants and Sampling
Chapter 3 - Ingredients of Hot-Mix Asphalt

TUESDAY - DAY 2 & WEDNESDAY - DAY 3

8:00 a.m. to 4:00 p.m.

LAB SCHEDULE - LEVEL I

Group A	**Group B**
Group C	**Group D**

Lab Session	8:00 a.m. Tuesday	1:00 p.m. Tuesday	8:00 a.m. Wednesday	1:00 p.m. Wednesday
Chapter 6("d"), Chapter 9 (TSR) Chapter 8 (Cores)	A, B	A, B	C, D	C, D
Chapter 7 ("D") Chapter 4 (Splitting)	C	D	A	B
Chapter 5 (AB Content	D	C	B	A

TUESDAY OR WEDNESDAY - DAY 2 or DAY 3

4:00 p.m. to 6:30 p.m.

Chapter 4 – Nuclear Density Course

THURSDAY - DAY 4

7:30 a.m. to 9:30 am

Chapter 10 – Control Chart Lecture and homework given.

9:00 am

Lab proficiency exams will be throughout the day at various times. Schedule will be given to students on Wednesday afternoon.

FRIDAY- DAY 5

7:45 a.m. to 8:00 a.m

Answer last minute questions before exams starts.

8:00 a.m. to 11:00 a.m

Written exam on Level I HMA Course.

11:00 a.m. to 12:30 p.m.

Written exam on Nuclear Density Tester Course.

**** Once exams are graded, finalized and uploaded, students will be able to login into the website to check their overall grade status. ****

To check their overall grade status, go to https://learn.lakelandcollege.edu/IDOT

- Login into your student profile
- Click on “My Enrollment History”
- Click on “Completed” tab
- To the right of the desired course, click on the “Print” button under the action and status tab
- Under the Choose Report drop down menu select “Statement of Grade” and then click “Print” to view.

This report will show you the overall grade status for that course. (Please print and provide a copy of this report to your employer/sponsor.)

Note: Due to FERPA Laws, we cannot provide any grade information over the phone or via email.

HOT-MIX ASPHALT LEVEL I TECHNICIAN COURSE

- **Students *must* attend *all* course sessions.**
- **Students are required to present photo identification on first day of class and prior to taking the written and physical exams.**

Prerequisite Course:

Either the Mixture Aggregate Technician Course (3-Day) or the Aggregate Technician Course (5-Day) is required to enroll in the Hot-Mix Asphalt Level I Technician Course.

Written Test (Part 1):

Time Limit is 3 hours (Open Book)
Minimum grade of 70 is required.

Practical Test (Part 2):

No time limit is specified (Open Book)
Minimum grade of 70 is required.

Retest:

If the student fails the written test (Part 1) or practical test (Part 2), a retest can be performed. A retest must be taken by the end of the academic year that the initial test was taken. The academic year runs from September 1st to August 31st. **(For example, if the test was taken December 8, 2023, the last date to retest is August 30, 2024)** Failure of the written or practical *retest*, or failure to retest within the academic year, shall require the student to retake the class and both parts of the test. The student shall be required to pay the appropriate fee for the additional class.

Written Retest:

A retest **will not** be performed on the same day as the initial test.
Time limit is 3 hours.
Minimum grade of 70 is required.

Practical Retest:

A retest **will not** be performed on the same day as the initial test.
No time limit is specified
Minimum grade of 70 is required.

This Page Is Reserved

NUCLEAR DENSITY TESTER COURSE

- **Students *must* attend *all* course sessions.**

- **Students are required to present photo identification on first day of class and prior to taking the written and physical exams.**

Prerequisite Course:

None.

Written Test:

- Time limit is 1 ½ hours.
- Minimum grade of 70 is required.

Retest:

If the student fails the written test a retest can be performed. A retest must be taken by the end of the academic year that the initial test was taken. The academic year runs from September 1st to August 31st. **(For example, if the test was taken December 8, 2023, the last date to retest is August 30, 2024.)** Failure of the written *retest*, or failure to retest within the academic year, shall require the student to retake the class and the test. The student shall be required to pay the appropriate fee for the additional class.

Written Retest:

- A retest **will not** be performed on the same day as the initial test.
- Time limit is 1 ½ hours.
- Minimum grade of 70 is required.

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LAKE LAND COLLEGE - INSTRUCTORS AND COURSE EVALUATION

Course: **Hot-Mix Asphalt Level I** Section No.__________ Date___________________

Lead Instructors Name:______________________ **Lab Instructor #1's Name:**______________________

Lab Instructor #2's Name:______________________

Lab Instructor #3's Name:______________________

PURPOSE: The main emphasis at Lake Land College is teaching. In this regard, each instructor must be continuously informed of the quality of his/her teaching and the respects in which that teaching can be improved. As a student, you are in a position to judge the quality of teaching from direct experience, and in order to help maintain the quality of instruction at Lake Land, you are asked to complete this evaluation.

DIRECTIONS: **DO NOT SIGN YOUR NAME**. Your frankness and honesty are appreciated.

First, please record your general impressions and/or comments on the following:

Course____

Lead Instructor____

Lab Instructor #1____

Lab Instructor #2____

Lab Instructor #3____

For each remaining item, please indicate by number, on a scale from 1 to 5, with 1 being WEAK and 5 being SUPERIOR, which seems most appropriate to you for the instructors and course that you are evaluating. You are strongly encouraged to make any comments that will clarify particular rating on the bottom of this form; please refer to each item you are discussing by its number.

(1=Weak, 2=Needs Improvement, 3=Average, 4=Good, 5=Superior)

OBJECTIVES AND APPROPRIATENESS OF THE COURSE:

1.	**Clarity of Objectives**	The objectives of the course were clearly identified. Objectives were adequately covered.	______
2.	**Selection content**	Content was relevant and met the level of the class.	______

ORGANIZATION AND CONTENT OF LESSONS:

			LEAD INSTR.	LAB INSTR. 1	LAB INSTR. 2	LAB INSTR. 3
3.	**Teacher preparation**	Instructor was organized and knowledgeable in subject matter and prepared for each class.	______	______	______	______
4.	**Organization of classes**	Classroom activities were well organized and clearly related to each other.	______	______	______	______
5.	**Selection of materials**	Instructional materials and resources used specific, current, and clearly related to the objectives of the course.	______	______	______	______

OVER

LAKE LAND COLLEGE - INSTRUCTORS AND COURSE EVALUATION

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			LEAD INSTR.	LAB INSTR. 1	LAB INSTR. 2	LAB INSTR. 3
6.	**Clarity of presentation**	Content of lessons was presented so that it was understandable to the students.	______	______	______	______
7.	**Clarity of presentation**	Different point of view and/or methods with specific illustrations were used when appropriate.	______	______	______	______

PERSONAL CHARACTERISTICS AND STUDENT RAPPORT:

8.	**Vocabulary**	Instructor's vocabulary level was Appropriate for the class and labs.	______	______	______	______
9.	**Pupil participation and interest**	Instructor encouraged students to ask questions and actively participate in class and labs.	______	______	______	______
10.	**Personal attributes**	Instructor indicated an interest and enthusiasm for teaching the subject matter.	______	______	______	______
11.	**Personal attributes**	Instructor was familiar with current industry practices.	______	______	______	______
12.	**Personal**	Instructor's mannerisms were pleasing.	______	______	______	______
13.	**Instructor-student rapport**	Instructor indicated a willingness to help you in times of difficulty.	______	______	______	______
14.	**Instructor-student rapport**	Instructor was fair and impartial in dealings with you.	______	______	______	______

SUMMARY:

15. Considering everything, how would you rate these instructors? ______ ______ ______ ______

16. Considering everything, how would you rate this course? ______

EXAMINATION:

17. **Exam material** The exam correlated to the materials being covered in class. ______

COMMENTS: (Please use the area below to add any additional comments regarding the class and exam.)

Specification Contents

The State of Illinois follows multiple specifications. It is important to know what specifications are required for the project you are working on. In this section, we will be highlighting the important aspects of the QC/QA, PFP and QCP specifications.

MoTP = Manual of Test Procedures
BDE = BDE Special Provisions

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SECTION 1030. HOT-MIX ASPHALT

1030.01 Description. This section describes the materials, mix designs, proportioning, mixing, and transportation requirements to produce and place hot-mix asphalt (HMA) following the Quality Management Program (QMP) designated in the plans.

Warm mix asphalt (WMA) is an asphalt mixture which can be produced at temperatures lower than allowed for HMA by utilizing qualified WMA technologies. WMA is produced with the use of additives, a water foaming process, or a combination of both. WMA shall conform to all HMA specifications unless specificly noted.

For simplicity of text, the following HMA nomenclature applies to this Section.

Mixture Type	Application	Mixture-Nominal Maximum Aggregate Size
High ESAL	Binder Course	IL-19.0, IL-9.5, IL-9.5FG, IL-4.75, SMA-12.5, SMA-9.5
	Surface Course	IL-9.5, IL-9.5FG, SMA-12.5, SMA-9.5
Low ESAL 1/	Binder Course	IL-19.0L, IL-9.5L
	Surface Course	IL-9.5L

1/ High ESAL mixtures may be used in similar Low ESAL mixture applications.

1030.02 Materials. Materials shall be according to the following.

	Item	Article/Section
(a)	Coarse Aggregate	1004.03
(b)	Fine Aggregate	1003.03
(c)	Reclaimed Asphalt Pavement	1031
(d)	Mineral Filler	1011
(e)	Hydrated Lime	1012.01
(f)	Slaked Quicklime (Note 1)	
(g)	Performance Graded Asphalt Binder	1032
(h)	Fibers (Note 2)	
(i)	WMA Technologies (Note 3)	
(j)	Reclaimed Asphalt Shingles	1031
(k)	Collected Dust	1102.01(a)(4)
(l)	Truck Bed Release Agents for HMA (Note 4)	1030.12
(m)	Liquid Anti-Strip (Note 5)	
(n)	Packaged, Dry, Rapid Hardening Mortar or Concrete	1018

Note 1. Slaked quicklime shall be according to ASTM C 5.

Note 2. A stabilizing additive such as cellulose or mineral fiber shall be added to stone matrix asphalt (SMA) mixtures and shall meet the requirements listed in Illinois Modified AASHTO M 325. Prior to approval and use of fibers, the Contractor shall submit a notarized certification by the producer of these materials stating they meet these requirements.

Note 3. WMA additives or foaming processes shall be selected from the Department's qualified producer list "Technologies for the Production of Warm Mix Asphalt (WMA)".

Note 4. Truck Bed Release Agents for HMA shall be selected from the Department's Qualified Product List "Asphalt Release Agents for Vehicles Transporting Hot-Mix Asphalt".

Note 5. Liquid additives to control stripping shall be shown effective by the Contractor by completing tensile strength and tensile strength ratio (TSR) testing according to AASHTO T 283 for the mix design and submitting the results to the Engineer.

1030.03 Equipment. Equipment shall be according to the following.

	Item	Article/Section
(a)	Hot-Mix Asphalt Plant	1102.01
(b)	Storage Tanks for Asphalt Binders (Note 1)	1102.01(a)(6)
(c)	Heating Equipment (Note 2)	1102.07

Note 1. Tanks for the storage of asphalt binder shall be clearly and uniquely identified. Different grades of asphalt binder shall not be blended.

Note 2. The asphalt binder shall be transferred to the asphalt tanks and brought to a temperature of 250 to 350 °F (120 to 180 °C). If, at anytime, the asphalt binder temperature exceeds 350 °F (180 °C), the asphalt binder shall not be used. Polymer modified asphalt binder, when specified, shall be shipped, maintained, and stored at the mix plant according to the manufacturer's requirements.

1030.04 Reference Documents. The HMA mixtures shall be designed, sampled, tested, and accepted according to the following.

(a) Appendices listed in the Manual of Test Procedures for Materials.

(1) Development of Gradation Bands on Incoming Aggregate at Hot-Mix Asphalt and Portland Cement Concrete Plants
(2) Model Annual Quality Control Plan for Hot-Mix Asphalt Production
(3) Model Quality Control Addendum for Hot-Mix Asphalt Production
(4) Procedure for Correlating Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt
(5) Hot-Mix Asphalt Test Strip Procedures
(6) Hot-Mix Asphalt QC/QA QC Personnel Responsibilities and Duties Checklist
(7) Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples
(8) Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations
(9) Hot-Mix Asphalt QC/QA Control Charts
(10) Hot-Mix Asphalt Mix Design Verification Procedure
(11) Calibration of Equipment for Asphalt Binder Content Determination (Nuclear Asphalt Binder Content Gauge and Ignition Oven)
(12) Hot-Mix Asphalt Mix Design Procedure for Dust Correction Factor Determination
(13) Calibration of the Ignition Oven for the Purpose of Characterizing Reclaimed Asphalt Pavements (RAP)
(14) Hot-Mix Asphalt Composite Sample Blending and Splitting Diagram

(15) Hot-Mix Asphalt (HMA) Production Gradation Windage Procedure for Minus #200 (minus 75 μm) Material
(16) Stripping of Hot-Mix Asphalt Mixtures Visual Identification and Classification
(17) Procedure for Introducing Additives to Hot-Mix Asphalt Mixtures and Testing in the Lab
(18) Ignition Oven Aggregate Mass Loss Procedure
(19) Procedure for Internal Angle Calibration of Superpave Gyratory Compactors (SGCs) Using the Dynamic Angle Validator (DAV-2)
(20) Segregation Control of Hot-Mix Asphalt
(21) Determination of Aggregate Bulk (Dry) Specific Gravity (Gsb) of Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS)
(22) Use of Corrections Factors for Adjusting the Gradation of Cores to Estimate the Gradation of the In-Place Pavement
(23) Off-Site Preliminary Test Strip Procedures for Hot-Mix Asphalt
(24) Hot-Mix Asphalt Production Inspection Checklist
(25) Hot-Mix Asphalt Rounding Test Values
(26) Hot-Mix Asphalt Laboratory Equipment
(27) Illinois Specification 101 Minimum Requirements for Electronic Balances
(28) Hot-Mix Asphalt PFP Pay Adjustments
(29) Hot-Mix Asphalt PFP and QCP Procedure for Determining Random Density Locations
(30) Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling
(31) Hot-Mix Asphalt PFP Dispute Resolution
(32) Hot-Mix Asphalt QCP Pay Adjustments
(33) Best Practices for Hot-Mix Asphalt PFP and QCP
(34) Hot-Mix Asphalt PFP and QCP Calculations of Monetary Deductions

(b) Illinois Modified AASHTO procedures listed in the Manual of Test Procedures for Materials.

AASHTO M 323	Standard Specification for Superpave Volumetric Mix Design
AASHTO M 325	Standard Specification for Stone Matrix Asphalt (SMA)
AASHTO R 30	Standard Practice for Mixture Conditioning of Hot Mix Asphalt (HMA)
AASHTO R 35	Standard Practice for Superpave Volumetric Design for Asphalt Mixtures
AASHTO R 46	Standard Practice for Designing Stone Matrix Asphalt (SMA)
AASHTO T 30	Standard Method of Test for Mechanical Analysis of Extracted Aggregate
AASHTO T 164	Standard Method of Test for Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)
AASHTO T 166	Standard Method of Test for Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
AASHTO T 209	Standard Method of Test for Theoretical Maximum Specific Gravity (Gmm) and Density of Asphalt Mixtures

AASHTO T 283	Standard Method of Test for Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage
AASHTO T 287	Standard Method of Test for Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method
AASHTO T 305	Standard Method of Test for Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures
AASHTO T 308	Standard Method of Test for Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method
AASHTO T 312	Standard Method of Test for Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor
AASHTO T 324	Standard Method of Test for Hamburg Wheel-Track Testing of Compacted Asphalt Mixtures
AASHTO T 393	Standard Test Method for Determining the Fracture Potential of Asphalt Mixtures Using the Illinois Flexibility Index Test (I-FIT)

(c) Illinois Modified ASTM procedures listed in the Manual of Test Procedures for Materials.

ASTM D 2950	Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods
ASTM D 8159	Standard Test Method for Automated Extraction of Asphalt Binder from Asphalt Mixtures

(d) Bureau of Materials Policy Memorandums.

(1) 1-08 Performance Graded Asphalt Binder Qualification Procedure

(2) 4-08 Approval of Hot-Mix Asphalt Plants and Equipment

(3) 6-08 Minimum Private Laboratory Requirements for Construction Materials Testing or Mix Design

(4) 21-08 Minimum Department and Local Agency Laboratory Requirements for Construction Materials Testing or Mix Design

1030.05 Mixture Design. The Contractor shall submit designs for each required mixture. The mixture design shall be performed at a HMA mix design laboratory according to the Bureau of Materials Policy Memorandum, “Minimum Private Laboratory Requirements for Construction Materials Testing or Mix Design”. Each design shall be verified and approved by the Department as detailed in the document "Hot-Mix Asphalt Mixture Design Verification Procedure”.

(a) Mixture Composition. The Job Mix Formula (JMF) represents the mix design comprised of aggregate gradation and asphalt binder content that produce the desired mix criteria in the laboratory. The ingredients of the mix design shall be combined in such proportions as to produce a mixture conforming to the composition limits by weight unless by volume is specified. The JMF shall fall within the following limits.

MIXTURE COMPOSITION (% PASSING) [1/]																
Sieve Size	IL-19.0		IL-19.0L [2/]		SMA-12.5 [3/]		SMA-9.5 [3/]		IL-9.5		IL-9.5L [2/]		IL-9.5FG		IL-4.75	
	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max
1 1/2 in. (37.5 mm)																
1 in. (25 mm)		100		100												
3/4 in. (19 mm)	90	100	95	100		100		100								
1/2 in. (12.5 mm)	75	89			90	99	95	100		100		100		100		100
3/8 in. (9.5 mm)					50	85	70	95	90	100	95	100	90	100		100
#4 (4.75 mm)	40	60	38	65	20	40	30	50	32	69	52	80	60	75 [7/]	90	100
#8 (2.36 mm)	26	42			16	24 [4/]	20	30	32	52 [5/]	38	65	45	60 [7/]	70	90
#16 (1.18 mm)	15	30						21	10	32			25	40	50	65
#30 (600 µm)								18					15	30		
#50 (300 µm)	6	15						15	4	15			8	15	15	30
#100 (150 µm)	4	9							3	10			6	10	10	18
#200 (75 µm)	3.0	6.0	3.0	7.0	8.0	11.0 [6/]	8.0	11.0 [6/]	4.0	6.0	4.0	8.0	4.0	6.5	7.0	9.0 [6/]
#635 (20 µm)						≤ 3		≤ 3								
Dust/Asphalt Binder Ratio		1.0		1.0						1.0		1.0		1.0		1.0

Notes:

1/ Based on percent of total aggregate weight.

2/ Percent passing the #30 (600 µm) sieve shall be less than 50 percent of the percentage passing the #4 (4.75 mm) sieve for IL-19.0L and #8 (2.36 mm) for the IL-9.5L.

3/ When the bulk specific gravity (Gsb) of the component aggregates vary by more than 0.20, the blend gradations shall be based on percent by volume.

4/ When establishing the Adjusted Job Mix Formula (AJMF) the percent passing the #8 (2.36 mm) sieve shall not be adjusted above 24 percent.

5/ The mixture composition shall not exceed 44 percent passing the #8 (2.36 mm) sieve for surface courses with Ndesign = 90.

6/ Additional minus #200 (75 µm) material required by the mix design shall be mineral filler, unless otherwise approved by the Engineer.

7/ When the mixture is used as a binder, the maximum shall be increased by 5 percent passing.

(b) Volumetric Requirements. The target value for the air voids of the HMA shall be 4.0 percent at the design number of gyrations. The voids in the mineral aggregate (VMA) of the HMA design shall be based on the nominal maximum size of the aggregate in the mix, and shall conform to the following requirements.

	Voids in the Mineral Aggregate (VMA), % Minimum for Ndesign				
Mix Design	30	50	70	80	90
IL-19.0		13.5	13.5		13.5
IL-9.5		15.0	15.0		15.0
IL-9.5FG		15.0	15.0		15.0
IL-4.75 1/		18.5			
SMA-12.5 1/		16.0		17.0	
SMA-9.5 1/		16.0		17.0	
IL-19.0L	13.5				
IL-9.5L	15.0				

1/ Maximum draindown shall be 0.3 percent according to Illinois Modified AASHTO T 305.

(c) Contractor Determination of Tensile Strength and Tensile Strength Ratio (TSR). The mixture designer shall determine if the proposed mix design meets minimum tensile strength requirements and is resistant to stripping. These determinations shall be made based on tests performed according to Illinois Modified AASHTO T 283.

The proposed mix design shall have a minimum conditioned tensile strength of 60 psi (415 kPa) for non-polymer modified performance graded (PG) asphalt binders and 80 psi (550 kPa) for polymer modified PG asphalt binders except modified PG 64-28 or lower asphalt binders which shall have a minimum tensile strength of 70 psi (485 kPa).

The conditioned to unconditioned TSR shall be equal to or greater than 0.85 for 6 in. (150 mm) specimens. Mixtures, either with or without an additive, with TSRs less than 0.85 for 6 in. (150 mm) specimens will be considered unacceptable. Also, the conditioned tensile strength for mixtures containing an anti-strip additive shall not be lower than the conditioned tensile strength of the same mixture without the anti-strip additive.

If it is determined that an additive is required, the additive may be hydrated lime, slaked quicklime, or a liquid additive. Dry hydrated lime shall be added at a minimum rate of 1.0 percent by weight of total dry aggregate. Slurry shall be added in such quantity as to provide the required amount of hydrated lime solids by weight of total dry aggregate. The method of application shall be according to Article 1102.01(a)(8).

(d) Mix Design Verification Testing. Mix designs shall be submitted for verification according to the document "Hot-Mix Asphalt Mixture Design Verification Procedure".

High ESAL mixture designs shall meet the following requirements for tensile strength, TSR, Hamburg wheel, and I-FIT criteria. Low ESAL mixture designs shall meet TSR and I-FIT criteria.

If a mix fails the Department's verification testing, the Contractor shall make necessary changes to the mix and provide passing volumetric, tensile strength, TSR, Hamburg wheel, and I-FIT procedure results before resubmittal. The Department will verify the passing results.

(1) Tensile Strength. The minimum allowable conditioned tensile strength shall be according to Article 1030.05(c).

(2) TSR. The minimum TSR shall be according to Article 1030.05(c).

(3) Hamburg Wheel Test. The maximum allowable rut depth shall be 0.5 in. (12.5 mm). The minimum number of wheel passes at the 0.5 in. (12.5 mm) rut depth is based on the high temperature binder grade of the mix as specified in the mix requirements table on the plans and shall be according to the following.

Illinois Modified AASHTO T 324 Requirements 1/	
PG Grade	Minimum Number of Wheel Passes
PG 58-xx (or lower)	5,000
PG 64-xx	7,500
PG 70-xx	15,000 2/
PG 76-xx (or higher)	20,000 2/

1/ When WMA is produced at temperatures of 275 ± 5 °F (135 ± 3 °C) or less, loose mix shall be oven aged at 270 ± 5 °F (132 ± 3 °C) for two hours prior to gyratory compaction of Hamburg wheel specimens.

2/ For IL-4.75 binder course, the minimum number of wheel passes shall be reduced by 5,000.

(4) I-FIT. The minimum flexibility index (FI) shall be as follows.

Illinois Modified AASHTO T 393		
Mixture	Short Term Aging, Minimum FI	Long Term Aging, Minimum FI 2/
HMA 1/	8.0	5.0 3/
SMA	16.0	10.0
IL-4.75	12.0	-

1/ All mix designs, except for SMA and IL-4.75 mixtures.

2/ Required for surface courses only.

3/ Production long term aging FI for HMA shall be a minimum of 4.0.

1030.06 Quality Management Program. The Quality Management Program (QMP) will be shown on the plans as Pay for Performance (PFP), Quality Control for Performance (QCP), or Quality Control / Quality Assurance (QC/QA) for each HMA mixture or full-depth pavement according to the following.

PFP shall be used on interstate, freeway, and expressway resurfacing and full-depth projects having a minimum quantity of 8,000 tons (7,260 metric tons) per mix.

QCP shall be used on mainline mixture quantities between 1,200 and 8,000 tons (1,016 and 7,620 metric tons) as well as shoulder applications greater than 8 ft (2.4 m) wide and at least 1,200 tons (1,016 metric tons).

QC/QA shall be used for mixtures less than 1,200 tons (1,016 metric tons), shoulder applications 8 ft (2.4 m) wide or less, hand method, variable width shoulders, incidental surfacing, intermittent resurfacing, driveways, entrances, minor sideroads, sideroad returns, patching, turn lanes less than 500 ft (152 m) in length, temporary pavement, and shared-use paths or bike lanes unless paved with the mainline pavement.

The following shall apply to PFP, QCP, and QC/QA.

(a) Laboratory. The Contractor shall provide a laboratory, at the plant, according to the Bureau of Materials Policy Memorandum, “Minimum Private Laboratory Requirements for Construction Materials Testing or Mix Design”. The requirements for the laboratory and equipment for production and mix design are listed in the document "Hot-Mix Asphalt Laboratory Equipment".

The Engineer may inspect measuring and testing devices at any time to confirm both calibration and condition. If laboratory equipment becomes inoperable, the Contractor shall cease mix production. If the Engineer determines the equipment is not within the limits of dimensions or calibration described in the appropriate test method, the Engineer may stop production until corrective action is taken.

(b) Annual QC Plan and QC Addenda. The Contractor shall submit, in writing to the Engineer, a proposed Annual QC Plan following the format of the document “Model Annual Quality Control Plan for Hot-Mix Asphalt Production" for each HMA plant for approval before each construction season. This shall include documentation that each HMA plant has been calibrated and approved by the Department. Job-specific QC Addenda to the Annual QC Plan must be submitted in writing to the Engineer following the format of the document "Model Quality Control Addendum for Hot-Mix Asphalt Production" for approval before the pre-construction conference. The Annual QC Plan and the QC Addenda shall address all elements involved in the production and quality control of the HMA incorporated in the project.

Production of HMA shall not begin without written approval of the Annual QC Plan and QC Addenda by the Engineer.

The approved Annual QC Plan and QC Addenda shall become part of the contract between the Department and the Contractor but shall not be construed, in itself, as acceptance of any HMA produced. Failure to execute the contract according to the approved Annual QC Plan and QC Addenda shall result in suspension of HMA production or other appropriate actions as directed by the Engineer.

The Annual QC Plan and QC Addenda may be amended during the progress of the work, by either party, subject to mutual agreement. Revisions shall require proper justification and be provided to the Department by the Contractor to ensure product quality. Any revision in the Annual QC Plan or QC Addenda must be approved in writing by the Engineer.

(c) General Quality Control (QC) by the Contractor. The Contractor's quality control activities shall ensure mixtures meet contract requirements.

(1) Inspection and Testing. The Contractor shall perform or have performed the inspection and testing required to conform with contract requirements. QC includes the recognition of obvious defects and their immediate correction. QC may require increased testing, communication of test results to the plant or the job site, modification of operations, suspension of HMA production, rejection of material, or other actions as appropriate.

The Engineer shall be immediately notified of any failing tests and subsequent remedial action. Passing tests shall be reported to the Engineer prior to the start of the next day's production.

(2) Personnel. The Contractor shall provide a QC Manager who shall have overall responsibility and authority for quality control. This individual shall have successfully completed the Department's "Hot-Mix Asphalt Level II" course.

In addition to the QC Manager, the Contractor shall provide sufficient personnel to perform the required visual inspections, sampling, testing, and documentation in a timely manner. Mix designs shall be developed by personnel who have successfully completed the Department's "Hot-Mix Asphalt Level III" course. Technicians performing mix design testing and plant sampling/testing shall have successfully completed the Department's "Hot-Mix Asphalt Level I" course. The Contractor may also provide a Gradation Technician who has successfully completed the Department's "Gradation Technician Course" to run gradation tests only under the supervision of a Hot-Mix Asphalt Level II Technician. The Contractor shall provide a Hot-Mix Asphalt Density Tester who has successfully completed the Department's "Nuclear Density Testing" course to run all nuclear density tests on the job site.

Only quality control personnel shall perform the required QC duties. The Contractor is referred to the document "Hot-Mix Asphalt QC Personnel Responsibilities and Duties Checklist" for a description of personnel qualifications and duties.

(d) Additional Contractor and Department Duties.

(1) The Engineer will initiate and witness asphalt binder sampling by the Contractor at a minimum frequency of one injection line-sample per week, per HMA plant. Sample containers will be furnished by the Department. The Engineer will take possession of and submit the properly identified samples, according to Policy Memorandum 1-08, to the Central Bureau of Materials for testing.

(2) Immediately upon completion of coring for density samples or thickness checks, the Contractor shall remove water from the core holes and fill the holes with packaged, dry, rapid hardening mortar or concrete. The cementitious material shall be mixed in a separate container, placed in the hole, consolidated by rodding, and struck-off flush with the adjacent pavement. Depressions in the surface of filled core holes greater than 1/4 in. (6 mm) at the time of final inspection shall require removal and replacement of the fill materials.

1030.07 Pay for Performance (PFP). PFP is a program that evaluates pay parameters using percent within limits to determine a pay adjustment. Monetary deductions for dust/AB ratios and unconfined edge densities may also apply.

(a) Definitions.

(1) Quality Control (QC). QC includes all production and construction activities by the Contractor necessary to achieve a level of quality.

(2) Quality Assurance (QA). QA includes all monitoring and testing activities by the Engineer necessary to assess product quality, to identify acceptability of the product, and to determine payment.

(3) Percent Within Limits (PWL). PWL is the percentage of material within the quality limits for a given quality characteristic.

(4) Quality Characteristic. The characteristics that are evaluated by the Department to determine payment using PWL. The quality characteristics (i.e. pay parameters) for this program are air voids, field VMA, and density. Field VMA will be calculated using the combined aggregates bulk specific gravity (G_{sb}) from the mix design.

(5) Quality Level Analysis (QLA). QLA is a statistical procedure for determining the amount of in-place mixture within specification limits.

(6) Mixture Lot. A mixture lot will begin once an acceptable test strip has been completed and the adjusted job mix fomula (AJMF) has been determined. If the test strip is waived, the mixture lot will begin with the start of production. A mixture lot consists of ten mixture sublots. If

seven or fewer mixture sublots remain at the end of production of a mixture, the test results for these sublots will be combined with the previous lot for evaluation of PWL and pay factors.

(7) Mixture Sublot. A mixture sublot for air voids and field VMA will be a maximum of 1,000 tons (910 metric tons). If the project quantity is less than 8,000 tons (7,260 metric tons), the sublot size will be adjusted to achieve a minimum of 8 tests.

a. If the remaining quantity is greater than 200 tons (180 metric tons) but less than 1,000 tons (910 metric tons), the last mixture sublot will be that quantity.

b. If the remaining quantity is 200 tons (180 metric tons) or less, the quantity shall be combined with the previous mixture sublot.

(8) Density Lot. A density lot consists of 30 density intervals. If 19 or fewer density intervals remain at the end of production of a mixture, the test results for these sublots will be combined with the previous lot for evaluation of percent within limits and pay factors.

(9) Density Interval. A density interval will be every 0.2 miles (320 m) for lift thicknesses of 3 in. (75 mm) or less and 0.1 miles (160 m) for lift thicknesses greater than 3 in. (75 mm). In cases where paving is completed over multiple lanes in a single pass of one or more pavers to eliminate unconfined edges or cold joints between lanes, the paving lane is defined as the total combined width of the lanes paved in that single pass. If the paving lane width is greater than 20 ft (6 m), the density intervals will be every 0.1 mi. (160 m) for lift thicknesses of 3 in. (75 mm) or less and 0.05 mi. (80 m) for lift thicknesses greater than 3 in. (75 mm). If the last density interval for a lift is less than 200 ft (60 m), it will be combined with the previous density interval.

(10) Density Specimen. A density specimen shall consist of a 4 in. (100 mm) core taken at a random test location within each density interval.

(11) Density Test. A density test shall consist of testing a density specimen according to Illinois Modified AASHTO T 166.

"When establishing the target density, the HMA maximum theoretical specific gravity (G_{mm}) will be based on the running average of four available Department test results for that project. If less than four G_{mm} test results are available, an average of all available Department test results for that project will be used. The initial G_{mm} will be the last available Department test result from a QMP project. If there is no available Department test result from a QMP project, the Department mix design verification test result will be used as the initial G_{mm}."

(12) Unconfined Edge Density. The location of the unconfined edge density test sample will be randomly selected within each 0.5 mile (800 m) sublot for each mixture with an unconfined edge according to the document "Hot-Mix Asphalt PFP and QCP Calculations of Monetary Deductions". The last sublot may be less than 0.5 mile (800 m) but at least 200 ft (60 m). If longitudinal joint sealant (LJS) is used at a joint, the joint will not be included in the unconfined edge density testing.

(13) Pay Adjustment. The pay adjustment is calculated using the test results of the pay parameters (air voids, field VMA and density).

(14) Combined Full-Depth Pay Adjustment. For full-depth pavements, the composite pay factors for all incorporated mixtures are combined to determine the combined full-depth pay adjustment.

(15) Monetary Deduction. In addition to the pay adjustment for the pay parameters air voids, field VMA, and density for each mix or full-depth pavement, it will be determined if there is a monetary deduction for dust/AB ratio and/or unconfined edge density.

(b) Quality Control (QC) by the Contractor. The Contractor's QC plan shall include the schedule of testing for both quality characteristics used to determine pay and other quality characteristics required to control the product. The schedule shall include sample time and location. The minimum test frequency shall be according to the following.

Minimum Quality Control Sampling and Testing Requirements

Quality Characteristic	Minimum Test Frequency	Sampling Location
Mixture Gradation	1/day	per QC Plan
Asphalt Binder Content		
G_{mm}		
G_{mb}		
Density	per QC plan	per QC Plan

The Contractor shall submit QC test results to the Engineer within 48 hours of sampling.

(c) Initial Production Testing. The Contractor shall split and test the first two samples with the Department for comparison purposes. The Contractor shall complete all tests and report all results to the Engineer within two working days of sampling. The Engineer will make Department test results of the initial production testing available to the Contractor within two working days from the receipt of the samples.

(d) Additional Contractor Duties. The Contractor shall obtain the random mixture samples identified by the Engineer according to the document "Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling". One composite sample per sublot shall be collected in the presence of the Engineer. The composite sample shall be split into four equal mix samples. The Contractor shall transport the Department's mix sample to the location designated by the Engineer.

The Contractor shall provide personnel and equipment to collect density specimens for the Engineer. Core locations will be determined by the Engineer following the document "Hot-Mix Asphalt PFP and QCP Procedure for Determining Random Density Locations". The Contractor shall cut the cores within the same day and prior to opening to traffic unless otherwise approved by the Engineer. The Contractor shall transport the Department's secured density specimens to the location designated by the Engineer.

(e) Quality Assurance (QA) by the Engineer. The Department's laboratories which conduct PFP testing will participate in the AASHTO re:source's (formerly AMRL) Proficiency Sample Program. The Engineer will test each mixture sublot for air voids, field VMA, and dust/AB ratio; and each density interval for density to determine payment according to the document "Hot-Mix Asphalt PFP Pay Adjustments". A sublot shall begin once an acceptable test-strip has been completed and the AJMF has been determined.

(1) Air Voids, Field VMA, and Dust/AB Ratio. For each sublot, the Engineer will determine the random tonnage for the sample and the Contractor shall be responsible for obtaining the sample according to the document "Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling". The Engineer will not disclose the random location of the sample until after the truck containing the random tonnage has been loaded and en-route to the project.

(2) Density. For each density interval, the Engineer will determine the random location for the density test according to the document "Hot-Mix Asphalt PFP and QCP Procedure for Determining Random Density Locations". The Engineer will not disclose the random location of the sample until after the final rolling.

The Engineer will witness and secure all mixture and density samples.

(f) Test Results. The Department's test results for the first mixture sublot and density interval, of every lot will be available to the Contractor within three working days from the receipt of secured samples. Test results for remaining sublots will be available to the Contractor within ten working days from receipt of the secured sample that was delivered to the Department's testing facility or a location designated by the Engineer.

The Engineer will maintain a complete record of Department test results. Copies will be furnished upon request. The records will contain, at a minimum, all the Department test results, raw data, random numbers used and resulting calculations for sampling locations, and QLA calculations.

(g) Dispute Resolution. Dispute resolution testing will only be permitted when the Contractor submits their split sample test results prior to receiving Department split sample test results and meets the requirements listed in the document "Hot-Mix Asphalt PFP Dispute Resolution". If dispute resolution is chosen, the Contractor shall submit a request in writing within four working days of receipt of the Department results of the QLA for the lot in question. The Engineer will document receipt of the request. The request shall specify Method 1 (pay parameter dispute) or Method 2 (individual parameter dispute) as defined in the document "Hot-Mix Asphalt PFP Dispute Resolution". The Central Bureau of Materials laboratory will be used for dispute resolution testing.

(h) Acceptance by the Engineer. To be considered acceptable, all the Department's test results shall be within the acceptable limits listed below.

Acceptable Limits		
Parameter		Acceptable Range
Air Voids		2.0 – 6.0 %
Field VMA		-1.0 – +3.0 % [1/]
Density	IL-19.0, IL-9.5, IL-9.5FG, IL-4.75	90.0 – 98.0 %
	SMA 12.5, SMA 9.5	92.0 – 98.0 %
Dust / AB Ratio		0.4 – 1.6 [2/]

1/ Based on minimum required field VMA as stated in the mix design volumetric requirements in Article 1030.05(b).

2/ Does not apply to SMA.

In addition, the PWL for any quality characteristic shall be 50 percent or above for any lot. No visible pavement distress shall be present such as, but not limited to, segregation, excessive coarse aggregate fracturing or flushing.

1030.08 Quality Control for Performance (QCP). QCP is a program that uses step-based pay without an incentive to determine pay adjustment. A monetary deduction for dust/AB ratios also applies.

(a) Definitions.

(1) Quality Control (QC). QC includes all production and construction activities by the Contractor necessary to achieve a level of quality.

(2) Quality Assurance (QA). QA includes all monitoring and testing activities by the Engineer necessary to assess product quality, to identify acceptability of the product, and to determine payment.

(3) Pay Parameters. Pay parameters are air voids, field VMA and density. Field VMA will be calculated using the combined aggregates bulk specific gravity (G_{sb}) from the mix design.

(4) Mixture Lot. A mixture lot will begin once an acceptable test strip has been completed and the AJMF has been determined. If the test strip is waived, a mixture lot will begin with the start of production. A mixture lot will consist of four sublots unless it is the last or only lot, in which case it may consist of as few as one sublot.

(5) Mixture Sublot. A mixture sublot for air voids, field VMA, and dust/AB ratio will be a maximum of 1,000 tons (910 metric tons).

a. If the remaining quantity is greater than 200 tons (180 metric tons) but less than 1,000 tons (910 metric tons), the last mixture sublot will be that quantity.

b. If the remaining quantity is 200 tons (180 metric tons) or less, the quantity will be combined with the previous mixture sublot.

(6) Density Interval. Density intervals will be every 0.2 miles (320 m) for lift thicknesses of 3 in. (75 mm) or less and 0.1 miles (160 m) for lift thicknesses greater than 3 in. (75 mm). In cases where paving is completed over multiple lanes in a single pass of one or more pavers to eliminate unconfined edges or cold joints between lanes, the paving lane is defined as the total combined width of the lanes paved in that single pass. If the paving lane width is greater than 20 ft (6 m), the density intervals will be every 0.1 mi. (160 m) for lift thicknesses of 3 in. (75 mm) or less and 0.05 mi. (80 m) for lift thicknesses greater than 3 in. (75 mm). If the last density interval for a lift is less than 200 ft (60 m), it will be combined with the previous density interval.

(7) Density Sublot. A density sublot will be the average of five consecutive density intervals.

a. If fewer than three density intervals remain outside a density sublot, they will be included in the previous density sublot.

b. If three to five density intervals remain, they will be considered a density sublot.

(8) Density Specimen. A density specimen shall consist of a 4 in. (100 mm) core taken at a random location within each density interval.

(9) Density Test. A density test shall consist of testing a density specimen according to Illinois Modified AASHTO T 166.

“When establishing the target density, the HMA maximum theoretical specific gravity (G_{mm}) will be based on the running average of four available Department test results for that project. If less than four G_{mm} test results are available, an average of all available Department test results for that project will be used. The initial G_{mm} will be the last available Department test result from a QMP project. If there is no available Department test result from a QMP project, the Department mix design verification test result will be used as the initial G_{mm}.”

(10) Pay Adjustment. The pay adjustment is calculated using the test results of the pay parameters (air voids, field VMA and density).

(11) Combined Full-Depth Pay Adjustment. For full-depth pavements, the composite pay factors for all incorporated mixtures are combined to determine the combined full-depth pay adjustment.

(12) Monetary Deduction. In addition to the pay adjustment for the pay parameters air voids, field VMA, and density for each mix or full-depth pavement, it will be determined if there is a monetary deduction for dust/AB ratio.

(b) Quality Control (QC) Testing by the Contractor. The Contractor’s QC plan shall include the schedule of testing for both pay parameters and non-pay parameters necessary to control the product. The minimum test frequency shall be according to the following table.

Minimum Quality Control Mixture Sampling and Testing Requirements		
Quality Characteristic		Minimum Test Frequency
Air Voids	G_{mb}	1 per sublot
	G_{mm}	
Washed Mixture Gradation		
Asphalt Binder Content		
Dust/AB Ratio [1/]		
Field VMA		

1/ Dust/AB ratio is not used in the calculation of the pay adjustment but is used to verify the mix is within acceptable limits and determine if there are monetary deductions for this parameter.

The Contractor's results from mix sample testing of split samples, in conjunction with additional quality control tests, shall be used to control production.

The Contractor shall submit their mix sample test results from the split sample to the Engineer within 48 hours of the time of sampling.

(c) Additional Contractor Duties. The Contractor shall obtain the random mixture samples at locations identified by the Engineer according to the document, "Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling". One composite sample per sublot shall be collected in the presence of the Engineer. The composite sample shall be split into four equal mix samples. The Contractor shall transport the Department's mix sample to the location designated by the Engineer.

The Contractor shall provide personnel and equipment to collect density specimens for the Engineer. Core locations will be determined by the Engineer following the document "Hot-Mix Asphalt PFP and QCP Procedure for Determining Random Density Locations". The Contractor shall cut the cores within the same day and prior to opening to traffic unless otherwise approved by the Engineer. The Contractor shall transport the Department's secured density specimens to the location designated by the Engineer.

(d) Quality Assurance (QA) by the Engineer. The Department's laboratories which conduct QCP testing will participate in the AASHTO re:source's (formerly AMRL) Proficiency Sample Program. Quality Assurance by the Engineer will be as follows.

(1) Air Voids, Field VMA, and Dust/AB Ratio. The Engineer will determine the random tonnage for the sample and the Contractor shall be responsible for obtaining the sample according to the document "Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling Procedure". The Engineer will not disclose the random location of the sample until after

the truck containing the random tonnage has been loaded and en-route to the project.

(2) Density. For each density interval, the Engineer will determine the random location for the density test according to the document "Hot-Mix Asphalt PFP and QCP Procedure for Determining Random Density Locations". The Engineer will not disclose the random location of the sample until after the final rolling.

The Engineer will witness and secure all mixture samples to be tested by the Department.

The Engineer will select at random one sublot mixture sample from each lot for testing of air voids, field VMA and dust/AB ratio. The Engineer will test a minimum of one mixture sample per project. The Engineer will test all pavement cores for density. QA test results will be available to the Contractor within ten working days from receipt of split mixture samples and cores from the last sublot from each lot.

The Engineer will maintain a complete record of all Department test results and copies will be provided to the Contractor with each set of sublot results. The records will contain, at a minimum, the originals of all Department test results and raw data, random numbers used and resulting calculations for sampling locations, and pay calculations.

When the QA mixture test results are compared to QC results for a sublot and they are within the precision limits listed in the following table, the QA sublot results will be defined as the final mixture results for that sublot. When QA results are compared to QC results for a sublot and they do not meet the precision limits listed in the following table, the Department will verify the results by testing the retained split sample. The retest results will replace all of the original results and will be defined as the final mixture results for that sublot.

If the final mixture QA results for the random sublot do not meet the 100 percent sublot pay factor limits listed in the document "Hot-Mix Asphalt QCP Pay Adjustments" or do not compare to QC results within the precision limits in the following table, the Engineer will test all sublot split mixture samples for the lot.

Test Parameter	Limits of Precision
G_{mb}	0.030
G_{mm}	0.026
Field VMA	1.0 %

If the dust/AB ratio results for the random sublot do not fall within 0.6 and 1.2, the Department will test the remaining sublots for that lot to determine the dust/AB ratio monetary deductions.

(e) Acceptance by the Engineer. To be acceptable, all of the Department's test results will be within the acceptable limits listed in the following table.

Test Parameter		Acceptable Limits
Air Voids		2.0 – 6.0 %
Field VMA		-1.0 – +3.0 % [1/]
Density	IL-19.0, IL-9.5, IL-9.5FG, IL-4.75	90.0 – 98.0 %
	SMA 12.5, SMA 9.5	92.0 – 98.0 %
Dust / AB Ratio		0.4 – 1.6 [2/]

1/ Based on minimum required VMA as stated in the mix design volumetric requirements in Article 1030.05(b).

2/ Does not apply to SMA.

In addition, no visible pavement distresses shall be present such as, but not limited to, segregation, excessive coarse aggregate fracturing or flushing.

1030.09 Quality Control / Quality Assurance (QC/QA). QC/QA is a method specification acceptance program with no pay adjustments or deductions.

(a) Required Mixture Tests. The Contractor shall complete testing of all required mixture samples within 3 1/2 hours of sampling.

(1) Mixture Sampling. The Contractor shall obtain required mixture samples according to the document, "Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples".

(2) Frequency. The Contractor shall use the test methods identified to perform the following mixture tests at a frequency not less than that indicated.

Frequency of Mixture Tests 3/, 4/

Parameter	Production Tons (Metric Tons) Per Day	Initial Daily Plant Tests	Daily Random Tests	Test Method
Aggregate Gradation of Washed Ignition Oven or Solvent Extraction	All	1	1	Illinois Modified AASHTO T 30
Asphalt Binder Content	All	1	1	Illinois Modified AASHTO T 164, T 287, T 308 1/
Field VMA 2/	< 1200 (1090)	1	1 for first 2 days	Illinois Modified AASHTO R 35
	≥ 1200 (1090)	1	1	
Air Voids Bulk Specific Gravity of Gyratory Sample	< 1200 (1090)	1	1 for first 2 days	Illinois Modified AASHTO T 312
	≥ 1200 (1090)	1	1	
Maximum Specific Gravity of Mixture	< 1200 (1090)	1	1 for first 2 days	Illinois Modified AASHTO T 209
	≥ 1200 (1090)	1	1	
Draindown IL-4.75, SMA-12.5 and SMA-9.5	All		1	Illinois Modified AASHTO T 305

1/ The ignition oven shall not be used if the calibration factor exceeds 1.5 percent.

2/ The combined G_{sb} used in the VMA calculation shall be listed in the approved mix design.

3/ If the day's production is less than 250 tons (225 metric tons) per mix, gradation analysis, air voids, field VMA and asphalt binder content tests will not be required on a specific mixture. A minimum of one set of mixture tests for each mix shall be performed for each five consecutive production-day period when the accumulated tonnage produced in that period exceeds 500 tons (450 metric tons). A Hot-Mix Asphalt Level II Technician shall oversee all QC operations.

4/ If the required tonnage of any mixture for a single pay item is less than 250 tons (225 metric tons) in total, the Contractor may propose intentions of waiving the "Required Mixture Tests" in the QC Addenda. The mixture shall be produced using a mix design that has been verified as specified and validated by the Department's recent acceptable field test data. A Hot-Mix Asphalt Level II Technician shall oversee all quality control operations for the mixture.

(3) Dust/AB Ratio and Moisture Content. During production, the dust/AB ratio and the moisture content of the mixture at discharge from the mixer shall meet the following.

Parameter	All Mixtures
Dust/AB Ratio [1/]	0.6 to 1.2
Moisture, max.	0.3 %

1/ Does not apply to SMA.

If at any time the dust/AB ratio or moisture content of the mixture falls outside the stated limits, production of the HMA shall cease. The cause shall be determined and corrective action satisfactory to the Engineer shall be initiated prior to resuming production.

(4) Additional HMA Samples. The Contractor shall, when necessary, take and test additional samples (designated "check" samples) at the plant during HMA production. These samples in no way replace the required plant samples described above. Check samples shall be tested only for the parameters deemed necessary by the Contractor. Check sample test results shall be noted in the Plant Diary but shall not be plotted on the control charts. The Contractor shall detail the situations in which check samples will be taken in the Annual QC Plan.

(b) Required Density Tests. The Contractor shall control the compaction process by testing the mix density at random locations as determined according to the document "Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations", and recording the results on forms approved by the Engineer. The Contractor shall follow the density testing procedures detailed in the document "Illinois Modified ASTM D 2950, Standard Test Method for Density of Bituminous Concrete In-Place by Nuclear Method". When required, the Contractor shall be responsible for establishing the correlation to convert nuclear density results to core densities according to the document "Procedure for Correlating Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt”. The Engineer may require a new nuclear/core correlation if the Contractor’s gauge is recalibrated during the project.

(1) Paving. For paving, density tests shall be performed at randomly selected locations within 0.5 mile (800 m) intervals for each lift of 3 in. (75 mm) or less in thickness. For lifts in excess of 3 in. (75 mm) in thickness, a test shall be performed within 0.25 mile (400 m) intervals. In no case shall more than one-half day's production be completed without performing QC density testing.

Longitudinal joint density testing shall also be performed at each random density test location. Longitudinal joint testing shall be located at a distance equal to 4 in. (100 mm) from each pavement edge.

(a) Confined Edge. Each confined edge density shall be represented by a one-minute nuclear density reading or a core density and shall be included in the average of density readings or core densities taken across the mat which represent the Individual Test.

(b) Unconfined Edge. Each unconfined edge joint density shall be represented by an average of three one-minute nuclear density readings or a single core density at the given density test location and shall meet the density requirements specified in the Density Control Limits table below. The three one-minute nuclear density readings shall be spaced 10 ft (3 m) apart longitudinally along the unconfined pavement edge and centered at the random density test location.

Density testing will not be required on longitudinal joints treated with longitudinal joint sealant (LJS).

(2) Patching. For patching, density tests shall be performed each day on randomly identified patches following the document "Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations". Density testing frequency shall be a minimum of one test per half day of production per mix.

(c) Control Limits. The AJMF values shall be plotted on the control charts within the following control limits.

CONTROL LIMITS						
Parameter	IL-19.0, IL-9.5, IL-9.5FG, IL-19.0L, IL-9.5L		SMA-12.5, SMA-9.5		IL-4.75	
	Individual Test	Moving Avg. of 4	Individual Test	Moving Avg. of 4	Individual Test	Moving Avg. of 4
% Passing: 1/						
1/2 in. (12.5 mm)	± 6 %	± 4 %	± 6 %	± 4 %		
3/8 in. (9.5mm)			± 4 %	± 3 %		
# 4 (4.75 mm)	± 5 %	± 4 %	± 5 %	± 4 %		
# 8 (2.36 mm)	± 5 %	± 3 %	± 4 %	± 2 %		
# 16 (1.18 mm)			± 4 %	± 2 %	± 4 %	± 3 %
# 30 (600 µm)	± 4 %	± 2.5 %	± 4 %	± 2.5 %		
Total Dust Content # 200 (75 µm)	± 1.5 %	± 1.0 %			± 1.5 %	± 1.0 %
Asphalt Binder Content	± 0.3 %	± 0.2 %	± 0.2 %	± 0.1 %	± 0.3 %	± 0.2 %
Air Voids	± 1.2 %	± 1.0 %	± 1.2 %	± 1.0 %	± 1.2 %	± 1.0 %
Field VMA 2/	-0.7 %	-0.5 %	-0.7 %	-0.5 %	-0.7 %	-0.5 %

1/ Based on washed ignition oven or solvent extraction gradation.

2/ Allowable limit below minimum design VMA requirement

DENSITY CONTROL LIMITS			
Mixture Composition	Ndesign	Individual Test (includes confined edges)	Unconfined Edge Joint Density, minimum
IL-4.75	50	93.0 – 97.4 %	91.0 %
IL-9.5FG	50 – 90	93.0 – 97.4 %	91.0 %
IL-9.5	90	92.0 – 96.0 %	90.0 %
IL-9.5, IL-9.5L,	< 90	92.5 – 97.4 %	90.0 %
IL-19.0	90	93.0 – 96.0 %	90.0 %
IL-19.0, IL-19.0L	< 90	93.0 [1/] – 97.4 %	90.0 %
SMA-9.5, SMA-12.5	50 or 80	93.5 – 97.4 %	91.0 %

1/ 92.0 percent when placed as first lift on an unimproved subgrade.

(d) Control Charts. Standardized control charts shall be maintained by the Contractor at the laboratory and shall be accessible at all times for review by the Engineer.

Control limits for each required parameter, both individual tests and the average of four tests, shall be plotted on control charts as described in the document "Hot-Mix Asphalt QC/QA Control Charts”.

The results of individual required tests listed in Article 1030.09(c) obtained by the Contractor shall be recorded on the control chart immediately upon completion of a test, but no later than 24 hours after sampling. Only the required tests and resamples shall be recorded on the control chart.

Control Chart Requirements	All Mixtures
Gradation [1/ 3/]	% Passing Sieves: 1/2 in. (12.5 mm) [2/] # 4 (4.75 mm) # 8 (2.36 mm) # 30 (600 µm)
Total Dust Content [1]	# 200 (75 µm)
Volumetric	Asphalt Binder Content
	Bulk Specific Gravity
	Maximum Specific Gravity of Mixture
	Air Voids
	Density
	Field VMA

1/ Based on washed ignition oven or solvent extraction.

2/ Does not apply to IL-4.75.

3/ SMA also requires the 3/8 in. (9.5mm) sieve.

(e) Corrective Action for Required Mixture Tests.

(1) Individual Test Results. When an individual test result exceeds its control limit, the Contractor shall immediately resample and retest. If at the end of the day no material remains from which to resample, the first sample taken the following day shall serve as the resample as well as the first sample of the day. This result shall be recorded as a retest. If the retest passes, the Contractor may contine the required test frequency. Additional check samples should be taken to verify mix compliance.

a. If the retest for air voids, field VMA, or asphalt binder content exceeds control limits, HMA production shall cease and immediate corrective action shall be instituted by the Contractor. After corrective action, HMA production shall be restarted, the HMA production shall be stabilized, and the Contractor shall immediately resample and retest. The corrective action shall be documented.

b. Gradation. For gradation retest failures, immediate corrective action shall be instituted by the Contractor. After corrective action, the Contractor shall immediately resample and retest. The corrective action shall be documented.

(2) Moving Average. When the moving average values trend toward the moving average control limits, the Contractor shall take corrective action and increase the sampling and testing frequency. The corrective action shall be documented.

The Contractor shall notify the Engineer whenever the moving average values exceed the moving average control limits. If two consecutive moving average values fall outside the moving average control limits, the Contractor shall cease mixture production. Corrective action shall be immediately instituted by the Contractor. Mixture production shall not be reinstated without the approval of the Engineer.

(3) Dust Control. If the washed ignition oven or solvent extraction gradation test results indicate fluctuating dust, corrective action to control the dust shall be taken. If the Engineer determines that positive dust control equipment is necessary, the equipment as specified in Article 1102.01(c)(7) shall be installed prior to the next construction season.

(f) Corrective Action for Required Nuclear Density Tests. When an individual nuclear density test exceeds the control limits, the Contractor shall immediately retest in a location that is halfway between the failed test site and the finish roller. If the retest passes, the Contractor shall continue the normal density test frequency. An additional density check test should be performed to verify the mix compaction.

If the retest fails, the Contractor shall immediately conduct one of the following procedures.

(1) Low Density. If the failing density retest indicates low densities, the Contractor shall immediately increase the compaction effort, review all mixture test results representing the HMA being produced, and make corrective action as needed. The Contractor shall immediately perform a second density retest within the area representing the increased compaction effort and mixture adjustments.

(2) High Density. If the failing density retest indicates high densities, the Contractor shall cease production and placement until all mixture test results are reviewed and corrective action is taken. If the high density failure is a result of a change in the mixture, existing material in the surge bin may be subject to rejection by the Engineer. After restart of HMA production, a second density retest shall then be performed in the area representing the mixture adjustments.

If the second retest from either procedure passes, production and placement of the HMA may continue. The increased compaction effort for low density failures shall not be reduced to that originally being used unless it is determined by investigation that the cause of the low density was unrelated to compaction effort, the cause was corrected, and tests show the corrective action has increased the density within the required limits.

If the second retest fails, production and placement of the HMA shall cease until the Contractor has completed an investigation and the problem(s) causing the failing densities has/have been determined. If the Contractor's corrective action is approved by the Engineer, production and placement of the HMA may then be resumed. The Contractor shall increase the frequency of density testing to show, to the satisfaction of the Engineer, that the corrective action taken has corrected the density problem.

(g) Additional Contractor Duties.

"(1) The Contractor shall sample approximately 150 lb (70 kg) of mix as required for the Department's random mixture verification tests according to Article 1030.09(h)(1)."

(2) The Contractor shall complete split verification sample tests listed in the Limits of Precision table in Article 1030.09(h)(2).

(3) The Contractor shall provide personnel and equipment to collect density verification cores for the Engineer. Core locations will be determined by the Engineer following the document "Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations" at density verification intervals defined in Article 1030.09(b). After the Engineer identifies a density verification location and prior to opening to traffic,

the Contractor shall cut a 4 in. (100 mm) diameter core. With the approval of the Engineer, the cores may be cut at a later time.

(h) Verification by the Engineer. The Engineer will observe the Contractor's quality control processes and complete testing of the test strip samples, identify random verification mixture sample locations, conduct mixture verification testing, identify random density verification locations, conduct density verification testing, and identify asphalt binder samples for testing.

(1) The Engineer will determine the random verification mixture sample locations according to the document "Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples".

"The Engineer will randomly identify one sample for each 3,000 tons (2,720 metric tons) of mix, with a minimum of one sample per mix. If the remaining mix quantity is 600 tons (544 metric tons) or less, the quantity will be combined with the previous 3,000 tons (2,720 metric tons) in the Engineer's random sample identification. If the required tonnage of a mixture for a single pay item is less than 250 tons (225 metric tons) in total, the Engineer will waive mixture verification tests."

The Engineer will witness, secure and take possession of the verification mixture sample. Department mixture testing will be completed on asphalt binder content, bulk specific gravity, maximum specific gravity and field VMA. If an anti-strip additive was used in the mixture, the Department will also test for stripping according to Illinois Modified AASHTO T 283. If the mixture fails to meet the minimum tensile strength and TSR criteria as specified in Article 1030.05(d), no further mixture will be accepted until the Contractor takes such action as is necessary to furnish a mixture meeting the criteria.

Differences between the Contractor's and the Department's split verification sample test results will be considered acceptable if within the following limits.

Test Parameter	Limits of Precision
Asphalt Binder Content	0.3 %
Maximum Specific Gravity of Mixture	0.026
Bulk Specific Gravity	0.030
Field VMA	1.0 %

If comparison of the mixture verification test results are outside the above limits of precision, the Engineer will complete an investigation. The investigation may include review and observation of the Contractor's and the Department's technician performance, testing procedure, and equipment.

(2) After final rolling and prior to paving subsequent lifts, the Engineer will identify the random density verification test locations. Cores will be used for density verification for all paving greater than or equal to 3 ft (1 m) in width when the paving length exceeds 300 ft (90 m). The Engineer may utilize nuclear gauges for paving less than 3 ft (1 m) in width, for any paving 300 ft (90 m) or less in length, and for patches. Additional items or locations where nuclear gauges will be used will be shown in the plans.

Density verification test locations will be determined according to the document "Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations". The density testing interval for paving wider than or equal to 3 ft (1 m) will be 0.5 miles (800 m) for lift thicknesses of 3 in. (75 mm) or less and 0.2 miles (320 m) for lift thicknesses greater than 3 in. (75 mm). The density testing interval for paving less than 3 ft (1 m) wide will be 1 mile (1,600 m). If a day's paving will be less than the prescribed density testing interval, the length of the day's paving will be the interval for that day. The density testing interval for mixtures used for patching will be 50 patches with a minimum of one test per mixture per project.

The Engineer will witness the Contractor coring, and secure and take possession of all density samples at the density verification locations. The Engineer will test the cores collected by the Contractor for density according to Illinois Modified AASHTO T 166 or AASHTO T 275.

"When establishing the target density, the HMA maximum theoretical specific gravity (G_{mm}) will be the Department mix design verification test result."

A density verification test will be the result of a single core or the average of the nuclear density tests at one location. The results of each density test must be within acceptable limits. The Engineer will promptly notify the Contractor of observed deficiencies.

(i) Acceptance by the Engineer. Final acceptance will be based on the following.

(1) Acceptable limits. To be considered acceptable, the Department's verification test results shall be within the following acceptable limits.

Parameter		Acceptable Limits
Field VMA		-1.0 – +3.0 % 1/
Air Voids		2.0 – 6.0 %
Density	IL-9.5, IL-19.0, IL-4.75, IL-9.5FG	90.0 – 98.0 %
	SMA 12.5, SMA 9.5	92.0 – 98.0 %
Dust / AB Ratio		0.4 – 1.6 2/

1/ Based on minimum required VMA as stated in the mix design volumetric requirements in Article 1030.05(b).

2/ Does not apply to SMA.

(2) The Contractor's process control charts and actions.

In addition, no visible pavement distress such as, but not limited to, segregation, excessive coarse aggegate fracturing, or flushing shall be present.

If any of the above is not met, the work will be considered in non-conformance with the contract.

(j) Documentation. The Contractor shall be responsible for maintaining the Annual QC Plan and QC Addendum.

The Contractor shall be responsible for documenting all observations, records of inspection, adjustments to the mixture, test results, retest results, and corrective actions in a bound hardback field book or bound hardback diary which will become the property of the Department.

The Contractor shall be responsible for the maintenance of all permanent records whether obtained by the Contractor, the Contractor's consultants, or the producer of the HMA.

The Contractor shall provide the Engineer full access to all documentation throughout the progress of the work.

Adjustments to mixture production and test results shall be recorded and sent to the Engineer on forms approved by the Engineer.

1030.10 Start of HMA Production and Job Mix Formula (JMF) Adjustments. The start of HMA production and JMF adjustments shall be as follows.

For each contract, a 300 ton (275 metric ton) test strip will be required at the beginning of HMA production for each mixture with a quantity of 3,000 tons (2,750 metric ton) or more according to the document "Hot-Mix Asphalt Test Strip Procedures".

An off-site preliminary test strip may be required for new mixture types according to the document "Off-Site Preliminary Test Strip Procedures for Hot-Mix Asphalt".

When a test strip is constructed, the Contractor shall collect and split the mixture according to the document "Hot-Mix Asphalt Test Strip Procedures". Within two working days after sampling the mixture placed in the test strip, the Contractor shall deliver prepared samples to the District laboratory for verification testing. The Contractor shall complete mixture tests stated in Article 1030.09(a). The Department will complete testing of loose mixture samples and gyratory cylinders provided by the Contractor. Mixture sampled shall include enough material for the Department to conduct mixture tests detailed in Article 1030.09(a) and in the document "Hot-Mix Asphalt Mixture Design Verification Procedure" Section 3.3. The mixture test results shall meet the requirements of Articles 1030.05(b) and 1030.05(d), except tensile strength and TSR testing will only be conducted on the first use of a mix design for the year and Hamburg wheel tests will only be conducted on High ESAL mixtures.

"When a test strip is not required, each HMA mixture with a quantity of 3,000 tons (2,750 metric tons) or more shall still be sampled on the first day of production: I-FIT and Hamburg wheel testing for High ESAL; I-FIT testing for Low ESAL. Within two working days after sampling the mixture, the Contractor shall deliver gyratory cylinders to the District laboratory for Department verification testing. The High ESAL mixture test results shall meet the requirements of Articles 1030.05(d)(3) and 1030.05(d)(4). The Low ESAL mixture test results shall meet the requirements of Article 1030.05(d)(4)."

If the test strip mixture fails to meet the requirements for tensile strength or TSR, a resample shall be provided by the Contractor to the Department. Failure of a resampled mixture test shall result in the Contractor stopping production. The Contractor shall take corrective action and re-submit for testing according to Article 1030.05(d), substitute an approved mix design, or submit a new mix design for mix verification testing according to Article 1030.05(d).

Based on the test results from the test strip, if any JMF adjustment or plant change is needed, the JMF shall become the Adjusted Job Mix Formula (AJMF). If an adjustment/plant change is made, the Engineer may require a new test strip to be constructed. Upon completion of the first acceptable test strip, the JMF shall become the AJMF regardless of whether or not the JMF has been adjusted.

If the HMA placed during the initial test strip is determined to be unacceptable to remain in place by the Engineer, it shall be removed and replaced. In no case shall the target for the amount passing be outside the mixture composition limits stated in Article 1030.05(a).

The limitations between the JMF and AJMF are as follows.

Parameter	High ESAL Adjustment	Low ESAL Adjustment
1/2 in. (12.5 mm)	± 5.0 %	± 6.0 %
# 4 (4.75 mm)	± 4.0 %	± 5.0 %
# 8 (2.36 mm)	± 3.0 %	
# 30 (600 µm)	1/	
# 200 (75 µm)	1/	± 2.5 %
Asphalt Binder Content	± 0.3 %	± 0.5 %

1/ In no case shall the target for the amount passing be greater than the JMF.

Adjustments outside the above limitations will require a new mix design.

“Production is not required to stop after a test strip has been constructed.”

Upon notification by the Engineer of a failing Hamburg wheel or I-FIT test, the Contractor shall immediately resample and the Department will test. Paving may continue as long as all other mixture criteria is being met. If the second set of Hamburg wheel or I-FIT tests fail, no additional mixture shall be produced until the Engineer receives both passing Hamburg wheel and I-FIT tests.

During production, the Contractor and Engineer shall continue to evaluate test results and mixture laydown and compaction performance. Adjustments within the above requirements may be necessary to obtain the desired mixture properties. If an adjustment/plant change is made, the Engineer may request additional growth curves and supporting mixture tests.

1030.11 Preparation of Mixture for Cracks, Joints, and Flangeways. When the mixture is prepared in a batch-type mixing plant, the heated aggregate and the asphalt binder shall be measured separately and accurately by weight or by volume. The heated aggregate and asphalt binder shall be mixed in a pug mill mixer. When the aggregate is in the mixer, the asphalt binder shall be added and mixing continued until a homogeneous mixture is produced in which all particles of aggregate are coated uniformly. The mixing time will be determined by the Engineer.

When the mixture is prepared in a dryer drum plant, the heated aggregate and asphalt binder shall be accurately proportioned and mixed in the dryer drum plant.

For all types of plants, the ingredients shall be combined in such proportions as to produce a mixture according to the following composition limits by weight.

This Page Is Reserved

Illinois Department of Transportation

Hot-Mix Asphalt Test Strip Procedures
Appendix B.4

Effective: May 1, 1993
Revised: December 1, 2023

When the quantity of a mixture is greater than or equal to 3000 tons (2750 metric tons) on a contract, the Contractor and the Department shall make an evaluation of the mixture using a 300 ton (275 metric ton) test strip at the beginning of HMA production. The Contractor shall adhere to the following procedures for constructing a test strip.

A. Contractor/Department Test Strip Team

As the test strip is constructed, a team of both Contractor and Department personnel will evaluate the mix.

The test strip team may consist of the following:

1. Resident Engineer
2. District Construction Supervising Field Engineer, or representative
3. District Materials Mixtures Control Engineer, or representative
4. District Nuclear Density Gauge Tester
5. Contractor's QC Manager, required
6. Contractor’s Paving Superintendent
7. Contractor's Density Tester

Optional:

8. Central Bureau of Construction representative
9. Central Bureau of Materials representative
10. Asphalt Binder Supplier representative

B. Communications

The Contractor shall advise the team members 48 hours in advance of the anticipated start date/time of production of the test strip mix. The QC Manager shall direct the activities of the test strip team. A Department appointed representative from the test strip team will act as spokesperson for the Department.

C. Test Strip Method

The mix design shall have been approved by the Department prior to the test strip. Target values shall be provided by the Contractor and will be approved by the Department prior to constructing the test strip.

The Contractor shall produce 300 tons (275 metric tons) of mix for the test strip.

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Hot-Mix Asphalt Test Strip Procedures
Appendix B.4

Effective: May 1, 1993
Revised: December 1, 2023

The procedures listed below shall be followed to construct a test strip.

1. Location of Test Strip - The test strip shall be located on a relatively flat portion of the roadway. Descending/ascending grades or ramps should be avoided.

2. Constructing the Test Strip - After the Contractor has produced and placed approximately 225 to 250 tons (200 to 225 metric tons) of mix, paving shall cease and a growth curve shall be constructed. After completion of the first growth curve, paving shall resume for the remaining 50 to 75 tons (45 to 70 metric tons), and the second growth curve shall be constructed within this area. The Contractor shall use normal rolling procedures for all portions of the test strip except for the growth curve areas which shall be compacted as directed by the QC Manager.

3. Mixture Sampling - Mixture samples shall be taken by the Contractor in the field at such a time as to represent the mixture in-between the two growth curves. The Contractor has the option to sample mixture for Department Hamburg Wheel, I-FIT, Tensile Strength, and TSR testing on the first production day after completion of an acceptable test strip. The sampling procedure shall follow the method of field sampling described in the document “Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples” Section D. Department Random Verification Mixture Sample Determination and Collection.

   In addition to the quantity of mix the Contractor collects for their volumetric tests per Standard Specification Article 1030.09(a), the Contractor shall also collect a sufficient quantity of mix for Department tests. This shall include 50 lb (23 kg) for volumetric testing, a minimum of 150 lb (70 kg) for the Contractor to fabricate Hamburg Wheel and I-FIT gyratory cylinders, and if this test strip is the first of the year for the mix design, an additional 100 lb (45 kg) for the Contractor to fabricate gyratory cylinders for Tensile Strength and TSR testing.

D. Compaction Requirements

1. Compaction Equipment - The Contractor shall provide a roller meeting the requirements of Article 1101.01(g) for dense graded mixtures and 1101.01(e) for SMA and IL-4.75 mixtures. It shall be the responsibility of the QC manager to verify roller compliance before commencement of growth curve construction.

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Hot-Mix Asphalt Test Strip Procedures
Appendix B.4

Effective: May 1, 1993
Revised: December 1, 2023

   a. Dense Graded Mixtures – A vibratory roller shall be used with an appropriate amplitude determined based on the roller weight and mat thickness to achieve maximum density. The vibratory roller speed shall be balanced with frequency so as to provide compaction at a rate of not less than 10 impacts per 1 ft (300 mm).

   b. SMA and IL-4.75 Mixtures – A static roller shall be used with the weight determined by the mixture composition, mat thickness, and ability to achieve maximum density.

2. Compaction Temperature - In order to make an accurate analysis of the density potential of the mixture, the initial compaction temperature of the mixture on the pavement at the beginning of the growth curve shall be no more than 10°F (5°C) lower than the minimum mixture placement temperature specified in Article 406.06.

3. Compaction and Testing - The Contractor shall direct the roller speed and number of passes required to obtain a completed growth curve. The nuclear gauge shall be placed near the center of the hot mat and the position marked for future reference. With the bottom of the nuclear gauge and source rod clean, a 1-minute nuclear reading (without mineral filler) shall be taken after each pass of the roller. Rolling shall continue until a growth curve can be plotted, the maximum density determined, and three consecutive passes show no appreciable increase in density or evident destruction of the mat.

4. Final Testing - A core shall be taken and will be secured by the Department from each growth curve to represent the density of the in-place mixture. Additional random cores may be required as determined by the Engineer.

E. Evaluation of Growth Curves

Mixtures which exhibit density potential less than or greater than the density ranges specified in 1030.09(c) shall be considered to have a potential density problem which is sufficient cause for mix adjustment.

If an adjustment is made at the plant, the Engineer may require an additional test strip to be constructed and evaluated. This information shall then be compared to the AJMF and required design criteria for acceptance.

F.

Illinois Department of Transportation

Hot-Mix Asphalt Test Strip Procedures
Appendix B.4

Effective: May 1, 1993
Revised: December 1, 2023

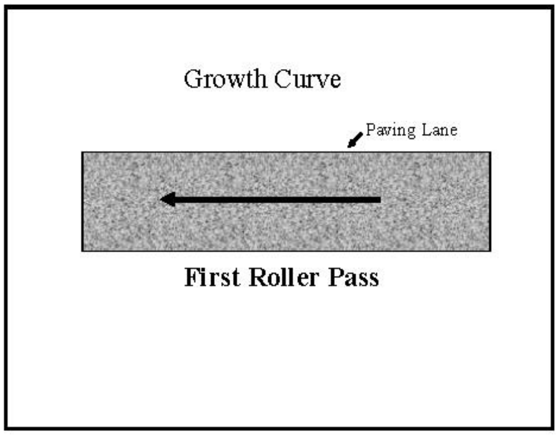
Nuclear/Core Correlation

When required, a correlation of core and nuclear gauge test results shall be performed on-site as defined in the document “Procedure for Correlating Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt”. This correlation shall be completed by the Contractor prior to the next day's production. Smoothness of the test strip shall be to the satisfaction of the Engineer.

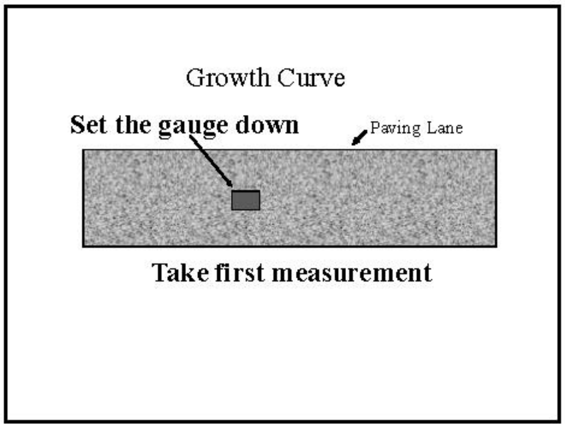
G. Documentation

All test strip volumetric test results, rolling pattern information (including growth curves), and nuclear readings and core test results for correlating the nuclear gauge shall be tabulated by the Contractor with a copy provided to each team member and the original retained in the project files.

Determining Growth Curve during the Test Strip Procedure



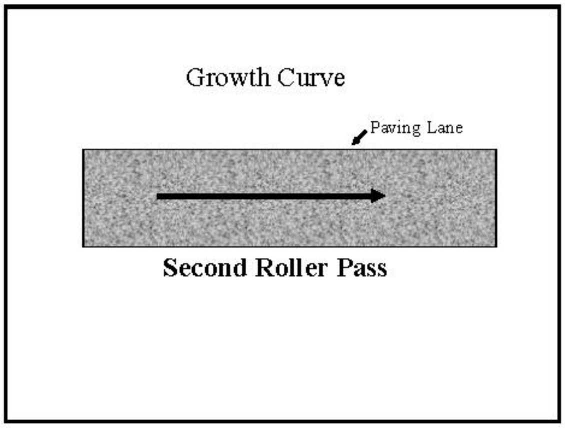
Determining Growth Curve during the Test Strip Procedure



Growth Curve

Set the gauge down

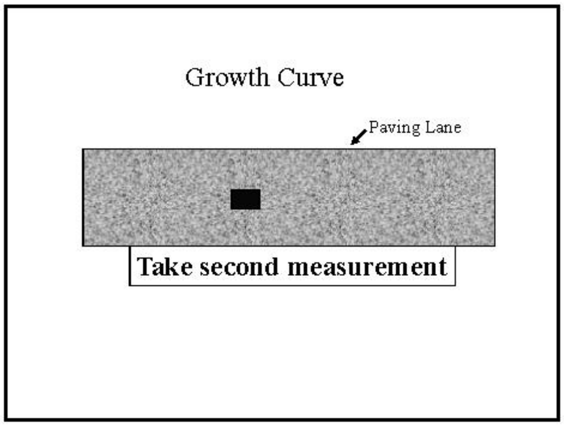
Take first measurement



Growth Curve

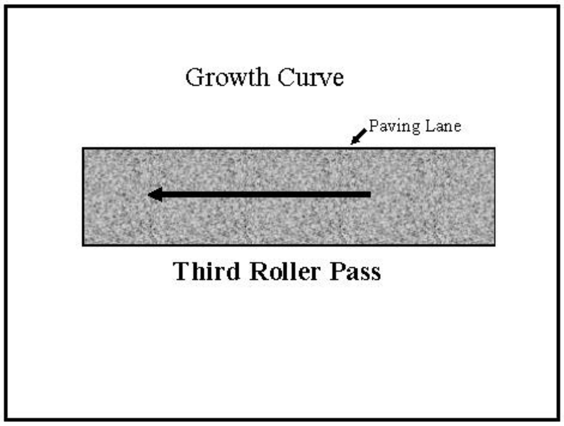
Second Roller Pass

Determining Growth Curve during the Test Strip Procedure



Growth Curve

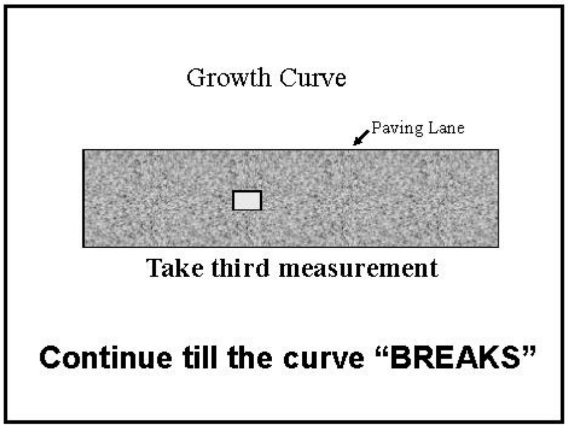
Take second measurement



Growth Curve

Third Roller Pass

Determining Growth Curve during the Test Strip Procedure

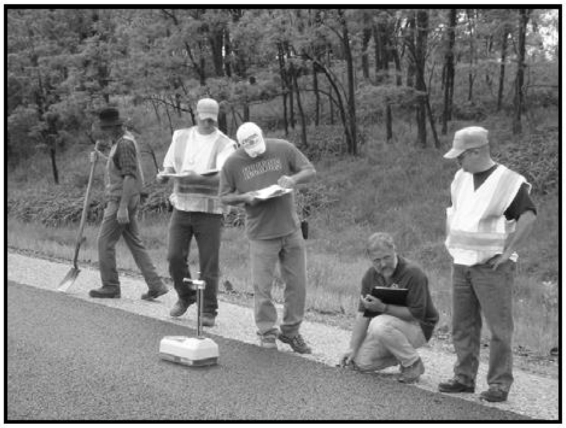


Growth Curve

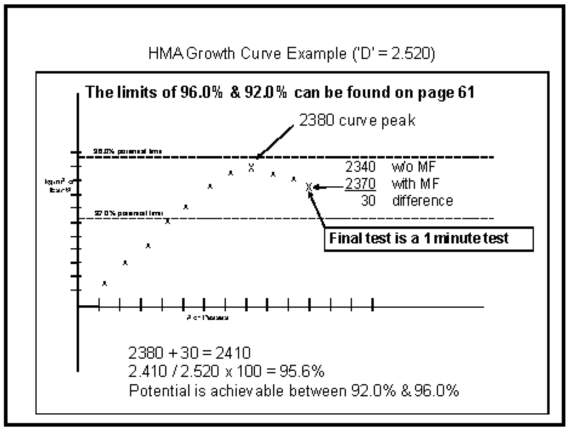
Take third measurement

Continue till the curve "BREAKS"

Determining Growth Curve during the Test Strip Procedure



Determining Growth Curve during the Test Strip Procedure



HMA Growth Curve Example ('D' = 2.520)

The limits of 96.0% & 92.0% can be found on page 61

2380 + 30 = 2410
2.410 / 2.520 x 100 = 95.6%
Potential is achievable between 92.0% & 96.0%

2340	Final Reading without MF
2370	Final Reading with MF
30	Difference in kg/m^3

Final tests are taken at 1 minute

2380 – Curve Peak
30 – Difference between 2 final readings
2.520 – Big "D" Value

2380 + 30 = 2.410
2.410 / 2.520 x 100 = 95.6%

Potential is achievable between 92.0% & 96.0%

Illinois Department of Transportation

Procedure for Correlating Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt

Appendix B.3

Effective Date: May 1, 2001
Revised Date: December 1, 2021

A. Scope

1. This method covers the proper procedures for correlating nuclear gauge densities to core densities.

2. The procedure shall be used on all projects containing 3000 tons (2750 metric tons) or more of any hot-mix asphalt mixture. It may also be used on any other project where feasible.

B. Applicable Documents

1. Illinois Department of Transportation Standard Test Methods

   Illinois Modified AASHTO T 166, "Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens"

   Illinois Modified AASHTO T 275, "Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Paraffin-Coated Specimens"

2. The density test procedure shall be in accordance with the Department's "Illinois Modified ASTM D2950, Density of Bituminous Concrete in Place by Nuclear Methods".

C. Definitions

Test Location: The station location for the density testing.

Test Site: Area where a single nuclear density and a core are collected. Five (5) test sites are positioned across the mat at each test location for the correlation process.

Nuclear Density: The average of two (2) or possibly three (3) nuclear density readings at a given test site.

Core Density: The core density result at a given test site.

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Procedure for Correlating Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt

Appendix B.3

Effective Date: May 1, 2001
Revised Date: December 1, 2021

D. Significance and Use

1. Density results from a nuclear gauge are relative. If an approximation of core density results is desired, a correlation must be developed to convert the nuclear density to core density.

2. A correlation developed in accordance with these procedures is applicable only to the specific gauge being correlated, the specific mixture, each specific thickness, and the specific project upon which it was correlated. A new correlation should be determined within a specific project if there is a significant change in the underlying materials.

E. Site Selection

1. The nuclear density tests and cores necessary for nuclear/core correlation shall be obtained during the test strip for each specific mixture for which a density specification is applicable.

2. Three test locations shall be selected. One test location shall be on each of the two growth curves from the first acceptable test strip. The third test location shall be chosen after an acceptable rolling pattern has been established and within the last 100 tons (90 metric tons) of material placed during the test strip. The material from the third test location shall correspond to the same material from which the second mixture sample was taken.

3. If a test strip is not required, two of the three test locations shall be in an area containing a growth curve.

F. Procedures for Obtaining Nuclear Readings and Cores – Backscatter Mode

1. At each of the three test locations, five individual test sites shall be chosen and identified as shown in Figure 1.

2. Two nuclear readings shall initially be taken at each of the 15 individual test sites. (See Figure 1.) The gauge shall be rotated 180 degrees between readings at each test site. The two uncorrected readings taken at a specific individual test site shall be within 1.5 lb/ft^3 (23 kg/m^3). If the two readings do not meet this criterion, one additional reading shall be taken in either direction. The nuclear readings are to be recorded on the Nuclear / Core Correlation Field Worksheet.

Illinois Department of Transportation

Procedure for Correlating Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt

Appendix B.3

Effective Date: May 1, 2001
Revised Date: December 1, 2021

3. All correlation locations should be cooled with ice, dry ice, or nitrogen so that cores can be taken as soon as possible. One 4 in. diameter core in good condition shall be obtained from each of the 15 individual test sites (Figure 1). Care should be exercised that no additional compaction occurs between the nuclear testing and the coring operation. The cores shall be tested for density in accordance with Illinois Modified AASHTO T 166 or T 275. The core densities are to be entered on the Nuclear / Core Correlation Field Worksheet.

4. Extreme care shall be taken in identifying which test location and test site each of the density readings represents. The data points have to be paired accurately or the correlation process will be invalid.

G. Mathematical Correlation -- Linear Regression

1. The two (or possibly three) nuclear readings at each test site shall be entered on the Nuclear / Core Correlation Field Worksheet and then averaged. The core density from each test site shall be entered on the worksheet. After the averaging, there will be 15 paired data points, each pair containing the average nuclear reading and core density for each of the 15 test sites.

2. The paired data points shall be correlated using the Department's linear regression program from the Central Bureau of Materials QMP Package or an approved and equivalent calculating method.

3. For the purpose of this procedure, standard statistical methods for measuring the "best fit" of a line through a series of 15 paired data points consisting of core density and corresponding average nuclear reading shall be used.

4. It should be recognized that correlations obtained by this or similar procedures may or may not be valid; each attempt should be judged on its merit. In general, a correlation coefficient for each correlation linear regression should be calculated.

5. Correlation coefficients (r) may range from minus 1.0 to plus 1.0. Only an r-value greater than 0.715 is considered acceptable.

6. The correlation shall be stated and used in the form:

$$y = mx + b$$

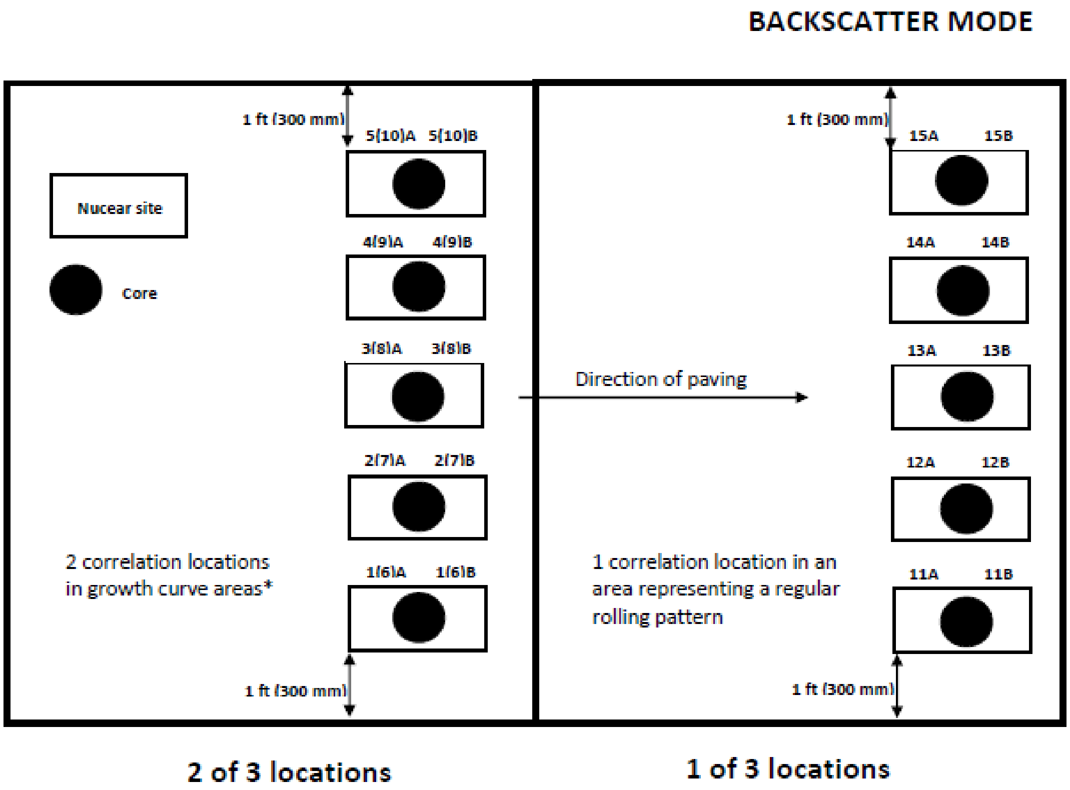
where:
y = core density
x = average nuclear reading
b = intercept
m = slope of linear regression "best fit" line

Illinois Department of Transportation

Procedure for Correlating Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt

Appendix B.3

Effective Date: May 1, 2001
Revised Date: December 1, 2021



* First growth curve is between 225 and 250 tons (200 and 225 metric tons). The second growth curve is between 275 and 300 tons (250 and 275 metric tons).

NUCLEAR /CORE CORRELATION TEST LOCATION LAYOUT

Figure 1

Illinois Department of Transportation

Nuclear / Core Correlation Field Worksheet

Date: ______________________

Contract: ______________________ Gauge No.: ______________

Job No.: ______________________ Layer Thickness: ______________

Route: ______________________ Gmm: ______________

Base Material: ☐ Milled ☐ Binder ☐ Aggregate Other: ______________________

Mix No.: ______________________

Mix Code: ______________________

Use: ______________________ (surface, 1st lift binder, etc.)

Reading 1	**Reading 2**	1.5 lb/ft^3 (23.5 kgs/m^3) tol. **Reading 3** (if applicable)	**Average Nuc.**	**Core Density**

STATION: ______________

1A)	1B)	1A) 1B)	1)	1)
2A)	2B)	2A) 2B)	2)	2)
3A)	3B)	3A) 3B)	3)	3)
4A)	4B)	4A) 4B)	4)	4)
5A)	5B)	5A) 5B)	5)	5)

STATION: ______________

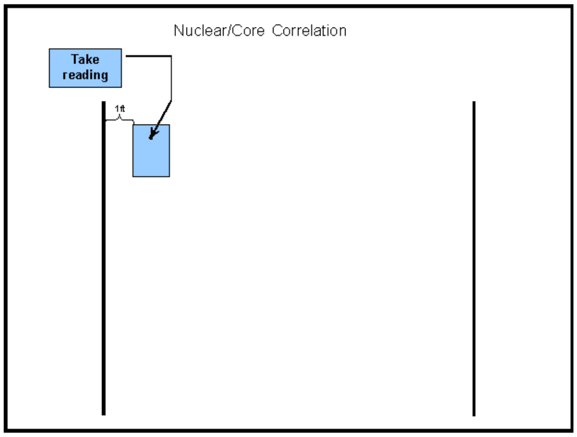
6A)	6B)	6A) 6B)	6)	6)
7A)	7B)	7A) 7B)	7)	7)
8A)	8B)	8A) 8B)	8)	8)
9A)	9B)	9A) 9B)	9)	9)
10A)	10B)	10A) 10B)	10)	10)

STATION: ______________

11A)	11B)	11A) 11B)	11)	11)
12A)	12B)	12A) 12B)	12)	12)
13A)	13B)	13A) 13B)	13)	13)
14A)	14B)	14A) 14B)	14)	14)
15A)	15B)	15A) 15B)	15)	15)

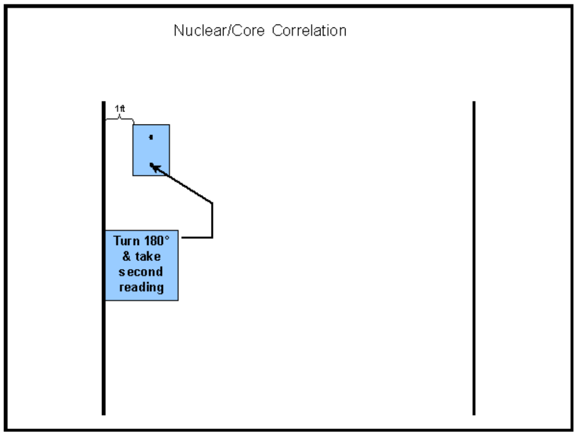
This Page Is Reserved

Nuclear Core Correlation Example



Nuclear/Core Correlation

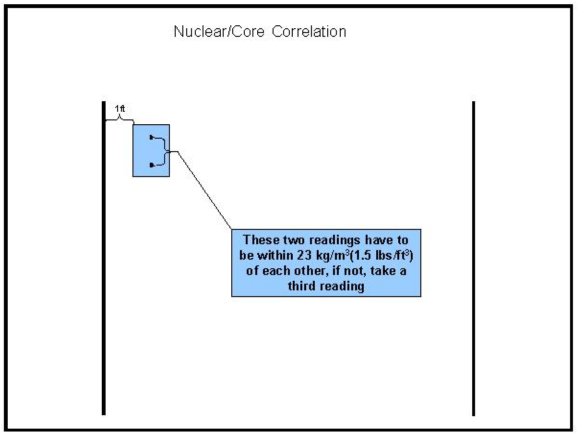
Take reading



Nuclear/Core Correlation

Turn 180° & take second reading

Nuclear Core Correlation Example

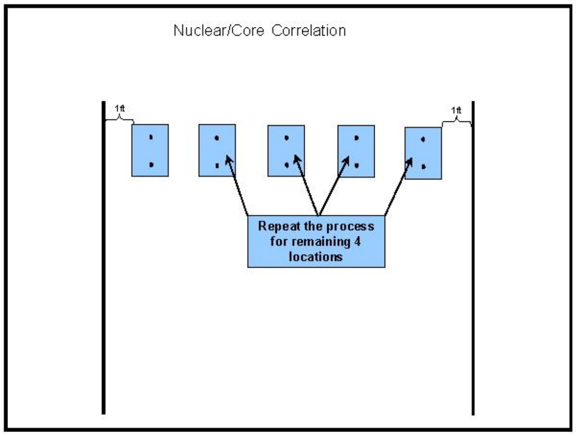


Nuclear/Core Correlation

These two readings have to be within 23 kg/m³(1.5 lbs/ft³) of each other, if not, take a third reading

The direction of the gauge is up to the technician on the third measurement

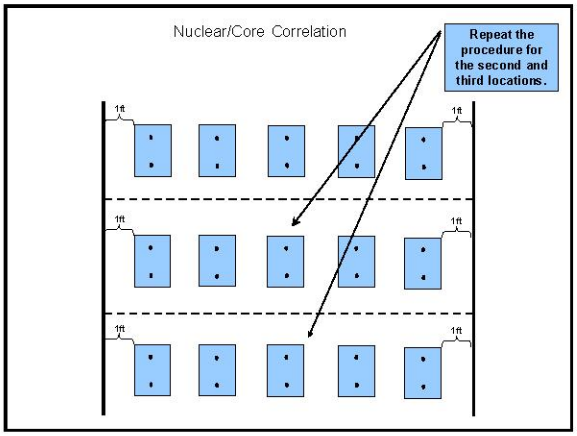
Nuclear Core Correlation Example



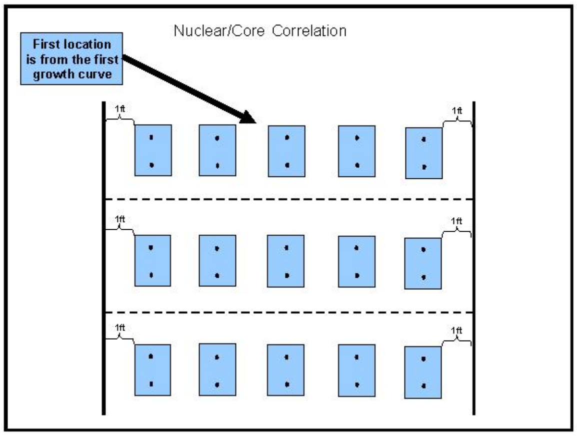
Nuclear/Core Correlation

Repeat the process for remaining 4 locations

Nuclear Core Correlation Example

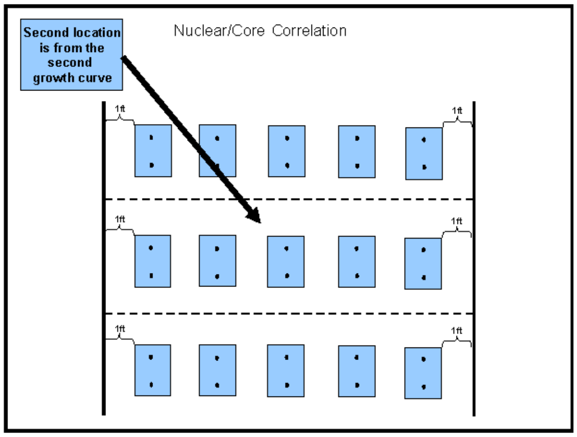

Nuclear/Core Correlation

Repeat the procedure for the second and third locations.


Nuclear/Core Correlation

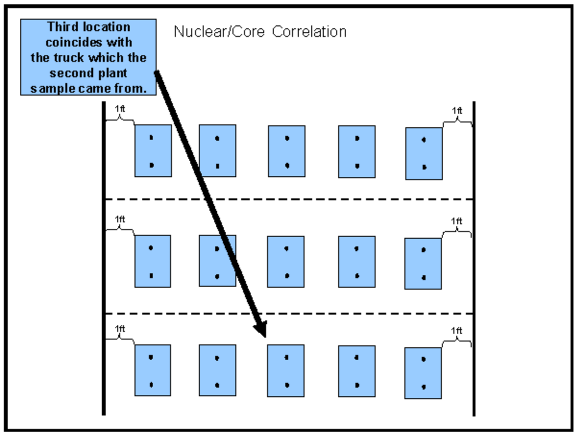
First location is from the first growth curve

Nuclear Core Correlation Example



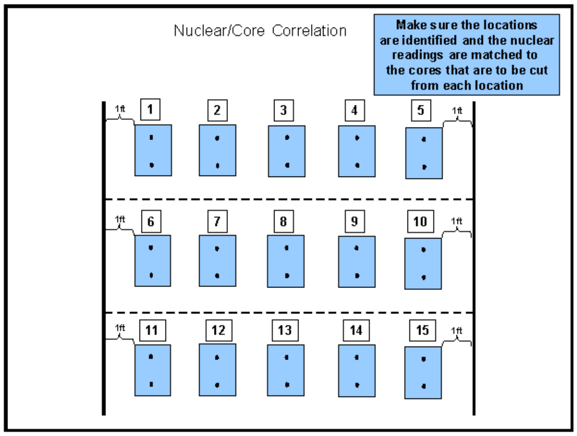
Nuclear/Core Correlation

Second location is from the second growth curve



Nuclear/Core Correlation

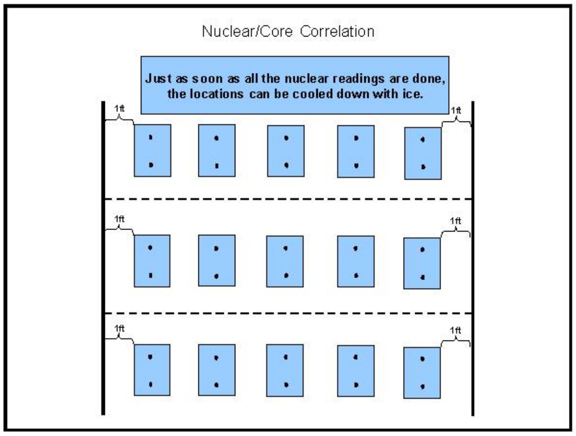
Third location coincides with the truck which the second plant sample came from.



Nuclear/Core Correlation

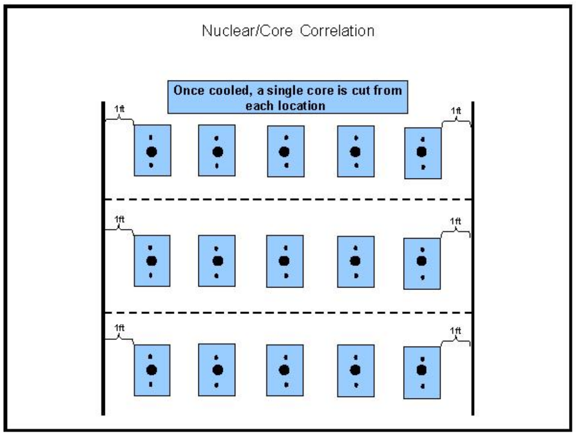
Make sure the locations are identified and the nuclear readings are matched to the cores that are to be cut from each location

Nuclear Core Correlation Example



Nuclear/Core Correlation

Just as soon as all the nuclear readings are done, the locations can be cooled down with ice.



Nuclear/Core Correlation

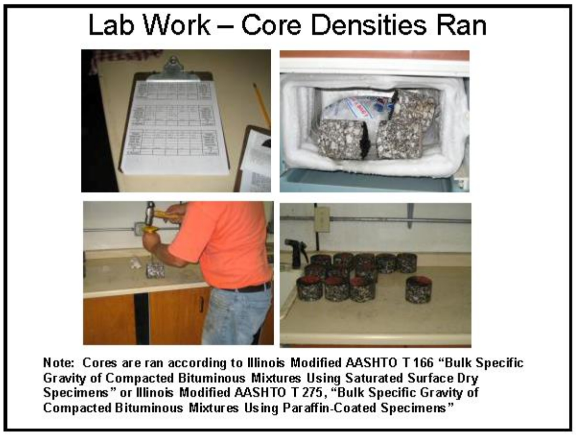
Once cooled, a single core is cut from each location

Nuclear Core Correlation Example

Nuclear Core Correlation Example

Nuclear Core Correlation Example

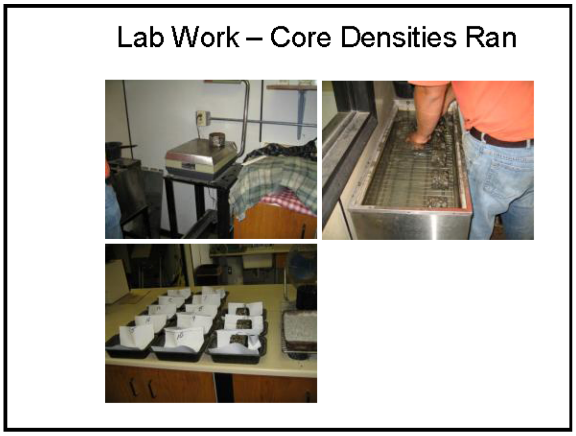
Nuclear Core Correlation Example



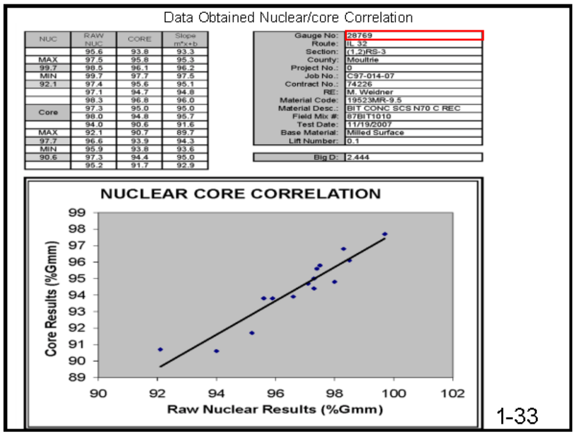
Lab Work – Core Densities Ran

Note: Cores are ran according to Illinois Modified AASHTO T 166 "Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface Dry Specimens" or Illinois Modified AASHTO T 275, "Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens"

Nuclear Core Correlation Example



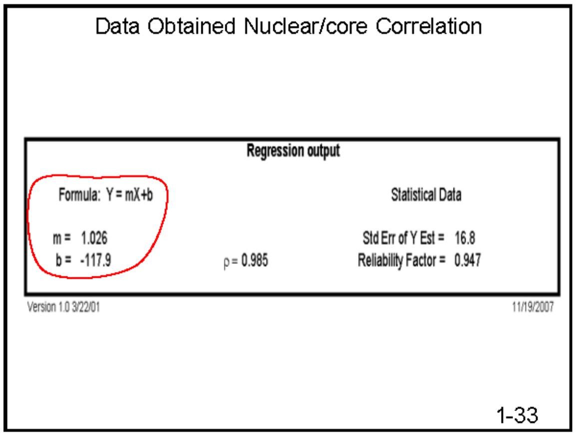
Lab Work – Core Densities Ran



Data Obtained Nuclear/core Correlation

NUC	RAW NUC	CORE	Slope m*x+b
	95.6	93.8	93.3
MAX	97.5	95.8	95.3
99.7	98.5	96.1	96.2
MIN	99.7	97.7	97.5
92.1	97.4	95.6	95.1
	97.1	94.7	94.8
	98.3	96.8	96.0
Core	97.3	95.0	95.0
	98.0	94.8	95.7
	94.0	90.6	91.6
MAX	92.1	90.7	89.7
97.7	96.6	93.9	94.3
MIN	95.9	93.8	93.6
90.6	97.3	94.4	95.0
	95.2	91.7	92.9

Gauge No:	28769
Route:	IL 32
Section:	(1,2)RS-3
County:	Moultrie
Project No.:	0
Job No.:	C97-014-07
Contract No.:	74226
RE:	M. Weidner
Material Code:	19523MR-9.5
Material Desc.:	BIT CONC SCS N70 C REC
Field Mix #:	87BIT1010
Test Date:	11/19/2007
Base Material:	Milled Surface
Lift Number:	0.1
Big D:	2.444



Data Obtained Nuclear/core Correlation

Regression output

Formula: Y = mX+b

m = 1.026
b = -117.9

ρ = 0.985

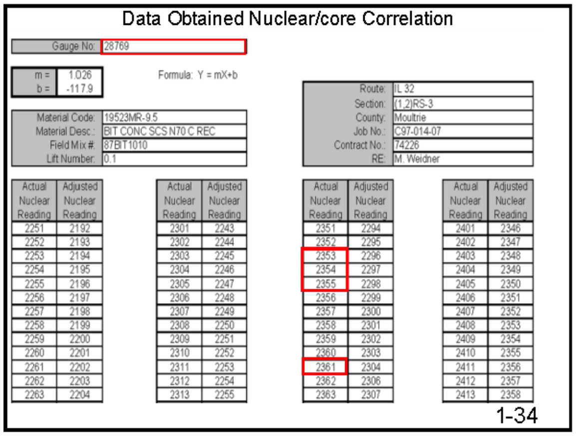
Statistical Data

Std Err of Y Est = 16.8
Reliability Factor = 0.947

Version 1.0 3/22/01

11/19/2007

Nuclear Core Correlation Example



Data Obtained Nuclear/core Correlation

Gauge No: 28769

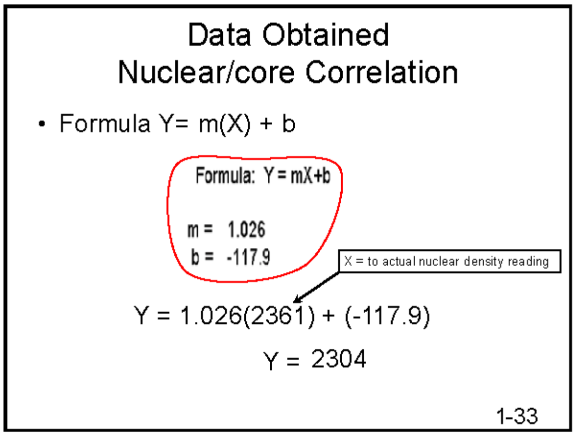
m = 1.026
b = -117.9

Formula: Y = mX+b

Material Code: 19523MR-9.5
Material Desc.: BIT CONC SCS N70 C REC
Field Mix #: 87BIT1010
Lift Number: 0.1

Route: IL 32
Section: (1,2)RS-3
County: Moultrie
Job No.: C97-014-07
Contract No.: 74226
RE: M. Weidner

Actual Nuclear Reading	Adjusted Nuclear Reading	Actual Nuclear Reading	Adjusted Nuclear Reading	Actual Nuclear Reading	Adjusted Nuclear Reading	Actual Nuclear Reading	Adjusted Nuclear Reading
2251	2192	2301	2243	2351	2294	2401	2346
2252	2193	2302	2244	2352	2295	2402	2347
2253	2194	2303	2245	2353	2296	2403	2348
2254	2195	2304	2246	2354	2297	2404	2349
2255	2196	2305	2247	2355	2298	2405	2350
2256	2197	2306	2248	2356	2299	2406	2351
2257	2198	2307	2249	2357	2300	2407	2352
2258	2199	2308	2250	2358	2301	2408	2353
2259	2200	2309	2251	2359	2302	2409	2354
2260	2201	2310	2252	2360	2303	2410	2355
2261	2202	2311	2253	2361	2304	2411	2356
2262	2203	2312	2254	2362	2306	2412	2357
2263	2204	2313	2255	2363	2307	2413	2358



Data Obtained Nuclear/core Correlation

- Formula Y= m(X) + b

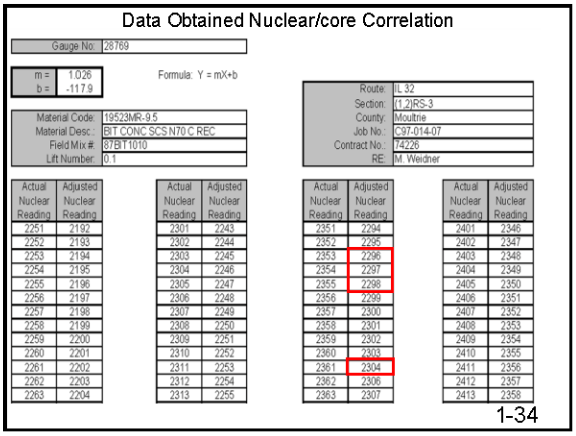
Formula: Y = mX+b

m = 1.026
b = -117.9

X = to actual nuclear density reading

Y = 1.026(2361) + (-117.9)

Y = 2304



Data Obtained Nuclear/core Correlation

Gauge No: 28769

m = 1.026
b = -117.9

Formula: Y = mX+b

Material Code: 19523MR-9.5
Material Desc.: BIT CONC SCS N70 C REC
Field Mix #: 87BIT1010
Lift Number: 0.1

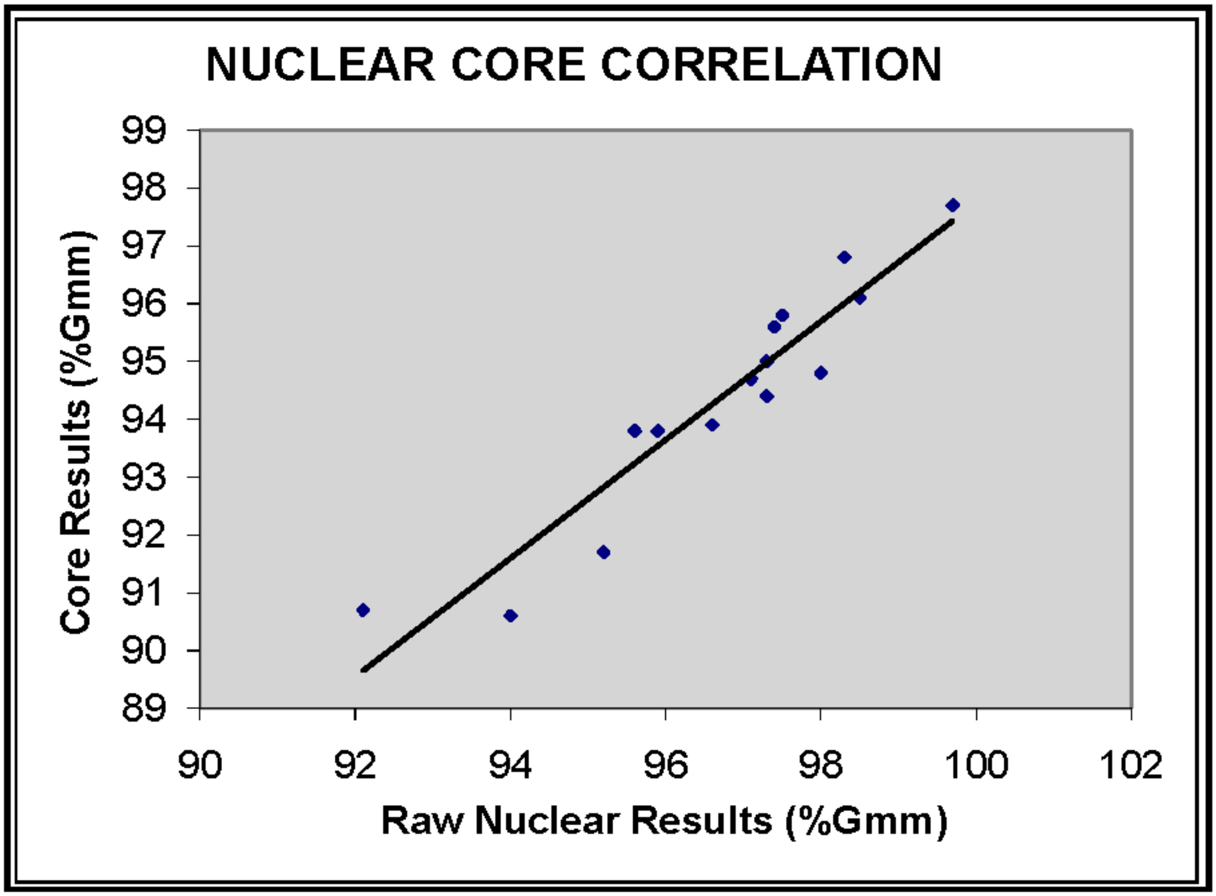
Route: IL 32
Section: (1,2)RS-3
County: Moultrie
Job No.: C97-014-07
Contract No.: 74226
RE: M. Weidner

Actual Nuclear Reading	Adjusted Nuclear Reading	Actual Nuclear Reading	Adjusted Nuclear Reading	Actual Nuclear Reading	Adjusted Nuclear Reading	Actual Nuclear Reading	Adjusted Nuclear Reading
2251	2192	2301	2243	2351	2294	2401	2346
2252	2193	2302	2244	2352	2295	2402	2347
2253	2194	2303	2245	2353	2296	2403	2348
2254	2195	2304	2246	2354	2297	2404	2349
2255	2196	2305	2247	2355	2298	2405	2350
2256	2197	2306	2248	2356	2299	2406	2351
2257	2198	2307	2249	2357	2300	2407	2352
2258	2199	2308	2250	2358	2301	2408	2353
2259	2200	2309	2251	2359	2302	2409	2354
2260	2201	2310	2252	2360	2303	2410	2355
2261	2202	2311	2253	2361	2304	2411	2356
2262	2203	2312	2254	2362	2306	2412	2357
2263	2204	2313	2255	2363	2307	2413	2358

NUC	RAW NUC	CORE	Slope m*x+b
	95.6	93.8	93.3
MAX	97.5	95.8	95.3
99.7	98.5	96.1	96.2
MIN	99.7	97.7	97.5
92.1	97.4	95.6	95.1
	97.1	94.7	94.8
	98.3	96.8	96.0
Core	97.3	95.0	95.0
	98.0	94.8	95.7
	94.0	90.6	91.6
MAX	92.1	90.7	89.7
97.7	96.6	93.9	94.3
MIN	95.9	93.8	93.6
90.6	97.3	94.4	95.0
	95.2	91.7	92.9

Gauge No:	28769
Route:	IL 32
Section:	(1,2)RS-3
County:	Moultrie
Project No.:	0
Job No.:	C9701423
Contract No.:	74226
RE:	M. Weidner
Material Code:	19523MR-9.5
Material Desc.:	BIT CONC SCS N70 C REC
Field Mix #:	87BIT1023
Test Date:	10/01/2023
Base Material:	Milled Surface
Lift Number:	0.1

Big D:	2.444



Regression output

Formula: Y = mX+b

Statistical Data

m = 1.026
b = -117.9

ρ = 0.985

Std Err of Y Est = 16.8
Reliability Factor = 0.947

Gauge No.	28769

m =	1.026
b =	-117.9

Formula Y = mX+b

Route:	IL 32
Section:	(1,2) RS-3
County:	Moultrie
Job No:	C9701423
Contract No.:	74226
RE:	M. Weidner

Material Code:	19523 -9.5
Material Desc:	BIT CONC SCS N70 C REC
Field Mix #:	87BIT1023
Lift Number:	.1

Actual Nuclear Reading	Adjusted Nuclear Reading	Actual Nuclear Reading	Adjusted Nuclear Reading	Actual Nuclear Reading	Adjusted Nuclear Reading	Actual Nuclear Reading	Adjusted Nuclear Reading
2251	2192	2301	2243	2351	2294	2401	2346
2252	2193	2302	2244	2352	2295	2402	2347
2253	2194	2303	2245	2353	2296	2403	2348
2254	2195	2304	2246	2354	2297	2404	2349
2255	2196	2305	2247	2355	2298	2405	2350
2256	2197	2306	2248	2356	2299	2406	2351
2257	2198	2307	2249	2357	2300	2407	2352
2258	2199	2308	2250	2358	2301	2408	2353
2259	2200	2309	2251	2359	2302	2409	2354
2260	2201	2310	2252	2360	2303	2410	2355
2261	2202	2311	2253	2361	2304	2411	2356
2262	2203	2312	2254	2362	2306	2412	2357
2263	2204	2313	2255	2363	2307	2413	2358
2264	2205	2314	2256	2364	2308	2414	2359
2265	2206	2315	2257	2365	2309	2415	2360
2266	2207	2316	2258	2366	2310	2416	2361
2267	2208	2317	2259	2367	2311	2417	2362
2268	2209	2318	2260	2368	2312	2418	2363
2269	2210	2319	2261	2369	2313	2419	2364
2270	2211	2320	2262	2370	2314	2420	2365
2271	2212	2321	2263	2371	2315	2421	2366
2272	2213	2322	2264	2372	2316	2422	2367
2273	2214	2323	2265	2373	2317	2423	2368
2274	2215	2324	2267	2374	2318	2424	2369
2275	2216	2325	2268	2375	2319	2425	2370
2276	2217	2326	2269	2376	2320	2426	2371
2277	2218	2327	2270	2377	2321	2427	2372
2278	2219	2328	2271	2378	2322	2428	2373
2279	2220	2329	2272	2379	2323	2429	2374
2280	2221	2330	2273	2380	2324	2430	2375
2281	2222	2331	2274	2381	2325	2431	2376
2282	2223	2332	2275	2382	2326	2432	2377
2283	2224	2333	2276	2383	2327	2433	2378
2284	2225	2334	2277	2384	2328	2434	2379
2285	2227	2335	2278	2385	2329	2435	2380
2286	2228	2336	2279	2386	2330	2436	2381
2287	2229	2337	2280	2387	2331	2437	2382
2288	2230	2338	2281	2388	2332	2438	2383
2289	2231	2339	2282	2389	2333	2439	2385
2290	2232	2340	2283	2390	2334	2440	2386
2291	2233	2341	2284	2391	2335	2441	2387
2292	2234	2342	2285	2392	2336	2442	2388
2293	2235	2343	2286	2393	2337	2443	2389
2294	2236	2344	2287	2394	2338	2444	2390
2295	2237	2345	2288	2395	2339	2445	2391
2296	2238	2346	2289	2396	2340	2446	2392
2297	2239	2347	2290	2397	2341	2447	2393
2298	2240	2348	2291	2398	2342	2448	2394
2299	2241	2349	2292	2399	2343	2449	2395
2300	2242	2350	2293	2400	2345	2450	2396

NUCLEAR GAUGE RAW DATA ENTRY
ENTER METRIC GAUGE READINGS IN kg/m3

Gauge #:	1	2	3	4	5	6	7	8	9	10
Gauge ID:	25124	28769								
1A	2360	2336								
1B	2347	2337								
1C										
2A	2412	2384								
2B	2414	2384								
2C										
3A	2416	2404								
3B	2438	2409								
3C										
4A	2434	2434								
4B	2448	2441								
4C										
5A	2403	2371								
5B	2410	2388								
5C										
6A	2389	2376								
6B	2397	2369								
6C										
7A	2416	2399								
7B	2422	2406								
7C										
8A	2428	2371								
8B	2405	2383								
8C										
9A	2383	2401								
9B	2401	2389								
9C										
10A	2315	2303								
10B	2318	2290								
10C										
11A	2326	2255								
11B	2291	2249								
11C	2286									
12A	2400	2351								
12B	2371	2370								
12C	2384									
13A	2383	2346								
13B	2377	2342								
13C										
14A	2420	2372								
14B	2416	2386								
14C										
15A	2331	2335								
15B	2333	2319								
15C										
Average	**2383.6**	**2363.3**								
Stand Dev.	**43.8**	**46.1**								
Max	**2448**	**2441**								
Min	**2286**	**2249**								

SUMMARY

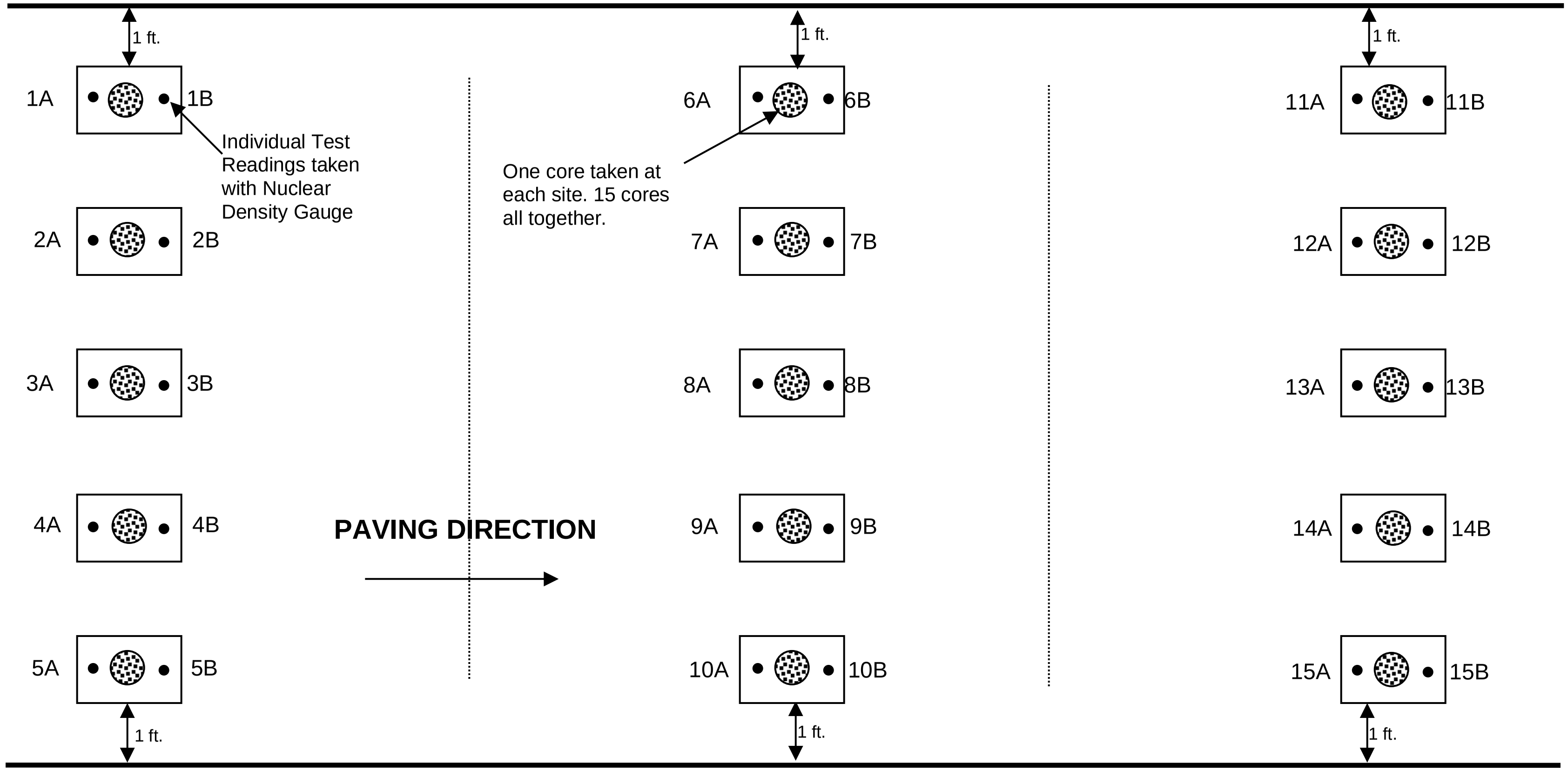
	RAW NUCLEAR GAUGE READINGS										CORES
Gauge #:	1	2	3	4	5	6	7	8	9	10	
Gauge ID:	25124	28769									
1	2353.5	2336.5									2292
2	2413	2384									2342
3	2427	2406.5									2349
4	2441	2437.5									2388
5	2406.5	2379.5									2336
6	2393	2372.5									2315
7	2419	2402.5									2366
8	2416.5	2377									2323
9	2392	2395									2316
10	2316.5	2296.5									2215
11	2301	2252									2217
12	2385	2360.5									2295
13	2380	2344									2292
14	2418	2379									2308
15	2332	2327									2242

NUCLEAR CORE CORRELATION LAYOUT

The first set of nuclear correlation cores is taken within the first growth curve, which is completed between 225 to 250 tons of material placed.

The second set of nuclear correlation cores is taken within the second growth curve, which is completed between 275 to 300 tons of material placed.

The third location shall be chosen after an acceptable rolling pattern has been established and within the last 100 tons of material placed during start-up. **The material from the third site shall correspond to the same material from which the second hot-mix sample was taken (within the next 100 to 200 tons).**



Individual Test Readings taken with Nuclear Density Gauge

One core taken at each site. 15 cores all together.

NOTE: Two (2) nuclear readings shall be taken at each of the 15 individual sites. The gauge shall be rotated 180 degrees between readings at each site. (The 2 uncorrected readings taken at a specific individual site shall be within **23 kg/m^3 [1.5 lbs/ft^3].** If the 2 readings do not meet this criterion, one (1) additional reading shall be taken in the desired direction. The nuclear densities are to be recorded on the correlation form.

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Mixture Composition	
Fine Aggregate (FA 1, FA 2 or FA 3)	93 - 96 %
Asphalt Binder (PG 58-28, PG 64-22)	6 - 9 %

With the permission of the Engineer, an approved cold-lay sand asphalt mixture may be used in lieu of the above mixture.

1030.12 Transportation. Vehicles used in transporting HMA shall have clean and tight beds. The beds shall be sprayed with asphalt release agents from the Department's qualified product list. In lieu of a release agent, the Contractor may use a light spray of water with a light scatter of manufactured sand (FA 20 or FA 21) evenly distributed over the bed of the vehicle. After spraying, the bed of the vehicle shall be in a completely raised position and it shall remain in this position until all excess asphalt release agent or water has been drained.

When the air temperature is below 60 °F (15 °C), the bed, including the end, endgate, sides and bottom shall be insulated with fiberboard, plywood, or other approved insulating material and shall have a thickness of not less than 3/4 in. (19 mm). When the insulation is placed inside the bed, the insulation shall be covered with sheet steel approved by the Engineer. Each vehicle shall be equipped with a cover of canvas or other suitable material meeting the approval of the Engineer which shall be used if any one of the following conditions is present.

(a) Ambient air temperature is below 60 °F (15 °C).

(b) The weather is inclement.

(c) The temperature of the HMA immediately behind the paver screed is below 250 °F (120 °C).

(d) The mixture being placed is SMA.

The cover shall extend down over the sides and ends of the bed for a distance of approximately 12 in. (300 mm) and shall be fastened securely. The covering shall be rolled back before the load is dumped.

SECTION 1031. RECLAIMED ASPHALT PAVEMENT AND RECLAIMED ASPHALT SHINGLES

1031.01 Description. Reclaimed asphalt pavement and reclaimed asphalt shingles shall be according to the following.

(a) Reclaimed Asphalt Pavement (RAP). RAP is the material produced by cold milling or crushing an existing hot-mix asphalt (HMA) pavement. The Contractor shall supply written documentation that the RAP originated from roadways or airfields under federal, state, or local agency jurisdiction.

(b) Reclaimed Asphalt Shingles (RAS). RAS is the material produced from the processing and grinding of preconsumer or post-consumer shingles. RAS shall be a clean and uniform material with a maximum of 0.5 percent unacceptable material by weight of RAS, as defined in Bureau of Materials Policy Memorandum, “Reclaimed Asphalt Shingle (RAS) Sources”. RAS shall come from a facility source on the Department’s “Qualified Producer List of Certified Sources for Reclaimed Asphalt Shingles” where it shall be ground and processed to 100 percent passing the 3/8 in. (9.5 mm) sieve and 93 percent passing the #4 (4.75 mm) sieve based on a dry shake gradation. RAS shall be uniform in gradation and asphalt binder content and shall meet the testing requirements specified herein. In addition, RAS shall meet the following Type 1 or Type 2 requirements.

(1) Type 1. Type 1 RAS shall be processed, preconsumer asphalt shingles salvaged from the manufacture of residential asphalt roofing shingles.

(2) Type 2. Type 2 RAS shall be processed post-consumer shingles only, salvaged from residential, or four unit or less dwellings not subject to the National Emission Standards for Hazardous Air Pollutants (NESHAP).

1031.02 Stockpiles. RAP and RAS stockpiles shall be according to the following.

(a) RAP Stockpiles. The Contractor shall construct individual RAP stockpiles meeting one of the following definitions. Stockpiles shall be sufficiently separated to prevent intermingling at the base. Stockpiles shall be identified by signs indicating the type as listed below (i.e. “Homogeneous Surface”).

Prior to milling, the Contractor shall request the Department provide documentation on the quality of the RAP to clarify the appropriate stockpile.

(1) Fractionated RAP (FRAP). FRAP shall consist of RAP from Class I, HMA (High and Low ESAL) mixtures. The coarse aggregate in FRAP shall be crushed aggregate and may represent more than one aggregate type and/or quality, but shall be at least C quality. FRAP shall be fractionated prior to testing by screening into a minimum of two size fractions with the separation occurring on or between the No. 4 (4.75 mm) and 1/2 in. (12.5 mm) sieves. Agglomerations shall be minimized such that 100 percent of the RAP in the coarse fraction shall pass the maximum sieve size specified for the mixture composition of the mix design.

(2) Homogeneous. Homogeneous RAP stockpiles shall consist of RAP from Class I, HMA (High and Low ESAL) mixtures and represent: 1) the same aggregate quality, but shall be at least C quality; 2) the same type of crushed aggregate (either crushed natural aggregate, ACBF slag, or steel slag); 3) similar gradation; and 4) similar asphalt binder content. If approved by the Engineer, combined single pass surface/binder millings may be considered “homogeneous” with a quality rating dictated by the lowest coarse aggregate quality present in the mixture.

(3) Conglomerate. Conglomerate RAP stockpiles shall consist of RAP from Class I, HMA (High and Low ESAL) mixtures. The coarse aggregate in this RAP shall be crushed aggregate and may represent more than one

aggregate type and/or quality, but shall be at least C quality. This RAP may have an inconsistent gradation and/or asphalt binder content prior to processing. Conglomerate RAP shall be processed prior to testing by crushing to where all RAP shall pass the 5/8 in. (16 mm) or smaller screen. Conglomerate RAP stockpiles shall not contain steel slag.

(4) Conglomerate "D" Quality (Conglomerate DQ). Conglomerate DQ RAP stockpiles shall be according to Articles 1031.02(a)(1) through 1031.02(a)(3), except they may also consist of RAP from HMA shoulders, bituminous stabilized subbases, or HMA (High or Low ESAL) binder mixture. The coarse aggregate in this RAP may be crushed or round but shall be at least D quality. This RAP may have an inconsistent gradation and/or asphalt binder content.

(5) Non-Quality. RAP stockpiles that do not meet the requirements of the stockpile categories listed above shall be classified as "Non-Quality".

RAP/FRAP containing contaminants, such as earth, brick, sand, concrete, sheet asphalt, non-bituminous surface treatment (i.e. high friction surface treatments), pavement fabric, joint sealants, plant cleanout, etc., will be unacceptable unless the contaminants are removed to the satisfaction of the Engineer. Sheet asphalt shall be stockpiled separately.

(b) RAS Stockpiles. Type 1 and Type 2 RAS shall be stockpiled separately and shall not be intermingled. Each stockpile shall be signed indicating what type of RAS is present.

Unless otherwise specified by the Engineer, mechanically blending manufactured sand (FM 20 or FM 22) or fine FRAP up to an equal weight of RAS with the processed RAS will be permitted to improve workability. The sand shall be B quality or better from an approved Aggregate Gradation Control System source. The sand shall be accounted for in the mix design and during HMA production.

Records identifying the shingle processing facility supplying the RAS, RAS type, and lot number shall be maintained by project contract number and kept for a minimum of three years.

Additional processed RAP/FRAP/RAS shall be stockpiled in a separate working pile, as designated in the QC Plan, and only added to the original stockpile after the test results for the working pile are found to meet the requirements specified in Articles 1031.03 and 1031.04.

1031.03 Testing. RAP/FRAP and RAS testing shall be according to the following.

(a) RAP/FRAP Testing. When used in HMA, the RAP/FRAP shall be sampled and tested either during or after stockpiling.

(1) During Stockpiling. For testing during stockpiling, washed extraction samples shall be run at the minimum frequency of one sample per 500 tons (450 metric tons) for the first 2,000 tons (1,800 metric tons)

and one sample per 2,000 tons (1,800 metric tons) thereafter. A minimum of five tests shall be required for stockpiles less than 4,000 tons (3,600 metric tons).

(2) After Stockpiling. For testing after stockpiling, the Contractor shall submit a plan for approval to the Department proposing a satisfactory method of sampling and testing the RAP/FRAP pile either in-situ or by restockpiling. The sampling plan shall meet the minimum frequency required above and detail the procedure used to obtain representative samples throughout the pile for testing.

Each sample shall be split to obtain two equal samples of test sample size. One of the two test samples from the final split shall be labeled and stored for Department use. The Contractor shall perform a washed extraction on the other test sample according to Illinois Modified AASHTO T 164. The Engineer reserves the right to test any sample (split or Department-taken) to verify Contractor test results.

(b) RAS Testing. RAS or RAS blended with manufactured sand shall be sampled and tested during stockpiling according to the Bureau of Materials Policy Memorandum, “Reclaimed Asphalt Shingle (RAS) Source”.

Samples shall be collected during stockpiling at the minimum frequency of one sample per 200 tons (180 metric tons) for the first 1,000 tons (900 metric tons) and one sample per 500 tons (450 metric tons) or a minimum of once per week, whichever is more frequent, thereafter. A minimum of five samples are required for stockpiles less than 1,000 tons (900 metric tons).

Before testing, each sample shall be split to obtain two test samples. One of the two test samples from the final split shall be labeled and stored for Department use. The Contractor shall perform a washed extraction and test for unacceptable materials on the other test sample according to Illinois Modified AASHTO T 164. The Engineer reserves the right to test any sample (split or Department-taken) to verify Contractor test results.

The Contractor shall obtain and make available all of the test results from the start of the original stockpile.

1031.04 Evaluation of Tests. Evaluation of test results shall be according to the following.

(a) Limits of Precision. The limits of precision between the Contractor’s and the Department’s split sample test results shall be according to the following.

Test Parameter	Limits of Precision		
% Passing	RAP	FRAP	RAS
1/2 in. (12.5 mm)	6.0 %	5.0 %	
# 4 (4.75 mm)	6.0 %	5.0 %	
# 8 (2.36 mm)	4.0 %	3.0 %	4.0 %
# 30 (600 µm)	3.0 %	2.0 %	4.0 %
# 200 (75 µm)	2.5 %	2.2 %	4.0 %
Asphalt Binder	0.4 %	0.3 %	3.0 %
G_{mm}	0.035	0.030	

If the test results are outside the above limits of precision, the Engineer will immediately investigate.

(b) Evaluation of RAP/FRAP Test Results. All of the extraction results shall be compiled and averaged for asphalt binder content and gradation, and when applicable G_{mm}. Individual extraction test results, when compared to the averages, will be accepted if within the tolerances listed below.

Parameter	FRAP/Homogeneous/ Conglomerate
1 in. (25 mm)	
1/2 in. (12.5 mm)	± 8 %
# 4 (4.75 mm)	± 6 %
# 8 (2.36 mm)	± 5 %
# 16 (1.18 mm)	
# 30 (600 µm)	± 5 %
# 200 (75 µm)	± 2.0 %
Asphalt Binder	± 0.4 % 1/
G_{mm}	± 0.03 2/

1/ The tolerance for FRAP shall be ± 0.3 percent.

2/ For stockpile with slag or steel slag present as determined in the Manual of Test Procedures Appendix B 21, “Determination of Aggregate Bulk (Dry) Specific Gravity (Gsb) of Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS)”.

If more than 20 percent of the test results for an individual parameter (individual sieves, G_{mm}, and/or asphalt binder content) are out of the above tolerances, the RAP/FRAP shall not be used in HMA unless the RAP/FRAP representing the failing tests is removed from the stockpile. All test data and acceptance ranges shall be sent to the Department for evaluation.

With the approval of the Engineer, the ignition oven may be substituted for solvent extractions according to the document “Calibration of the Ignition

Oven for the Purpose of Characterizing Reclaimed Asphalt Pavement (RAP)".

(c) Evaluation of RAS and RAS Blended with Manufactured Sand or Fine FRAP Test Results. All of the test results, with the exception of percent unacceptable materials, shall be compiled and averaged for asphalt binder content and gradation. Individual test results, when compared to the averages, will be accepted if within the tolerances listed below.

Parameter	RAS
# 8 (2.36 mm)	± 5 %
# 16 (1.18 mm)	± 5 %
# 30 (600 µm)	± 4 %
# 200 (75 µm)	± 2.5 %
Asphalt Binder Content	± 2.0 %

If more than 20 percent of the test results for an individual parameter (individual sieves and/or asphalt binder content) are out of the above tolerances, or if the unacceptable material exceeds 0.5 percent by weight of material retained on the No. 4 (4.75 mm) sieve, the RAS or RAS blend shall not be used in Department projects. All test data and acceptance ranges shall be sent to the Department for evaluation.

1031.05 Quality Designation of Aggregate in RAP/FRAP.

(a) RAP. The aggregate quality of the RAP for homogeneous, conglomerate, and conglomerate DQ stockpiles shall be set by the lowest quality of coarse aggregate in the RAP stockpile. RAP originating from roadways under state jurisdiction shall be designated as follows.

Class B Quality	Class C Quality	Class D Quality
Class I Surface	Class I Binder	Bituminous Aggregate Mixture (BAM) Stabilized Subbase
HMA (High ESAL) Surface	HMA (High ESAL) Binder	
SMA	HMA (Low ESAL)	BAM Shoulder

(b) FRAP. If the Engineer has documentation of the quality of the FRAP aggregate, the Contractor shall use the assigned quality provided by the Engineer.

If the quality is not known, the quality shall be determined as follows. Coarse and fine FRAP stockpiles containing plus No. 4 (4.75 mm) sieve coarse aggregate shall have a maximum tonnage of 5,000 tons (4,500 metric tons). The Contractor shall obtain a representative sample witnessed by the Engineer. The sample shall be a minimum of 50 lb (25 kg). The sample shall be extracted according to Illinois Modified AASHTO T 164 by a consultant laboratory prequalified by the Department for the specified testing. The consultant laboratory shall submit the test results along with the recovered aggregate sample to the District Office. Consultant laboratory services will be at no additional cost to the Department. The District will forward the sample to the Central Bureau of Materials Aggregate Lab for MicroDeval Testing, according to Illinois Modified AASHTO T 327. A maximum loss of 15.0 percent will be applied for all HMA applications.

1031.06 Use of RAP/FRAP and/or RAS in HMA. The use of RAP/FRAP and/or RAS shall be the Contractor's option when constructing HMA in all contracts.

(a) RAP/FRAP. The use of RAP/FRAP in HMA shall be as follows.

(1) Coarse Aggregate Size. The coarse aggregate in all RAP shall be equal to or less than the nominal maximum size requirement for the HMA mixture to be produced.

(2) Steel Slag Stockpiles. Homogeneous RAP stockpiles containing steel slag will be approved for use in all HMA (High ESAL and Low ESAL) surface and binder mixture applications.

(3) Use in HMA Surface Mixtures (High and Low ESAL). RAP/FRAP stockpiles for use in HMA surface mixtures (High and Low ESAL) shall be FRAP or homogeneous in which the coarse aggregate is Class B quality or better. FRAP from conglomerate stockpiles shall be considered equivalent to limestone for frictional considerations. Known frictional contributions from plus No. 4 (4.75 mm) homogeneous FRAP stockpiles will be accounted for in meeting frictional requirements in the specified mixture.

(4) Use in HMA Binder Mixtures (High and Low ESAL), HMA Base Course, and HMA Base Course Widening. RAP/FRAP stockpiles for use in HMA binder mixtures (High and Low ESAL), HMA base course, and HMA base course widening shall be FRAP, homogeneous, or conglomerate, in which the coarse aggregate is Class C quality or better.

(5) Use in Shoulders and Subbase. RAP/FRAP stockpiles for use in HMA shoulders and stabilized subbase (HMA) shall be FRAP, homogeneous, or conglomerate.

(6) When the Contractor chooses the RAP option, the percentage of asphalt binder replacement (ABR) shall not exceed the amounts indicated in Article 1031.06(c)(1) below for a given Ndesign.

(b) RAS. RAS meeting Type 1 or Type 2 requirements will be permitted in all HMA applications as specified herein.

(c) RAP/FRAP and/or RAS Usage Limits. Type 1 or Type 2 RAS may be used alone or in conjunction with RAP or FRAP in HMA mixtures up to a maximum of 5.0 percent by weight of the total mix.

(1) RAP/RAS. When RAP is used alone or RAP is used in conjunction with RAS, the percentage of virgin ABR shall not exceed the amounts listed in the following table.

HMA Mixtures - RAP/RAS Maximum ABR % 1/ 2/			
Ndesign	Binder	Surface	Polymer Modified Binder or Surface
30	30	30	10
50	25	15	10
70	15	10	10
90	10	10	10

1/ For Low ESAL HMA shoulder and stabilized subbase, the RAP/RAS ABR shall not exceed 50 percent of the mixture.

2/ When RAP/RAS ABR exceeds 20 percent, the high and low virgin asphalt binder grades shall each be reduced by one grade (i.e. 25 percent ABR would require a virgin asphalt binder grade of PG 64-22 to be reduced to a PG 58-28).

(2) FRAP/RAS. When FRAP is used alone or FRAP is used in conjunction with RAS, the percentage of virgin asphalt binder replacement shall not exceed the amounts listed in the following table.

HMA Mixtures - FRAP/RAS Maximum ABR % 1/ 2/			
Ndesign	Binder	Surface	Polymer Modified Binder or Surface
30	55	45	15
50	45	40	15
70	45	35	15
90	45	35	15
SMA	- -	- -	25
IL-4.75	- -	- -	35

1/ For Low ESAL HMA shoulder and stabilized subbase, the FRAP/RAS ABR shall not exceed 50 percent of the mixture.

2/ When FRAP/RAS ABR exceeds 20 percent for all mixes, the high and low virgin asphalt binder grades shall each be reduced by one grade (i.e. 25 percent ABR would require a virgin asphalt binder grade of PG 64-22 to be reduced to a PG 58-28).

1031.07 HMA Mix Designs. At the Contractor's option, HMA mixtures may be constructed utilizing RAP/FRAP and/or RAS material meeting the detailed requirements specified herein.

(a) RAP/FRAP and/or RAS. RAP/FRAP and/or RAS mix designs shall be submitted for verification. If additional RAP/FRAP and/or RAS stockpiles are tested and found that no more than 20 percent of the individual parameter test results, as defined in Article 1031.04, are outside of the control tolerances set for the original RAP/FRAP and/or RAS stockpile and HMA mix design, and meets all of the requirements herein, the additional

RAP/FRAP and/or RAS stockpiles may be used in the original mix design at the percent previously verified.

(b) RAS. Type 1 and Type 2 RAS are not interchangeable in a mix design.

The RAP, FRAP, and RAS stone bulk specific gravities (G_{sb}) shall be according to the "Determination of Aggregate Bulk (Dry) Specific Gravity (G_{sb}) of Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS)" procedure in the Department's Manual of Test Procedures for Materials.

1031.08 HMA Production. HMA production utilizing RAP/FRAP and/or RAS shall be as follows.

To remove or reduce agglomerated material, a scalping screen, gator, crushing unit, or comparable sizing device approved by the Engineer shall be used in the RAP/FRAP and/or RAS feed system to remove or reduce oversized material.

If the RAP/FRAP and/or RAS control tolerances or HMA test results require corrective action, the Contractor shall cease production of the mixture containing RAP/FRAP and/or RAS and either switch to the virgin aggregate design or submit a new mix design.

(a) RAP/FRAP. The coarse aggregate in all RAP/FRAP used shall be equal to or less than the nominal maximum size requirement for the HMA mixture being produced.

(b) RAS. RAS shall be incorporated into the HMA mixture either by a separate weight depletion system or by using the RAP weigh belt. Either feed system shall be interlocked with the aggregate feed or weigh system to maintain correct proportions for all rates of production and batch sizes. The portion of RAS shall be controlled accurately to within ± 0.5 percent of the amount of RAS utilized. When using the weight depletion system, flow indicators or sensing devices shall be provided and interlocked with the plant controls such that the mixture production is halted when RAS flow is interrupted.

(c) RAP/FRAP and/or RAS. HMA plants utilizing RAP/FRAP and/or RAS shall be capable of automatically recording and printing the following information.

(1) Dryer Drum Plants.

a. Date, month, year, and time to the nearest minute for each print.

b. HMA mix number assigned by the Department.

c. Accumulated weight of dry aggregate (combined or individual) in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).

d. Accumulated dry weight of RAP/FRAP/RAS in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).

e. Accumulated mineral filler in revolutions, tons (metric tons), etc. to the nearest 0.1 unit.

f. Accumulated asphalt binder in gallons (liters), tons (metric tons), etc. to the nearest 0.1 unit.

g. Residual asphalt binder in the RAP/FRAP/RAS material as a percent of the total mix to the nearest 0.1 percent.

h. Aggregate and RAP/FRAP/RAS moisture compensators in percent as set on the control panel. (Required when accumulated or individual aggregate and RAP/FRAP/RAS are recorded in a wet condition.)

i. A positive dust control system shall be utilized when the combined contribution of reclaimed material passing the No. 200 sieve exceeds 1.5 percent.

(2) Batch Plants.

a. Date, month, year, and time to the nearest minute for each print.

b. HMA mix number assigned by the Department.

c. Individual virgin aggregate hot bin batch weights to the nearest pound (kilogram).

d. Mineral filler weight to the nearest pound (kilogram).

e. RAP/FRAP/RAS weight to the nearest pound (kilogram).

f. Virgin asphalt binder weight to the nearest pound (kilogram).

g. Residual asphalt binder in the RAP/FRAP/RAS material as a percent of the total mix to the nearest 0.1 percent.

The printouts shall be maintained in a file at the plant for a minimum of one year or as directed by the Engineer and shall be made available upon request. The printing system will be inspected by the Engineer prior to production and verified at the beginning of each construction season thereafter.

1031.09 RAP in Aggregate Applications. RAP in aggregate applications shall be according to the Bureau of Materials Policy Memorandum, “Reclaimed Asphalt Pavement (RAP) for Aggregate Applications” and the following.

(a) RAP in Aggregate Surface Course and Aggregate Wedge Shoulders, Type B. The use of RAP in aggregate surface course (temporary access entrances only) and aggregate wedge shoulders, Type B shall be as follows.

(1) Stockpiles and Testing. RAP stockpiles may be any of those listed in Article 1031.02, except “Non-Quality” and “FRAP”. The testing requirements of Article 1031.03 shall not apply.

(2) Gradation. One hundred percent of the RAP material shall pass the 1 1/2 in. (37.5 mm) sieve. The RAP material shall be reasonably well graded from coarse to fine. RAP material that is gap-graded or single sized will not be accepted.

SECTION 1032. BITUMINOUS MATERIALS

1032.01 Description. Bituminous materials shall include asphalt binders, emulsified asphalts, rapid curing liquid asphalt, medium curing liquid asphalts, slow curing liquid asphalts, asphalt fillers, and road oils. All bituminous materials used in a given construction shall be prepared from petroleum and be uniform in character, appearance, and consistency.

1032.02 Measurement. Asphalt binders, emulsified asphalts, rapid curing liquid asphalts, medium curing liquid asphalts, slow curing liquid asphalts, asphalt fillers, and road oils will be measured by weight.

A weight ticket for each truck load shall be furnished to the Engineer. The truck shall be weighed at a location approved by the Engineer. The ticket shall show the weight of the empty truck (the truck being weighed each time before it is loaded), the weight of the loaded truck, and the net weight of the bituminous material.

When an emulsion or cutback is used for prime or tack coat, the percentage of asphalt residue of the actual certified product shall be shown on the producer's bill of lading or attached certificate of analysis. If the producer adds extra water to an emulsion at the request of the purchaser, the amount of water shall also be shown on the bill of lading.

Payment will not be made for bituminous materials in excess of 105 percent of the amount specified by the Engineer.

1032.03 Delivery. When bituminous materials are not approved at their source by the Department, they shall be delivered far enough in advance of their use to permit the necessary tests to be made. When not delivered in tank cars or tank trucks, the bituminous materials shall be delivered in suitable containers or packages, plainly labeled to show the kind of material, the name of manufacturer, and the lot or batch number. Each shipment and each carload shall be kept separate until the material has been accepted.

Asphalt binder, when delivered in tank cars or tank trucks, shall be delivered at a temperature not to exceed 350 °F (175 °C).

Petroleum asphalts PAF-1 and PAF-2 shall be shipped in new, double end, metal drums. The thickness of the metal used shall not be less than 0.0149 in. (0.4 mm). The side seams of the drums shall be double lapped, spot welded single lapped, or stitch welded single lapped. The seams shall meet the approval of the Engineer. The drums shall be manufactured so that there will be no leakage during hot weather. The capacity of each drum shall be approximately 460 lb (210 kg), the drums being 35 in. (890 mm) maximum in height and approximately 22 in. (560 mm) in diameter.

Petroleum asphalts PAF-3 and PAF-4 shall be shipped in new, open end, metal drums. The thickness of the metal used shall be not less than the 0.0149 in. (0.4 mm). The seams shall be constructed so that the filled drums will withstand shipping and handling. The inside of the drums shall be coated with talc or other approved material to facilitate peeling. The capacity of each drum shall be approximately 460 lb (210 kg), the drums being 35 in. (890 mm) maximum in height and approximately 22 in. (560 mm) in diameter. Petroleum asphalts PAF-3 and PAF-4 may, when specified, be shipped in approved 100 lb (45 kg) cartons.

1032.04 Spraying Application. The spraying application temperature ranges for bituminous material applied by a pressure distributor shall be according to the following table.

Spraying Application Temperature Ranges		
Type and Grade of Bituminous Material	Temperature Ranges	
	°F min. - max.	°C min. - max.
PEP	60 - 130	15 - 55
MC-30, E-2	85 - 190	30 - 90
MC-70, RC-70, SC-70, E-3	120 - 225	50 - 105
MC-250, SC-250, E-4	165 - 270	75 - 130
MC-800, SC-800	200 - 305	95 - 150
MC-3000, SC-3000	230 - 345	110 - 175
PG 46-28	275 - 350	135 - 175
PG 52-28, PG 58-22, PG 58-28, PG 64-22	285 - 350	140 - 175
RS-1, CRS-1	75 - 130	25 - 55
RS-2, CRS-2	110 - 160	45 - 70
NTEA	160 - 180	70 - 80
SS-1, SS-1h, CSS-1, CSS-1h SS-1hP, CSS-1hP	75 - 130	25 - 55
HFE-90, HFE-150, HFE-300 HFRS-2P, CRS-2P, HFRS-2	150 - 180	65 - 80
LJS, FLS	265 - 330	130 - 165

1032.05 Performance Graded Asphalt Binder. These materials will be accepted according to the Bureau of Materials Policy Memorandum, "Performance Graded Asphalt Binder Qualification Procedure." The Department will maintain a qualified producer list. These materials shall be free from water and shall not foam when heated to any temperature below the actual flash point.

When requested, producers shall provide the Engineer with viscosity/temperature relationships for the performance graded asphalt binders delivered and incorporated in the work.

(a) Performance Graded (PG) Asphalt Binder. The asphalt binder shall meet the requirements of AASHTO M 320, Table 1 "Standard Specification for Performance Graded Asphalt Binder" for the grade shown on the plans. Air blown asphalt will not be allowed.

(b) Polymer Modified Performance Graded (PG) Asphalt Binder. The asphalt binder shall meet the requirements of AASHTO M 320, Table 1 "Standard Specification for Performance Graded Asphalt Binder" for the grade shown on the plans. Elastomers shall be added to the base asphalt binder to achieve the specified performance grade and shall be either a styrene-butadiene diblock or triblock copolymer without oil extension, or a styrene-butadiene rubber. Air blown asphalts, acid modification, and other modifiers will not be allowed. Asphalt modification at hot-mix asphalt plants will not be allowed. The modified asphalt binder shall be smooth, homogeneous, and be according to the requirements shown in Table 1 or 2 for the grade shown on the plans.

Table 1 - Requirements for Styrene-Butadiene Copolymer (SB/SBS) Modified Asphalt Binders

Test	Asphalt Grade SB/SBS PG 64-28 SB/SBS PG 70-22 SB/SBS PG 70-28	Asphalt Grade SB/SBS PG 76-22 SB/SBS PG 76-28
Separation of Polymer ITP, "Separation of Polymer from Asphalt Binder" Difference in °F (°C) of the softening point between top and bottom portions.	4 (2) max.	4 (2) max.
Force Ratio AASHTO T 300, f_2/f_1 [1/]	0.30 min.	0.35 min.
TESTS ON RESIDUE FROM ROLLING THIN FILM OVEN TEST (AASHTO T 240)		
Elastic Recovery ASTM D 6084, Procedure A, 77 °F (25 °C), 100 mm elongation, %	60 min.	70 min. [2/]

1/ Shall have a minimum elongation of 300 mm prior to rupture.

2/ When SBS/SBR PG 76-22 or SBS/SBR PG 76-28 is specified for mixture IL-4.75, the elastic recovery shall be a minimum of 80.

Table 2 - Requirements for Styrene-Butadiene Rubber (SBR) Modified Asphalt Binders

Test	Asphalt Grade SBR PG 64-28 SBR PG 70-22 SBR PG 70-28	Asphalt Grade SBR PG 76-22 SBR PG 76-28
Separation of Polymer ITP, "Separation of Polymer from Asphalt Binder" Difference in °F (°C) of the softening point between top and bottom portions.	4 (2) max.	4 (2) max.
Toughness ASTM D 5801, 77 °F (25 °C), 20 in./min. (500 mm/min.), in.-lbs (N-m).	110 (12.5) min.	110 (12.5) min.
Tenacity ASTM D 5801, 77 °F (25 °C), 20 in./min. (500 mm/min.), in.-lbs (N-m).	75 (8.5) min.	75 (8.5) min.
TESTS ON RESIDUE FROM ROLLING THIN FILM OVEN TEST (AASHTO T 240)		
Elastic Recovery ASTM D 6084, Procedure A, 77 °F (25 °C), 100 mm elongation, %	40 min.	50 min.

Note. When SBS/SBR PG 76-22 or SBS/SBR PG 76-28 is specified for mixture IL-4.75, the elastic recovery shall be a minimum of 80.

The following grades may be specified as tack coats.

Asphalt Grade	Use
PG 58-22, PG 58-28, PG 64-22	Tack Coat

1032.06 Emulsified Asphalts. Emulsified asphalts will be accepted according to the Bureau of Materials Policy Memorandum, "Emulsified Asphalt Qualification Procedure." The Department will maintain a qualified producer list. These materials shall be homogeneous and shall show no separation of asphalt after thorough mixing, within 30 days after delivery, provided separation has not been caused by freezing. The emulsified asphalts shall coat the aggregate to the satisfaction of the Engineer and be according to the following requirements.

(a) Anionic Emulsified Asphalt. Anionic emulsified asphalts shall be according to AASHTO M 140, except as follows.

(1) The cement mixing test will be waived when the emulsion is being used as a tack coat.

(2) The Solubility in Trichloroethylene test according to AASHTO T 44 may be run in lieu of Ash Content and shall meet a minimum of 97.5 percent.

(b) Cationic Emulsified Asphalt. Cationic emulsified asphalts shall be according to AASHTO M 208, except as follows.

(1) The cement mixing test will be waived when the emulsion is being used as a tack coat or slurry seal.

(2) The Solubility in Trichloroethylene test according to AASHTO T 44 may be run in lieu of Ash Content and shall meet a minimum of 97.5 percent.

(c) High Float Emulsion. High float emulsions are medium setting and shall be according to the following table.

Test	HFE-90	HFE-150	HFE-300
Viscosity, Saybolt Furol, at 122 °F (50 °C), (AASHTO T 59), SFS [1/]	50 min.	50 min.	50 min.
Sieve Test, retained on No. 20 (850 µm) sieve, (AASHTO T 59), %	0.10 max.	0.10 max.	0.10 max.
Storage Stability Test, 1 day, (AASHTO T 59), %	1 max.	1 max.	1 max.
Coating Test (All Grades), (AASHTO T 59), 3 minutes	stone coated thoroughly		
Distillation Test, (AASHTO T 59): Residue from distillation test to 500 °F (260 °C), % Oil distillate by volume, %	 65 min. 7 max.	 65 min. 7 max.	 65 min. 7 max.
Characteristics of residue from distillation test to 500 °F (260 °C): Penetration at 77 °F (25 °C), (AASHTO T 49), 100 g, 5 sec, dmm	90-150	150-300	300 min.
Float Test at 140 °F (60 °C), (AASHTO T 50), sec.	1200 min.	1200 min.	1200 min.

1/ The emulsion shall be pumpable.

(d) Penetrating Emulsified Prime (PEP). The PEP shall be according to the following.

Test (AASHTO T 59)	Result
Viscosity, Saybolt Furol, at 77 °F (25 °C), SFS	75 max.
Sieve test, retained on No. 20 (850 µm) sieve, %	0.10 max.
Distillation to 500 °F (260 °C) residue, %	38 min.
Oil distillate by volume, %	4 max.

The PEP shall be tested according to the Bureau of Materials Illinois Laboratory Test Procedure (ILTP), "Sand Penetration Test of Penetrating Emulsified Prime (PEP)". The time of penetration shall be equal to or less than that of MC-30. The depth of penetration shall be equal to or greater than that of MC-30.

(e) Polymer-Modified Emulsified Asphalt. Polymer-modified emulsified asphalts shall be according to AASHTO M 316, except as follows.

(1) The cement mixing test will be waived when the polymer-modified emulsion is being used as a tack coat.

(2) CQS-1hP (formerly CSS-1h Latex Modified) emulsion for micro-surfacing treatments shall use latex as the modifier.

(3) Upon examination of the storage stability test cylinder after standing undisturbed for 24 hours, the surface shall show minimal to no white, milky colored substance and shall be a homogenous brown color throughout.

(4) The distillation for all polymer-modified emulsions shall be performed according to AASHTO T 59, except the temperature shall be 374 ± 9 °F (190 ± 5 °C) to be held for a period of 15 minutes and measured using an ASTM 16F (16C) thermometer.

(5) The specified temperature for the Elastic Recovery test for all polymer-modified emulsions shall be 50.0 ± 1.0 °F (10.0 ± 0.5 °C).

(6) The Solubility in Trichloroethylene test according to AASHTO T 44 may be run in lieu of Ash Content and shall meet a minimum of 97.5 percent.

(f) Non-Tracking Emulsified Asphalt. Non-Tracking Emulsified Asphalt (NTEA) shall be according to the following.

Test	Requirement
Saybolt Viscosity at 77 °F (25 °C), (AASHTO T 59), SFS	20-100
Storage Stability Test, 24 hr, (AASHTO T 59), %	1 max.
Residue by Distillation, 500 ± 10 °F (260 ± 5 °C), or Residue by Evaporation, 325 ± 5 °F (163 ± 3 °C), (AASHTO T 59), %	50 min.
Sieve Test, No. 20 (850 µm), (AASHTO T 59), %	0.3 max.
Tests on Residue from Distillation/Evaporation	
Penetration at 77 °F (25 °C), 100 g, 5 sec, (AASHTO T 49), dmm	40 max.
Softening Point, (AASHTO T 53), °F (°C)	135 (57) min.
Ash Content, (AASHTO T 111), % 1/	1 max.

1/ The Solubility in Trichloroethylene test according to AASHTO T 44 may be run in lieu of Ash Content and shall meet a minimum of 97.5 percent.

The different grades are, in general, used for the following.

Grade	Use
SS-1, SS-1h, RS-1, RS-2, CSS-1, CRS-1, CRS-2, CSS-1h, HFE-90, SS-1hP, CSS-1hP, NTEA	Tack coat or fog seal
PEP	Prime coat
RS-2, HFE-90, HFE-150, HFE-300, CRS-2P, HFRS-2P, CRS-2, HFRS-2	Bituminous surface treatment
CQS-1hP	Micro-surfacing
CQS-1h	Slurry sealing
CRS-2P, HFRS-2P	Cape seal

1032.07 Rapid Curing Liquid Asphalt. Rapid curing liquid asphalt will be accepted according to the Bureau of Materials Policy Memorandum, “Cutback Asphalt and Road Oil Qualification Procedure.” The Department will maintain a qualified producer list. These materials shall be a rapid curing cutback asphalt consisting of a petroleum residuum fluxed with a suitable distillate. The liquid asphalt shall be free from water, show no separation on standing, and shall be according to the requirements listed in the following table.

Test	Grade RC-70
Viscosity, Kinematic, at 140 °F (60 °C), (AASHTO T 201), cSt (mm^2/s)	70 to 140
Distillation Test: (AASHTO T 78)	
Distillate, percent by volume of total distillate to 680 °F (360 °C)	
Distillate to 374 °F (190 °C)	10 min.
Distillate to 437 °F (225 °C)	50 min.
Distillate to 500 °F (260 °C)	70 min.
Distillate to 600 °F (315 °C)	85 min.
Residue from distillation to 680 °F (360 °C), percent volume by difference	55 min.
Tests on residue from distillation:	
Penetration, 77 °F (25 °C), 100 g, 5 sec, (AASHTO T 49), dmm	80 to 120
Ductility at 77 °F (25 °C), (AASHTO T 51), mm[1/]	1000 min.
Solubility in trichloroethylene, (AASHTO T 44), %	99.5 min.

1/ If ductility is less than 1000 mm at 77 °F (25 °C), the material will be acceptable if the ductility is more than 1000 mm at 60 °F (15 °C).

The grade is, in general, used for the following.

Grade	Use
RC-70	Tack coat and soil curing

1032.08 Medium Curing Liquid Asphalts. Medium curing liquid asphalts will be accepted according to the Bureau of Materials Policy Memorandum, "Cutback Asphalt and Road Oil Qualification Procedure". The Department will maintain a qualified producer list. These materials shall be medium curing cutback asphalts consisting of a petroleum residuum fluxed with a suitable distillate. They shall be free from water, show no separation on standing, and shall be according to the requirements listed in the following table.

Test	Grades				
	MC-30	MC-70	MC-250	MC-800	MC-3000
Flash Point, (Tag open cup), (AASHTO T 79), °F (°C) [1/]	100 min. (38 min.)	100 min. (38 min.)	-- --	-- --	-- --
Flash Point, (Cleveland open cup), (AASHTO T 48), °F (°C)	-- --	-- --	150 min. (65 min.)	150 min. (65 min.)	150 min. (65 min.)
Viscosity, Kinematic, at 140 °F (60 °C), (AASHTO T 201), cSt (mm^2/s)	30 to 60	70 to 140	250 to 500	800 to 1600	3000 to 6000
Distillation Test (AASHTO T 78):					
Distillate, % by volume of total distillate to 680 °F (360 °C):					
Distillate to 437 °F (225 °C)	25 max.	20 max.	10 max.	--	--
Distillate to 500 °F (260 °C)	40 to 70	20 to 60	15 to 55	35 max.	15 max.
Distillate to 600 °F (315 °C)	75 to 93	70 to 90	60 to 87	45 to 80	15 to 75
Residue from distillation to 680 °F (360 °C), % volume by difference	50 min.	55 min.	67 min.	75 min.	80 min.
Tests on residue from distillation:					
Penetration at 77 °F (25 °C), 100 g, 5 sec, (AASHTO T 49), dmm	120 to 250	120 to 250	120 to 250	120 to 250	120 to 250
Ductility at 77 °F (25 °C), (AASHTO T 51), mm [2/]	1000 min.	1000 min.	1000 min.	1000 min.	1000 min.
Solubility in trichloroethylene, (AASHTO T 44), %	99.5 min.	99.5 min.	99.5 min.	99.5 min.	99.5 min.

1/ Flash point by Cleveland open cup may be used for products having a flash point above 175 °F (80 °C).

2/ If ductility is less than 1000 mm at 77 °F (25 °C), the material will be acceptable if the ductility is more than 1000 mm at 60 °F (15 °C).

The different grades are, in general, used for the following.

Grade	Use
MC-30	Prime coats
MC-70	Soil curing
MC-250, MC-800, MC-3000	Surface treatments and seal coats

1032.09 Slow Curing Liquid Asphalts. Slow curing liquid asphalts will be accepted according to the Bureau of Materials Policy Memorandum, "Cutback Asphalt and Road Oil Qualification Procedure." The Department will maintain a qualified producer list. These materials shall be slow curing liquid asphalts produced by the distillation of petroleum. The liquid asphalts shall be residues, distillates, or residues fluxed to the desired consistency with petroleum distillates. Each shipment of liquid asphalt shall be uniform in appearance and consistency. All grades shall be free from water and shall not foam when heated to 225 °F (107 °C). The residues of specified penetration shall be smooth and homogeneous in appearance. This material shall be according to the requirements listed in the following table.

Test	Grades			
	SC-70	SC-250	SC-800	SC-3000
Flash Point, Cleveland open cup, (AASHTO T 48), °F (°C)	150 min. (65 min.)	175 min. (80 min.)	200 min. (93 min.)	225 min. (107 min.)
Viscosity, Kinematic, at 140 °F (60 °C), (AASHTO T 201), cSt (mm²/s)	70 to 140	250 to 500	800 to 1600	3000 to 6000
Residue of 100 penetration, (ASTM D 243), %	50 min.	60 min.	70 min.	80 min.
Ductility at 77 °F (25 °C), of residue of specified penetration, (AASHTO T 51), mm [1/]	1000 min	1000 min	1000 min	1000 min.
Loss on heating at 325 °F (163 °C), 50 g, 5 hours, (ASTM D 6/D 6M), %	11 max.	8 max.	5 max.	4 max.
Solubility in trichloroethylene, (AASHTO T 44), %	99.0 min.	99.0 min.	99.0 min.	99.0 min.

1/ If ductility is less than 1000 mm at 77 °F (25 °C), the material will be acceptable if the ductility is more than 1000 mm at 60 °F (15 °C).

The different grades are, in general, used for the following.

Grade	Use
SC-70	For dust layer and for prime coats
SC-250	For road mix and traveling plant mix surfaces dense-graded aggregate type
SC-800	For plant mix surfaces dense-graded aggregate type
SC-3000	Surface treatments and seal coats

1032.10 Road Oils. Road oils will be accepted according to the Bureau of Materials Policy Memorandum, "Cutback Asphalt and Road Oil Qualification Procedure." The Department will maintain a qualified producer list. These materials shall be slow curing asphaltic oils. They shall show no separation on standing and shall be according to the requirements listed in the following table.

Test	Grades		
	E-2 Light	E-3 Medium	E-4 Heavy
Water, by volume, percent	0.5 max.	0.5 max.	0.5 max.
Flash Point, Cleveland open cup, (AASHTO T 48) °F (°C)	200 min. (93 min.)	200 min. (93 min.)	200 min. (93 min.)
Viscosity, Kinematic, at 122 °F (50 °C), (AASHTO T 201), cSt (mm^2/sec),	168 to 285	285 to 510	510 to 785
Viscosity, Saybolt Furol, at 122 °F (50 °C), (AASHTO T 59), SFS	80 to 135	135 to 240	240 to 370
Solubility in trichloroethylene, (AASHTO T 44), %	99.5 min.	99.5 min.	99.5 min.
Residue of 100 penetration, ASTM D 243, %	50 min.	55 min.	60 min.
Ductility at 77 °F (25 °C), (AASHTO T 51), of residue of specified penetration, mm	1000 min.	1000 min.	1000 min.

The different grades are used for surface treatment of earth roads.

1032.11 Asphalt Fillers (Prepared from Petroleum). These materials shall be free from water and shall not foam when heated to the flash point. They shall be according to the requirements listed in the following table.

Test	Grades			
	PAF-1	PAF-2	PAF-3	PAF-4
Flash Point, Cleveland open cup, (AASHTO T 48), °F (°C)	450 min. (232 min.)	450 min. (232 min.)	450 min. (232 min.)	475 min. (246 min.)
Softening Point, ring and ball method, (AASHTO T 53), °F (°C)	122 min. (50 min.)	135 min. (57 min.)	167 to 185 (75 to 85)	180 min. (82 min.)
Penetration at 32 °F (0 °C), 200g, 60 sec	30 min.	15 min.	10 min.	15 min.
Penetration at 77 °F (25 °C), (AASHTO T 49), 100g, 5 sec	80 to 100	40 to 55	25 to 40	30 to 50
Penetration at 115 °F (46.1 °C), 50g, 5 sec	--	190 max.	90 max.	80 max.
Loss on heating at 325 °F (163 °C), 50 g, 5 hrs., (ASTM D 6/D 6M), %	1.0 max.	1.0 max.	1.0 max.	1.0 max.
Penetration at 77 °F (25 °C), 100 g, 5 sec, of asphalt after heating at 325 °F (163 °C), as compared with penetration of asphalt before heating, %	70.0 min.	70.0 min.	70.0 min.	70.0 min.
Ductility at 77 °F (25 °C), (AASHTO T 51), mm	400 min.	150 min.	25 min.	25 min.
Bitumen soluble in trichloroethylene, (AASHTO T 44), %	99.0 min.	99.0 min.	99.0 min.	99.0 min.

The different grades are, in general, used for the following.

PAF-1 & PAF-2	For filling cracks in portland cement concrete pavement.
PAF-3	For sealing expansion and contraction joints in portland cement concrete pavement and for undersealing portland cement concrete pavement.
PAF-4	For sealing expansion and contraction joints in portland cement concrete pavement and for filler in brick pavement.

1032.12 Longitudinal Joint Sealant (LJS). Longitudinal joint sealant (LJS) in the form of spray applied liquid or pre-formed roll will be accepted according to the Bureau of Materials Policy Memorandum, "Performance Graded Asphalt Binder Qualification Procedure". The Department will maintain a qualified producer list. The bituminous material used for the LJS shall be according to the following table. Elastomers shall be added to a base asphalt and shall be either a styrene-butadiene diblock or triblock copolymer without oil extension, or a styrene-butadiene rubber. Air blown asphalt, acid modification, or other modifiers will not be allowed.

Test	Test Requirement	Test Method
Dynamic shear @ 88°C (unaged), G*/sin δ, kPa	1.00 min.	AASHTO T 315
Creep stiffness @ -18°C (unaged), Stiffness (S), MPa m-value	300 max. 0.300 min.	AASHTO T 313
Ash Content, %	1.0 – 4.0 1/	AASHTO T 111
Elastic Recovery, 100 mm elongation, cut immediately, 25°C, % 2/	70 min.	ASTM D 6084 (Procedure A)
Separation of Polymer, Difference in °C of the softening point (ring and ball) 2/	3 max.	ILTP "Separation of Polymer from Asphalt Binder"

1/ For LJS in a pre-formed roll, the ash content shall be a maximum of 20 percent.

2/ For LJS in a pre-formed roll, this test shall be waived.

1032.13 Full Lane Sealant (FLS). Full lane sealant (FLS) will be accepted according to the Bureau of Materials Policy Memorandum, "Performance Graded Asphalt Binder Qualification Procedure". The Department will maintain a qualified producer list. The bituminous material used for the FLS shall be according to Article 1032.12, except fillers shall not be added and the ash content test shall be waived.

SECTION 1033. TEMPORARY RUBBER AND TEMPORARY PLASTIC RAMPS

1033.01 Temporary Rubber Ramps. For butt joints, temporary rubber ramp material shall be according to the following.

Property	Test Method	Requirement
Durometer Hardness, Shore A	ASTM D 2240	80 ±10
Tensile Strength, psi (kPa)	ASTM D 412	800 (5500) min.
Elongation, %	ASTM D 412	100 min.
Specific Gravity	ASTM D 297	1.1 - 1.3
Brittleness, °F (°C)	ASTM D 746	-40 (-40)

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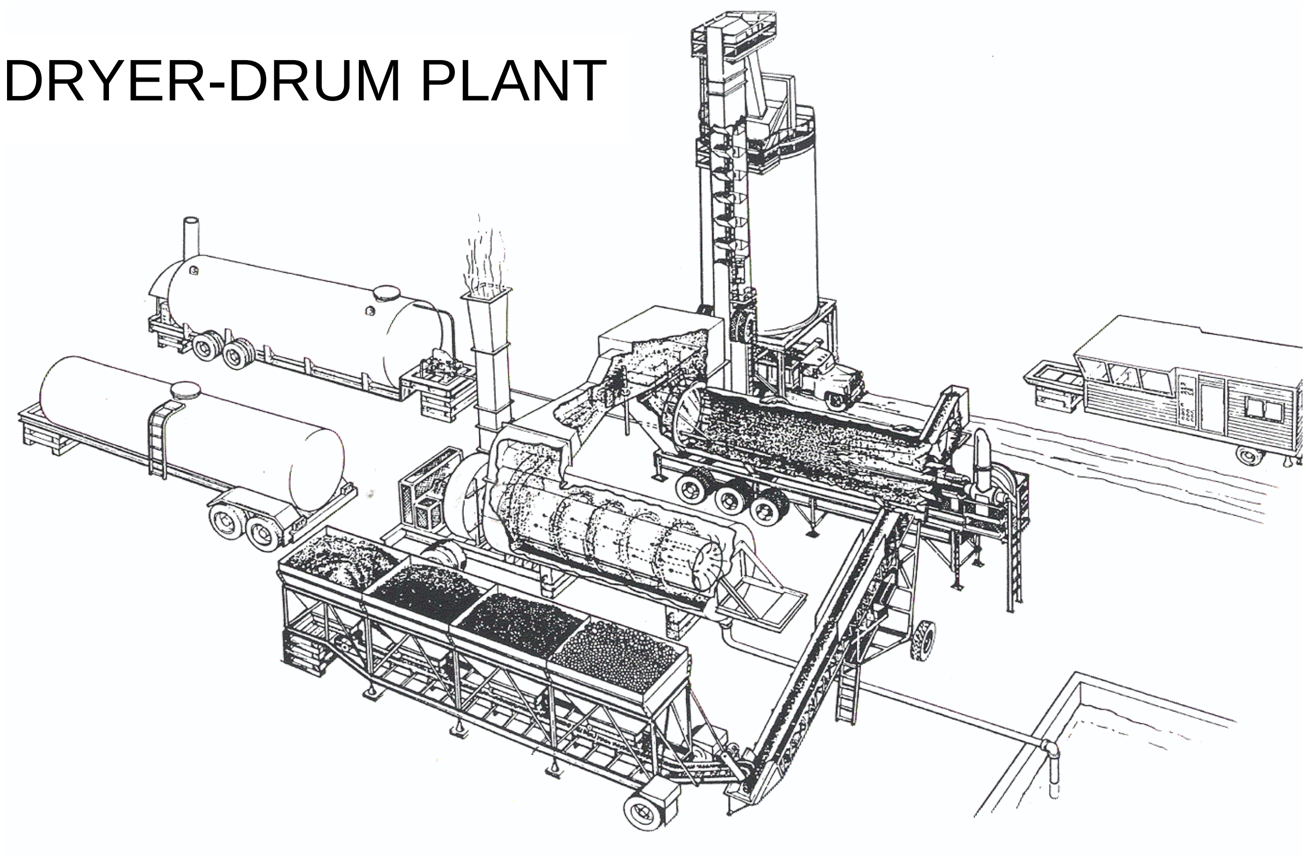
Types of Plants (Photos)

DRYER-DRUM PLANT

Drum mixing is a relatively simple process of producing asphalt hot-mix. The mixing drum from which this type of plant gets its name is very similar in appearance to the drying drum of a batch plant. The difference between dryer-drum mix plants and batch plants is that, in dryer-drum mix plants the aggregate is not only dried and heated within the drum, but also mixed with asphalt cement. There are no gradation screens, hot-bins, weigh hoppers or pug mills in a dryer-drum mix plant. As the mix is discharged from the dryer-drum it is carried to a surge bin from which it is subsequently loaded into trucks. Aggregate gradation is controlled at the cold feeds. The fundamental components of the -drum mix plant are shown in Figure 2.1.



DRYER-DRUM PLANT

Figure 2.1

BATCH PLANTS

Batch plants get their name from the fact that during operation, they produce hot-mix asphalt (HMA) in batches. The plant produces one batch at a time, one after the other. The size of a batch varies according to the capacity of the plants pug mill (the mixing chamber where aggregate and asphalt are blended together). Batch plants are distinguished from continuous or Dryer-drum plants, which produce HMA in a steady flow. Figure 2.2 illustrates the major components of a typical asphalt batch plant.

BATCH PLANT

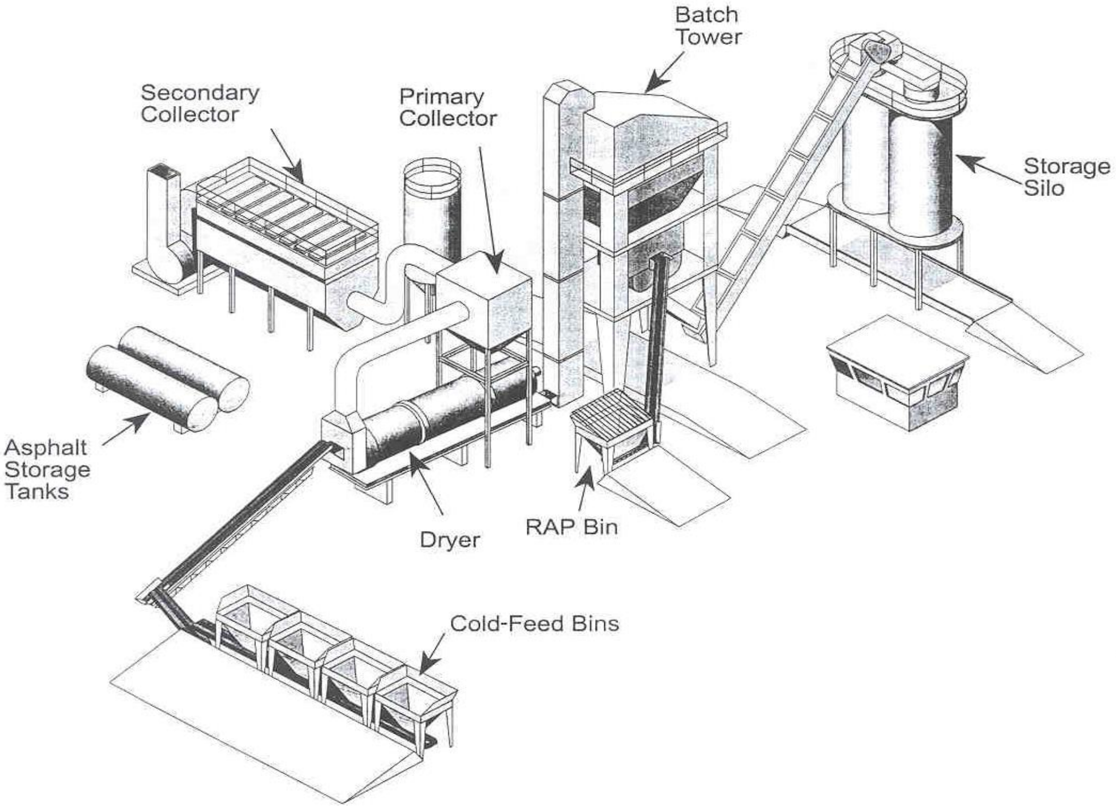


Figure 2.2

PLANT GENERAL REQUIREMENTS

STOCKPILES

Stockpiling procedures and sampling have been discussed during the aggregate training class. The required sample sizes are listed below. During HMA production, aggregate is loaded out of each stockpile and placed into separate cold feed bins. Care should be taken during stockpile load-out to remix segregated material.

Illinois Specification 201
Illinois Department of Transportation (IDOT)
AGGREGATE GRADATION SAMPLE SIZE TABLE & QUALITY CONTROL SIEVES

Effective: December 1, 2021

COARSE AGGREGATE GRADATION TABLE

CA(CM)^{1,2}	Minimum Field Sample Size ^{3}	Minimum Test Sample Size^{3}	3”	2 1/2”	2”	1 3/4”	1 1/2”	1”	3/4”	5/8”	1/2”	3/8”	1/4”	#4	#8	#16	#40	#50	#200
CA01	110 lbs (50 kg)	10,000 g	X	X^{MN}	X		X	X											X
CA02	110 lbs (50 kg)	10,000 g		X	X^{MN}		XC	X	XC		X			X		X	X		X
CA03	110 lbs (50 kg)	10,000 g		X	X^{MN}		X	X			X								X
CA04	110 lbs (50 kg)	10,000 g			X		X^{MN}	X	XC		X	XC		X		X	X		X
CA05$^{\underline{5}}$	110 lbs (50 kg)	10,000 g				X	X^{MN}	X$^{MB\underline{,6}}$	XC		X			X^{6}					X
CA06	55 lbs (25 kg)	5,000 g					X	X^{MN}	XC		X	XC		X		X	X		X
CA07$^{\underline{5}}$	55 lbs (25 kg)	5,000 g					X	X^{MN}	XC	XC	X$^{MB\underline{,6}}$	XC	XC	X^{6}					X
CA08	55 lbs (25 kg)	5,000 g					X	X^{MN}	X	XC	X	XC	XC	X		X			X
CA09	55 lbs (25 kg)	5,000 g					X	X^{MN}	XC	XC	X	XC	XC	X		X			X
CA10	55 lbs (25 kg)	5,000 g						X	X^{MN}	XC	X	XC	XC	X		X	X		X
CA11$^{\underline{5}}$	55 lbs (25 kg)	5,000 g						X	X^{MN}	XC	X$^{MB\underline{,6}}$	XC	XC	X		X^{6}			X
CA12	35 lbs (16 kg)	2,000 g							X		X^{MN}	X	XC	X	XC	X	X		X
CA13$^{\underline{5}}$	35 lbs (16 kg)	2,000 g							X		X^{MN}	X	XC	X$^{MB\underline{,6}}$	XC	X^{6}			X
CA14$^{\underline{5}}$	35 lbs (16 kg)	2,000 g								X	X^{MN}	X$^{MB\underline{,6}}$	XC	X^{6}					X
CA15	35 lbs (16 kg)	2,000 g									X	X^{MN}	XC	X	XC	X			X
CA16$^{\underline{5}}$	25 lbs (11 kg)	1,500 g									X	X^{MN}	XC	X$^{MB\underline{,6}}$	XC	X^{6}			X
CA17	35 lbs (16 kg)^{4}	4,000 g^{4}	X		XC			XC			XC	XC		X$^{MN, 4}$		X		X	X
CA18	35 lbs (16 kg)^{4}	4,000 g^{4}	X					X$^{MN, 4}$			XC	XC		X		X		X	X
CA19	35 lbs (16 kg)^{4}	4,000 g^{4}	X					X$^{MN, 4}$			XC	XC		X		X	X	X	X
CA20	25 lbs (11 kg)	2,000 g									X	X^{MN}	XC	X	X	X			X

Note: See footnotes below Fine Aggregate Gradation Table for explanation of symbols.

Illinois Specification 201
Illinois Department of Transportation (IDOT)
AGGREGATE GRADATION SAMPLE SIZE TABLE & QUALITY CONTROL SIEVES

Effective: <u>December 1, 2021</u>

<u>Notes below apply to Fine and Coarse Aggregate Gradation Tables Only</u>

FINE AGGREGATE GRADATION TABLE

FA(FM)[1,2]	Minimum Field Sample Size [3]	Minimum Test Sample Size[3]	1”	1/2”	3/8”	#4	#8	#10	#16	#30	#40	#50	#80	#100	#200
FA01	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	X^{MB}		X		X	X
FA02	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	X^{MB}		X		X	X
FA03	25 lbs (11 kg)	500 g			X	X^{MN}		X			X		X		X
FA04	25 lbs (11 kg)	500 g			X				X^{MN}						
FA05	25 lbs (11 kg)	500 g			X	X^{MN}								X	X
FA06	25 lbs (11 kg)	500 g	X	X	X	X^{MN}								X	X
FA07	25 lbs (11 kg)	100 g				X		X^{MN}			X		X		X
FA08	25 lbs (11 kg)	100 g					X				X^{MN}			X	X
FA09	25 lbs (11 kg)	100 g					X					X^{MN}		X	X
FA10	25 lbs (11 kg)	100 g						X			X^{MN}		X		X
FA20[5]	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	$X^{MB, 6}$		X		X	X^{6}
FA21[5]	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	$X^{MB, 6}$		X		X	X^{6}
FA22[5]	25 lbs (11 kg)	500 g			X	X^{MB}	$X^{MB, 6}$		X						X^{6}
FA23[5]	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	$X^{MB, 6}$		X		X	X^{6}
FA24[5]	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	$X^{MB, 6}$		X		X	X^{6}

X = Required Gradation Specification Sieves
XC = Required Cutter Sieves
MB = Master Band Sieves for Category I Coarse Aggregate for PCC and HMA Mixes; Bituminous use only for fine aggregate.
MN = Maximum Nominal Sieve for Crushed Gravels – Maximum Nominal Size is defined as the first specification sieve in the product gradation on which material may be retained.
1 = CA = Coarse Aggregate; CM = Coarse Aggregate, Modified; FA = Fine Aggregate; FM = Fine Aggregate, Modified
2 = CM and FM gradations shall be sampled and tested the same as the corresponding CA and FA gradations.
3 = Slag should be adjusted accordingly due to its lighter or heavier mass.
4 = Will vary with the gradation of the material being used
5 = Control Charts Required
6 = Required Sieve for Control Charts

Illinois Specification 201
Illinois Department of Transportation (IDOT)
AGGREGATE GRADATION SAMPLE SIZE TABLE & QUALITY CONTROL SIEVES

Effective: December 1, 2021

LARGE SIZED AGGREGATE GRADATION TABLE

CS/RR[1,2]	Minimum Test Sample Size[3]	8”	6”	4”	3”	2”	1 ½”	1”	½”	#4
CS01	50,000 g	X	X	X	XC	X		XC	XC	X
CS02	50,000 g		X	X	XC	X		XC	XC	X
RR01	20,000 g				X	XC	X	XC	XC	X
RR02	20,000 g			X	XC	X	XC	XC	XC	X

Notes below apply to Large Sized Aggregate Gradation Table Only

X = Required Gradation Specification Sieves
XC = Required Cutter Sieves
1 = CS = Coarse Aggregate Subgrade; RR/RRM = Rip Rap
2 = Dry Gradations Only
3 = Slag should be adjusted accordingly due to its lighter or heavier mass.
4 = A round nosed shovel may be used for sampling.
5 = Metal plates with precisely sized square holes by be used for the gradation
6 = Test sample size shall be taken in the field. No splitting is required.

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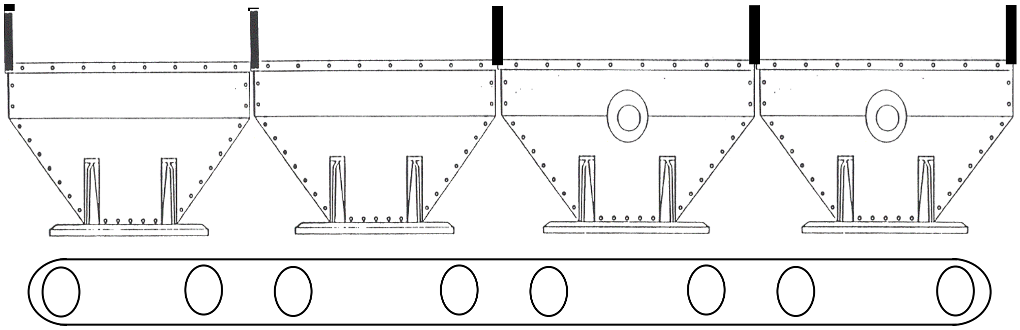
COLD AGGREGATE BINS AND FEEDERS

The specifications state, that the asphalt plant be equipped with a minimum of four (4) cold aggregate bins and feeders. (Fig. 2.3) The bottom of each bin has a gate which can be adjusted to control the amount of aggregate being fed from the bin. At some plants, however, the gates are set and locked, and the aggregate flow rate is controlled by a variable speed apron or belt feeder (Figure 2.4 Illustrates different types of feeders).



COLD FEED SYSTEM

Figure 2.3

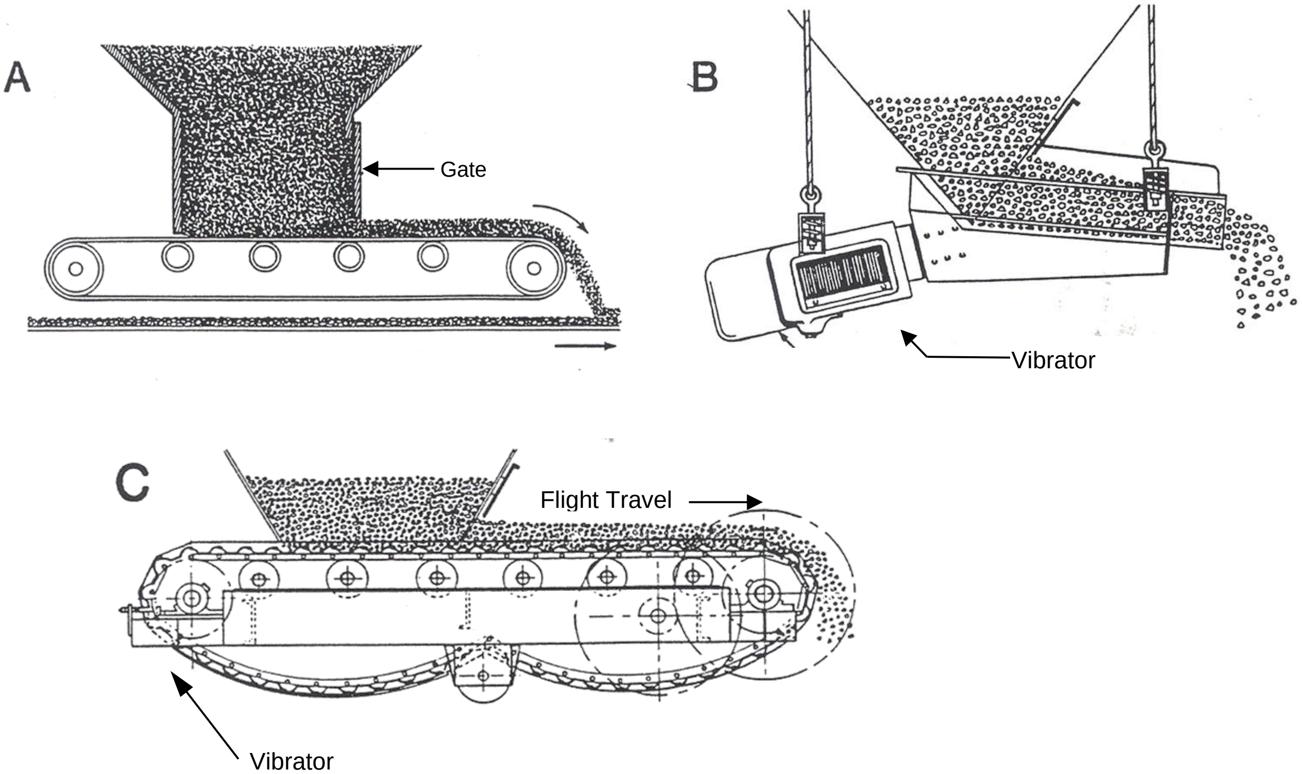


Figure 2.4 – Typical Types of Cold Feed Systems: A. Continuous Belt Feeder. B. Vibratory Feeder. And C. Apron Flow Feeder

The following sampling procedures may be used for **cold aggregate bins:**

A. Belt Stream

One method to obtain a belt stream sample is to use the pan method. In order to obtain this sample in the safest and most convenient manner, IDOT recommends that two people take the sample. The first person places a flat tray (pan) on the collector conveyor, behind the aggregate feeder. As the pan travels under the aggregate feeder, material from the feeder will be deposited in the pan. The second person then picks up the pan before it passes under the next cold bin. This procedure shall be repeated until the required weight of material is obtained.

At some plants it is impossible to use the pan method. In this case, contractors shall provide a sampling device that will cut the entire flow of aggregate being fed from the cold aggregate bin in an acceptable manner, as described in the Aggregate Class Workbook.

COLLECTOR/WEIGH BELT

At a dryer-drum plant, samples of the combined aggregates are taken from either the collector belt or the weigh-belt conveyor. As shown in Figure 2.3, aggregate deposited from each cold belt feeder is dropped onto a collector belt that collects the aggregate discharged from each of the bins. The speed of the collector belt, which is located beneath all of the individual cold feed conveyors, is constant. The material on the collector belt is transferred to the weigh belt.

The weigh belt conveyor, as shown in Figure 2.5, includes a gravity belt take-up, a weigh bridge, and a belt speed sensor. The gravity belt take-up keeps a constant tension on the belt when it is operating. The weigh bridge consists of a load cell or torsion system that monitors the weight of material going over the weigh bridge. The belt speed sensor determines the rate that the belt is traveling.

Signals from both the load cell or torsion system and the belt speed sensor are sent to the control console. This information is then used to determine the correct amount of asphalt, mineral filler, and any additive that is fed into the drum mixer.

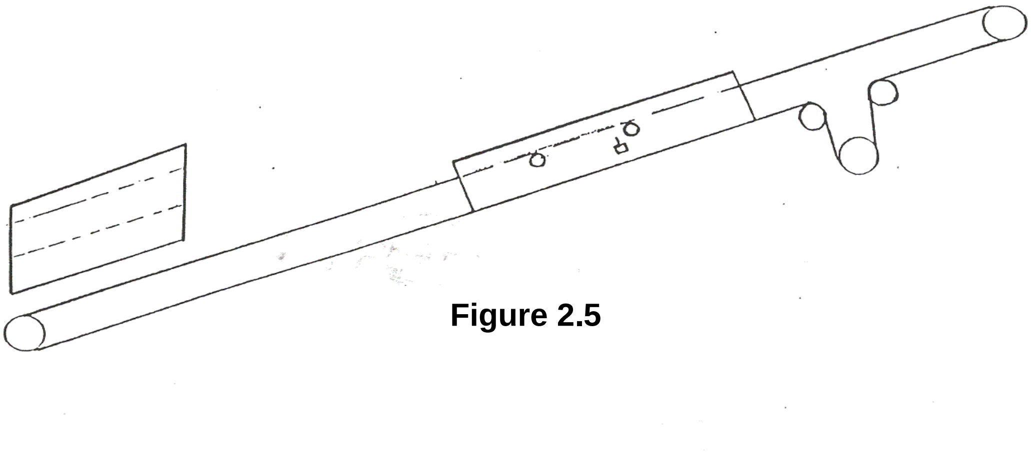


Figure 2.5

The following sampling procedures may be used for **collector/weigh belt sampling:**

A. On-Belt

The On-Belt procedure uses a light-weight, two-sided template which has the same contour shape of the belt. The distance between the two sides of the template should be adjustable. Normal distance is 18 inches. As detailed in the Aggregate Class Workbook, all the aggregate, including fines, is scraped and brushed off of the belt and into a sample pan. The contractor shall provide a platform in order to obtain these samples. The plant is required to stop three (3) times in a 15 minute period in order to obtain the representative sample.

B. Belt Stream

Stopping the plant three (3) times in a 15 minute period is inconvenient for the plant operator and generally promotes inconsistency in the HMA product. Therefore, the normal means of obtaining this combined aggregate sample without stopping the plant would be belt stream sampling.

Belt stream sampling, requires passing a sampling device through the entire stream of aggregate from outside the stream on one side to outside the stream on the other side. This will be done at least three (3) times over a 15 minute sampling period to obtain a representative sample.

In addition, the contractor could also implement automatic sampling devices for combined aggregate samples. This would allow the plant to continually run while obtaining the sample without personnel being present. If this option is implemented, IDOT would have to approve the automatic sampling device prior to production.

DRYER

After the aggregate has been fed from the aggregate feeders it is then deposited into the dryer where it is dried and heated to the required temperature. At a drum plant, the aggregate is dried for the first 2/3 of the drum and the asphalt and mineral filler are injected approximately 2/3 of the way down the drum where they are mixed with the dried aggregate and discharged as a finished product (HMA) at the end of the drum.

SCREENS AND HOT BINS

SCREEN DECK ARRANGEMENT

At a batch plant, the heated dried aggregate is discharged from the dryer and elevated to the screen deck. The screen deck, as shown in Fig. 2.6 will separate the aggregate into various hot-bins. The gradation of aggregate in each hot bin is dependent upon the screen size above the bin.

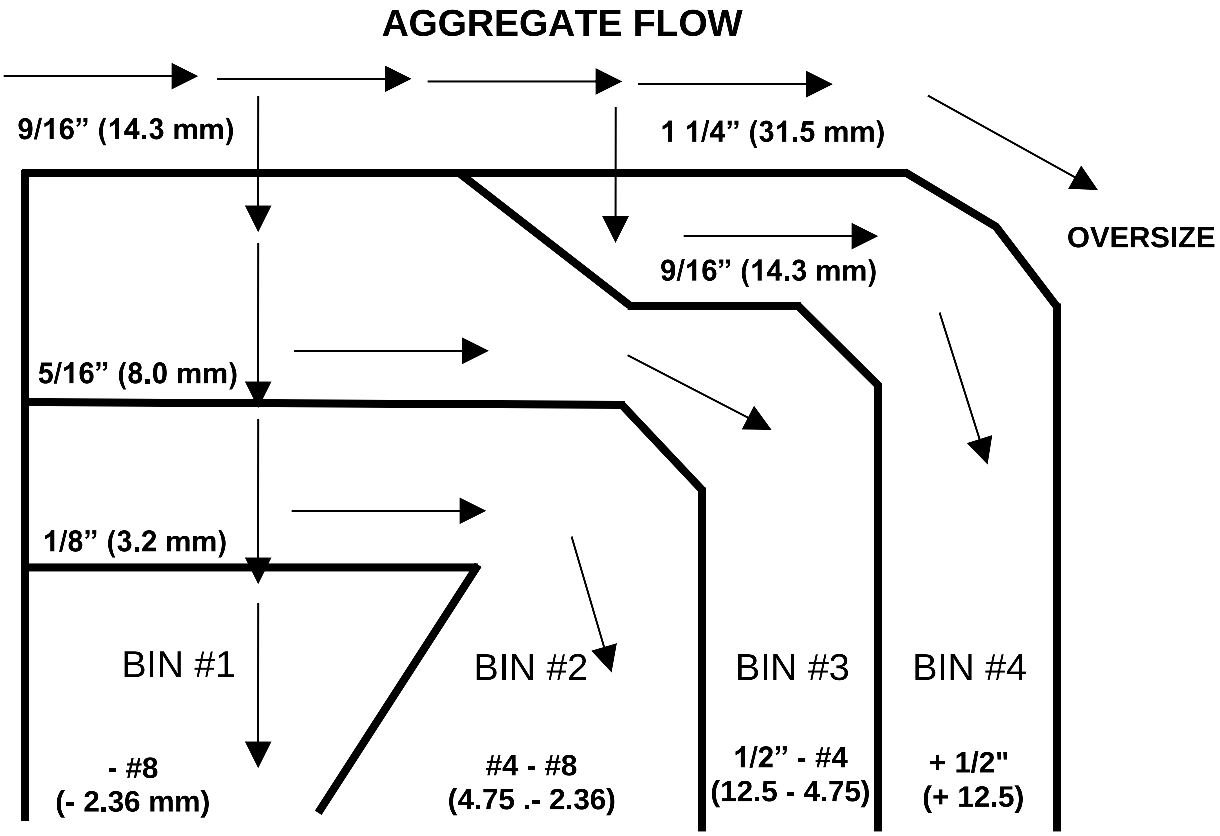


Figure 2.6

SEGREGATION AND SAMPLING

Segregation is the accumulation of coarse or fine particles in one area. Segregation can and does exist in hot bins, where the extra fine particles pass through the screens very quickly and the larger particles pass through further down the screen (Fig. 2.7). For this reason, it is mandatory for the hot bin sampling pan to be as wide as the bin gate opening. Ideally, the aggregate should not overflow the sample pan. However, this is probably impossible (Fig. 2.8). The sampling pan should be inserted into its proper location, the hot-bin gate opened completely and closed immediately.

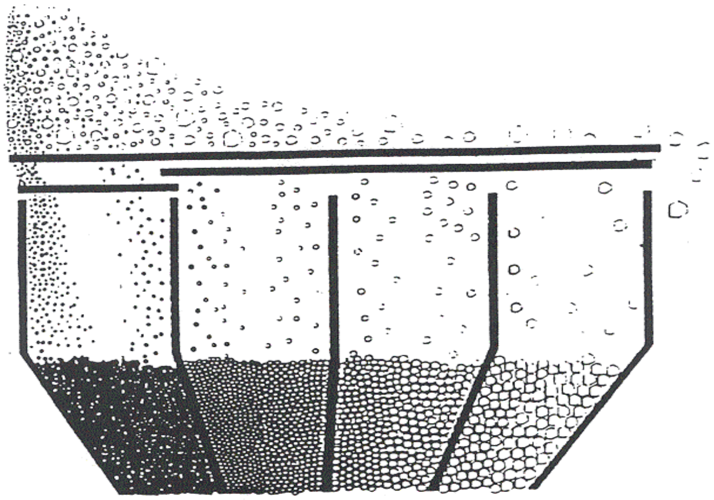


Figure 2.7 - Segregation of Materials in Hot Bins

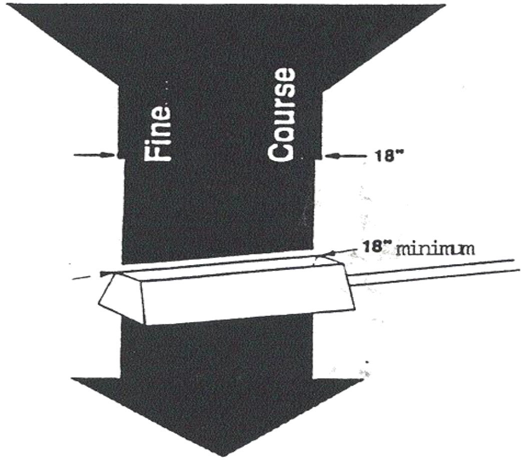


Figure 2.8 - Correct use of Sampling Device

This process shall be repeated until a minimum field sample size can be obtained from each hot bin according to the chart below. (Fig. 2.9)

The sampling pan shall be dumped into a bucket or other container for transporting to the aggregate splitting area. Care must be taken not to spill any of the aggregate when pouring into the bucket. The sample shall be split in accordance with the current aggregate workbook, to the required test size sample weight (Fig. 2.9). (Weight based on nominal aggregate size.)

HOT BIN SAMPLE SIZES

MINIMUM SAMPLE WEIGHTS

BIN	AGGREGATE SIZE	FIELD SAMPLE	TEST - SAMPLE
# 4	+ 1/2 (12.5 mm)	18 kg (40 lbs.)	3,000 gm
# 3	1/2 - #4 (12.5 - 4.75 mm)	16 kg (35 lbs.)	2,000 gm
# 2	#4 - #8 (4.75 - 2.3 mm)	11 kg (25 lbs.)	500 gm
# 1	- 8 (- 2.36 mm)	11 kg (25 lbs.)	500 gm

Figure 2.9

Surge and Storage Silos

PURPOSE

The main purpose of a silo (Fig. 2.10) on a batch plant is to allow the plant to maintain production while trucks are not available to load-out from the pugmill. For a dryer-drum mix plant, the primary purpose of the silo is to connect a continuous mixing operation into an intermittent truck loading process and to hold the mix temporarily until the next truck is available.

Figure 2.10

DRAG SLAT CONVEYOR

A variety of conveying devices are used to transport the hot-mix asphalt from the discharge chute on the dryer-drum mixer or from the hopper under the pug mill of a batch plant to the surge silo. Of the conveying devices, the drag slat conveyor is the most popular, as shown in Figure 2.10. In this system, a continuous set of flights connected together by a drag chain pull the mix up an inclined metal conveyor to a silo.

BATCHER (GOB HOPPER)

The most effective means to reduce segregation is to employ a temporary holding hopper or batcher at the top of the silo to temporarily store the mix being carried by the conveying device. This hopper, shown in Figure 2.11, collects the continuous flow of mix. When the gob hopper is nearly full the hopper gates open and the mix is dropped into the silo as a mass. The mix will hit the bottom of the empty silo or the top of mix already in the silo. Upon contact, the mix will splatter in all directions uniformly, reducing segregation.

SURGE VERSUS STORAGE

A silo is generally termed a surge silo when the silo is used to store asphalt mix between the arrivals of trucks at the plant. A storage silo is a silo which is employed to hold the asphalt mix for a long period of time. A storage silo can easily be used as a surge silo; however, a surge silo may not be suitable for use as a storage silo.

Differences between a surge and storage silo:

- The capacity of a storage silo is typically greater than a surge silo.
- The storage silo is always insulated and usually heated while the surge silo is usually insulated but not heated.
- The gates at the bottom of the storage silo are heated and sealed while the gates of a surge silo are not normally heated and sealed.

SURGE BIN

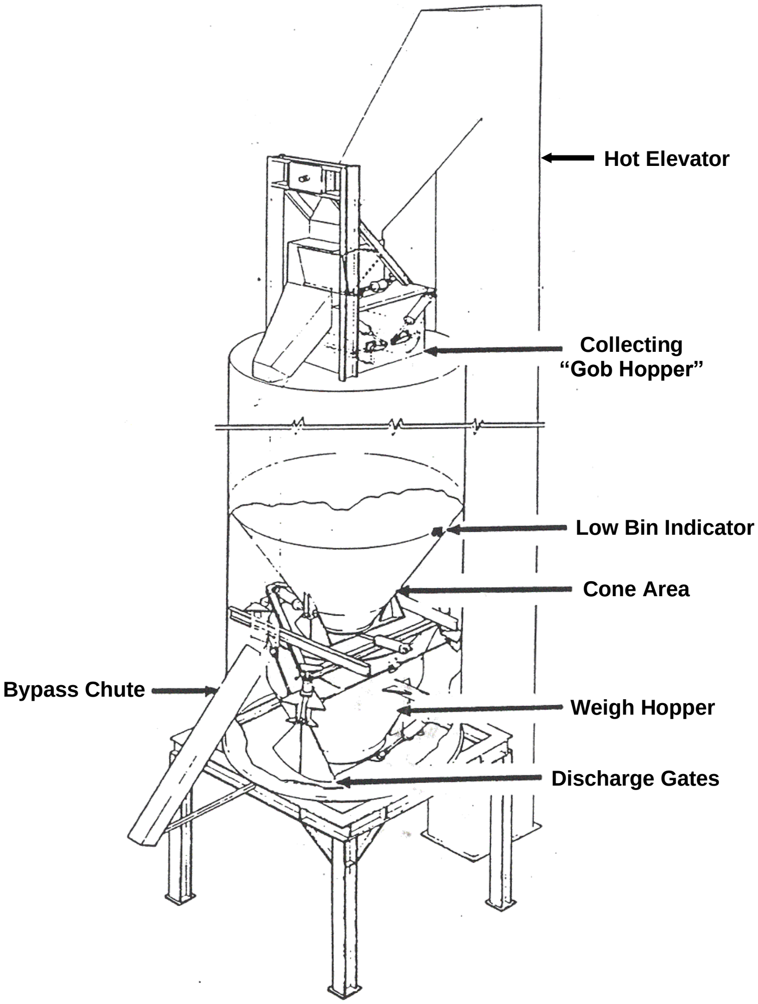


Figure 2.11

Loading and Segregation

SEGREGATION

If all the mix is dropped into the hauling vehicle in one drop from the silo (Fig. 2.12) segregation of the coarser aggregate particles can occur. When the mix is placed in the center of the truck bed, the material builds a conical-shaped pile. The sides of the truck restrict the growth of the pile thus allowing bigger particles to roll toward the front and the tailgate of the truck. This will produce segregation in the mat behind the lay down machine at the end of each truck load.

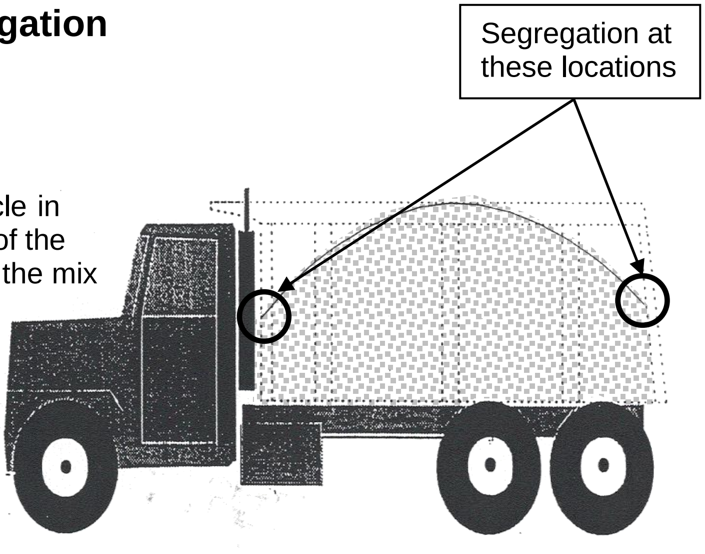


Figure 2.12

Illinois Department of Transportation recommends dividing the load-out of the asphalt mix from the silo into the truck into multiple drops (at least 3), each delivered to a different section of the bed of the truck to alleviate any segregation problem. The first drop should be placed into the center of the front half of the truck. The truck should then be pulled forward so that the second drop can be deposited into the center of the back half of the bed, near the tailgate. The truck should then be moved backwards so the remaining drop can be placed into the center of the bed between the first two silo drops. This loading sequence is shown in Figure 2.13.

If larger trucks are used for hauling of the mixture the number of drops should be increased to distribute the material along the length of the truck. In no case shall the mix be loaded into a truck moving forward under the silo as the mix is being discharged. This will increase the amount of coarse aggregate particles collecting at the tailgate end, thus increasing the amount of segregation.

Minimum Segregation in Truck

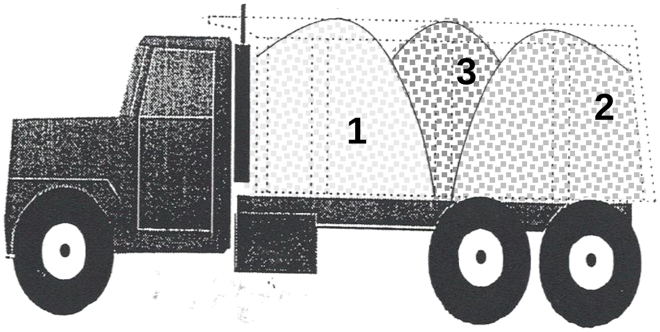


Figure 2.13

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Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling
Appendix E.4

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Revised Date: December 1, 2021

Hot-mix asphalt (HMA) samples shall be obtained at the frequency specified in the Standard Specification Article 1030.07 for mixtures using Pay for Performance (PFP) criteria and 1030.08 for mixtures using Quality Control for Performance (QCP) criteria.

The jobsite mixture samples shall be taken at randomly selected test locations within each sublot. Prior to paving, the random test locations will be determined by the Engineer using the “Random Numbers” table as specified herein or the Department’s Quality Management Program (QMP) Package software. The values are to be considered confidential and are not to be disclosed to anyone outside of the Department prior to the truck containing the random tonnage arriving at the jobsite. Disclosing the information would violate the intent of this procedure and federal regulations.

The sample location will be determined by calculating the longitudinal distance the truck delivering the random sample tonnage would travel to discharge the random sample tonnage. The starting station for the longitudinal distance measurement is the location of the paver where the truck begins to unload the mixture into the paver or Material Transfer Device (MTD). Computations are made to the nearest 1 ft (300 mm) (see examples in the appendix herein). In the event the job site conditions pose a safety risk, the Engineer will adjust the random test location to the nearest safe location. Unsafe conditions include: intersections, narrow or restricted areas such as underpasses, on interchange ramps within 100 ft (30 m) of an access controlled highway, or any other situation deemed unsafe.

If the paving is completed for a mixture before the specified sampling test location for the last mixture sublot is completed, a sample will not be taken and the tonnage will be added to the previous lot.

The Contractor may select either sampling behind the paver or sampling from the MTD discharge chute. The Contractor shall provide the necessary equipment and HMA Level I personnel to obtain the required samples, for whatever method is chosen, as specified herein.

A. Behind the Paver Sampling.

This method covers the procedures for sampling HMA mixtures at the point of delivery immediately behind the paver and before initial compaction. This method is intended to provide a single composite sample that is representative of the mixture as produced (i.e. excludes paver effects).

1. Equipment.

    a) IDOT Approved Sampling Shovel (Figure 1).

    b) Sample Containers (4 each). Metal sample buckets with a minimum capacity of 3.5 gal (13 L).

    c) IDOT Approved HMA Sample Splitter.

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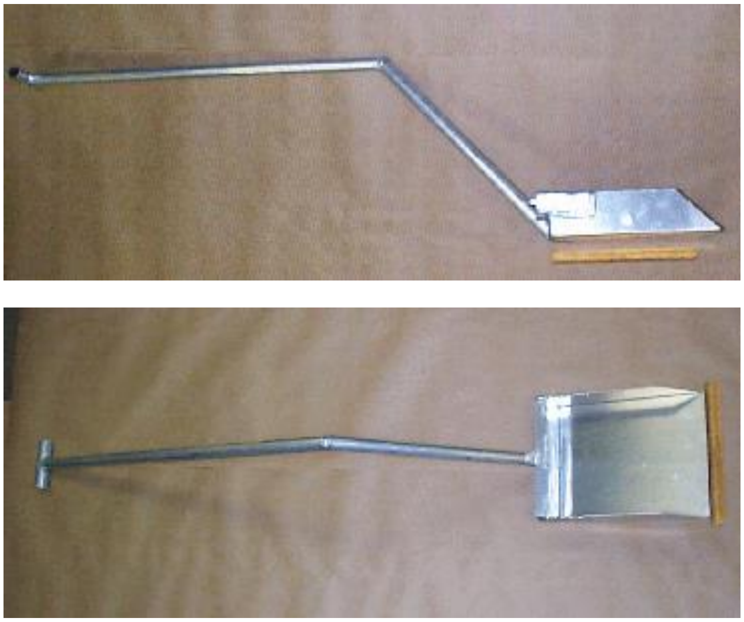
d) Plate/Shovel Sampling. The following additional equipment is needed when sampling HMA placed directly over a milled surface, rubblized concrete or an aggregate base.

1) Sampling Plates (4 each). The sampling plates shall be rectangular and have a minimum size of 14 x 28 in. (360 x 720 mm). Plates shall have a hole approximately 0.25 in. (6 mm) in diameter drilled through each of the four corners.

2) Lifting Handles and Wire Lead. A 24 in. (600 mm) length of wire shall be attached to the two holes on one side of the plate to serve as a lifting handle. An additional wire lead shall be attached to one of the lifting handles for locating the buried plate in the pavement. This wire shall extend to the edge of the pavement.

3) Hammer and masonry nails for securing plates and wire lead.



Overall Length = 5 ft (1.5 m)
Shovel Width = 10 in. (255 mm)
Shovel Length = 12 in. (305 mm)
Shovel Sides = 4 in. (100 mm)

Figure 1. Aluminum Sampling Shovel & Dimensions

2. Shovel Sample Sampling Procedure (Without Plates). This method shall be used when sampling over smooth HMA and concrete surfaces.

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a) The sampling shovel shall be used at each of the four offsets illustrated in Figure 2. to dig directly downward into the HMA behind the paver until it comes into contact with the previous pavement surface. When in contact, the shovel shall be pushed forward until it is full. The shovel shall be lifted up slowly. The mix shall be carefully placed into the sample container in order to prevent any loss of HMA.

3. Shovel/Plate Sampling Procedure (With Plates). This method shall be used when sampling HMA directly over aggregate base, stabilized subbase, rubblized concrete, or a milled surface. This method may not be appropriate for a 3/4 in. (19 mm) binder lift over a milled surface. In the case of IL-4.75 or IL-9.5 FG mixtures, if approved by the Engineer, these mixtures may be shovel sampled from the auger area at the designated random location. Intentions of sampling IL-4.75 or IL-9.5 FG mixtures in this manner shall be listed in the approved QC Plan.

   a) Each plate with the wire lead attached to the handle shall be placed at one of four positions at the designated location ahead of the paver according for Figure 2. If conditions on the project require restricting movement of the plate, a nail shall be driven through one of the holes in the plate and into the pavement.

   b) The wire lead shall be extended beyond the edge of the pavement. Trucks, pavers, and/or material transfer devices will be allowed to cross over the plate and/or wire lead.

   c) After the HMA is placed, the wire lead shall be used to locate the plate. Once located, the wire handles shall be lifted out of the pavement. This will locate the four corners of the plate.

   d) Once the plate edges are defined, the shovel shall be used to dig downward through the thickness of the HMA behind the paver until it is in contact with the plate. The shovel shall be pushed forward until it is full. The shovel shall be lifted up slowly. The mix shall be carefully placed into the sample container in order to prevent any loss of HMA.

   e) Remove the sampling plates from the pavement.

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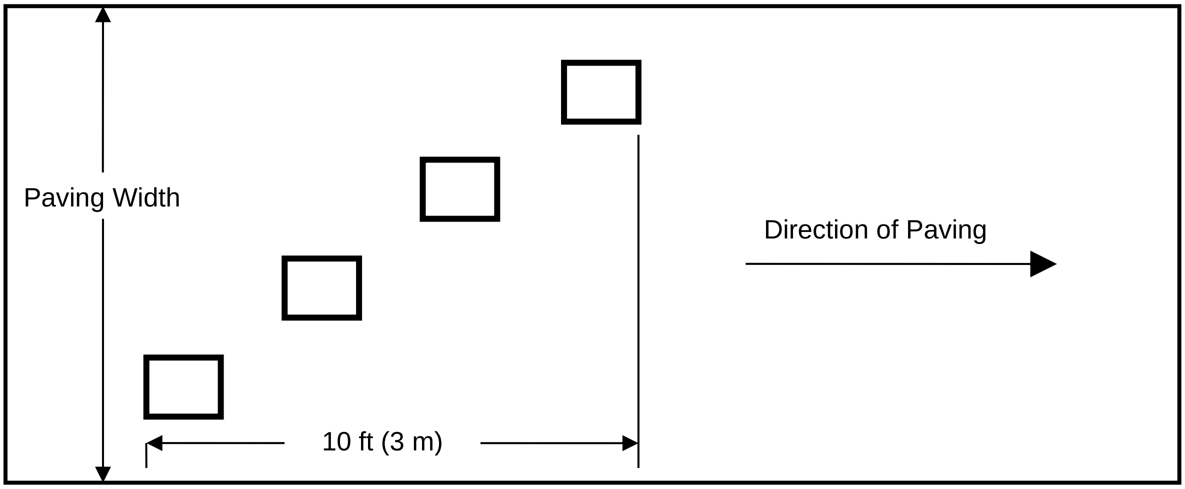

Figure 2. Behind the Paver Sampling Layout

4. Composite/Lab Samples.

   a) HMA samples shall be taken, blended and split, using an IDOT approved HMA splitter, onsite by the Contractor and witnessed by the Engineer. The sample shall be taken immediately behind the paver and before initial roller compaction. One composite sample consists of four increments collected within 10 ft (3 m) longitudinally and diagonally across the width of the paving operation (Fig. 2). The four increments shall be blended according to HMA Level I procedures to provide a single composite sample.

   b) Composite Sample.

      PFP and QCP. A composite sample size shall be a minimum of 200 lb (90 kg).

   c) Lab Sample.

      PFP and QCP. The minimum lab sample size of 50 lb (23 kg) shall be obtained by splitting the composite samples into four equal lab samples using an IDOT approved HMA splitter. The Engineer will secure three Department lab samples for the Contractor to transport to the District Materials Laboratory.

5. Sample Site Repair.

   a) HMA from the paver auger system shall be used to fill the voids left in the pavement from sampling. To reduce segregation and low density in the finished mat, buckets shall be used to fill the voids left by the samples.

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1) HMA from the augers system shall be placed in clean metal buckets just prior to sampling the pavement.

2) The metal buckets shall be filled with approximately 25% more HMA than will be removed from the voids.

b) The buckets shall be dumped directly over the voids.

c) The HMA shall be slightly leveled to provide a gradual hump over the filled voids to allow compression of the mix by the roller.

d) Unacceptable site repair shall be removed and replaced at the Contractor’s expense.

B. MTD Sampling.

This method covers the procedures for sampling HMA paving mixtures at the point of delivery from a material transfer device (MTD).

1. Equipment.

a) MTD Sampling Device. A portable device mounted either in the bed of a pickup truck or on a trailer. The device shall be equipped with a funnel large enough to capture the full stream of HMA from the MTD discharge chute without spillage and shall be capable of capturing a minimum composite sample. See Figures 3, 4, and 5 for illustrations of various MTD sampling device configurations.

b) Sample Containers – Metal containers each capable of holding a minimum of 50 lb (23 kg) of HMA.

2. MTD Sampling Procedure.

The Engineer will identify the truck containing the sample tonnage immediately prior to sampling. Immediately after the truck containing the random HMA tonnage has finished unloading, the MTD shall pull forward away from the paver far enough to allow the sampling device to be positioned under the MTD discharge chute. The sampling device shall be positioned as level as possible in a safe location readily accessible by the MTD. The MTD shall discharge without spillage a minimum of 200 lb (90 kg) of HMA for PFP and QCP into the funnel of the sampling device.

3. Composite/Lab Sample.

a) Composite Sample. HMA from all four sample containers of the sampling device shall be blended into one composite sample and split to lab sample size by the Contractor onsite using an IDOT approved HMA splitter. The blending and splitting shall be according to HMA Level I procedures and will be witnessed by the Engineer.

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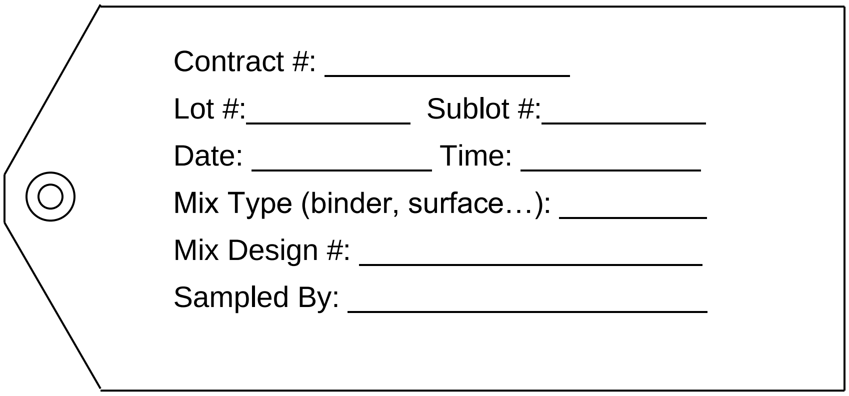
b) Lab Sample.

PFP and QCP. The minimum lab sample size of 50 lb (23 kg) shall be obtained by splitting the composite samples into four equal lab samples using an IDOT approved HMA splitter. The Engineer will secure three Department lab samples for the Contractor to transport to the District Materials Laboratory.

C. Documentation – After the sample has been obtained, the following information shall be written on each sample bag or box with a felt tip marker.



Contract #: ________________
Lot #:___________ Sublot #:___________
Date: ____________ Time: ____________
Mix Type (binder, surface…): __________
Mix Design #: ______________________
Sampled By: _______________________

D. Sample Security – Each sample bag will be secured by the Engineer using a locking ID tag. Sample boxes will be sealed/taped using a security ID label.

E. Sample Transportation – The Contractor shall deliver the secured sample to the District Laboratory, during regular working hours, within two days of sampling.

F. Examples:

1. Behind Paver Sampling. Determination of random sample locations for behind the paver sampling.

   This example illustrates the determination of the random behind the paver test location within a sublot:

   Given: A surface mix with a design G_{mb} of 2.400 is being placed 12 feet wide and 1.5 inches thick. The Engineer has determined all the undisclosed random tonnages prior to production. The plan quantity on the project was 10,000 tons and enough random values were determined to allow for a 5% overrun assuring enough random tonnages were generated. Discard any overrun random tonnages if the placed tonnage on the project is less than the calculated tonnage.

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Sublot Number	Random Number	Sublot Tonnage	Cumulative Job Tonnage
1	0.1669	167	167
2	0.5202	520	1520
3	0.3000	300	2300
4	0.6952	695	3695
5	0.4472	447	4447
6	0.2697	270	5270
7	0.5367	537	6537
8	0.7356	736	7736
9	0.4045	405	8405
10	0.3356	336	9336
11	0.0899	90	10090

The truck containing the mix representing the 167 ton shall be the first sublot tested. The truck in question contains 12 tons of mix, the 160 to 172 cumulative tons to be placed on the project. Determine the random location by dividing the value of the selected truck tonnage to determine the random distance value to 3 decimal places.

167 – 160 = 7 (where the random ton falls within the truck)

7/(172-160) = 7/12 = 0.583 (random distance value)

Determine the distance using 58.3% of the distance the mix in the truck will pave out using the following formula:

$$Longitudinal\ Distance = \frac{384.6 \times Tons \times RD}{Gmb \times width \times thickness}$$

Where:

Longitudinal Distance = random distance from starting station (ft)
Tons = total tons within the sample truck
RD = random distance value as calculated above
G_{mb} = design G_{mb} for the mix being placed
Width = width of mat being paved (ft)
Thickness = thickness of mat being paved (in.)

$$Longitudinal\ Distance = \frac{384.6 \times 12 \times .583}{2.400 \times 12 \times 1.5}$$

Longitudinal Distance = 62.3 ft = 62 ft

Measure the calculated longitudinal distance from the starting station where the truck began to unload. Determine and document the random sample station and obtain the random mix sample as outlined herein.

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Starting Station = 105+00
Random Sample Location = 105+00 + 62 = 105+62

This process shall be repeated for the subsequent sublots.

2. Examples of MTD Sampling Devices.

Figure 3. Example of MTD Sampling Device

Figure 4. Additional Examples of MTD Sampling Devices

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Figure 5. Additional Examples of MTD Sampling Devices

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Figure 6. Additional Examples of MTD Sampling Devices

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RANDOM NUMBERS

0.576	0.730	0.430	0.754	0.271	0.870	0.732	0.721	0.998	0.239
0.892	0.948	0.858	0.025	0.935	0.114	0.153	0.508	0.749	0.291
0.669	0.726	0.501	0.402	0.231	0.505	0.009	0.420	0.517	0.858
0.609	0.482	0.809	0.140	0.396	0.025	0.937	0.301	0.253	0.761
0.971	0.824	0.902	0.470	0.997	0.392	0.892	0.957	0.040	0.463
0.053	0.899	0.554	0.627	0.427	0.760	0.470	0.040	0.904	0.993
0.810	0.159	0.225	0.163	0.549	0.405	0.285	0.542	0.231	0.919
0.081	0.277	0.035	0.039	0.860	0.507	0.081	0.538	0.986	0.501
0.982	0.468	0.334	0.921	0.690	0.806	0.879	0.414	0.106	0.031
0.095	0.801	0.576	0.417	0.251	0.884	0.522	0.235	0.389	0.222
0.509	0.025	0.794	0.850	0.917	0.887	0.751	0.608	0.698	0.683
0.371	0.059	0.164	0.838	0.289	0.169	0.569	0.977	0.796	0.996
0.165	0.996	0.356	0.375	0.654	0.979	0.815	0.592	0.348	0.743
0.477	0.535	0.137	0.155	0.767	0.187	0.579	0.787	0.358	0.595
0.788	0.101	0.434	0.638	0.021	0.894	0.324	0.871	0.698	0.539
0.566	0.815	0.622	0.548	0.947	0.169	0.817	0.472	0.864	0.466
0.901	0.342	0.873	0.964	0.942	0.985	0.123	0.086	0.335	0.212
0.470	0.682	0.412	0.064	0.150	0.962	0.925	0.355	0.909	0.019
0.068	0.242	0.777	0.356	0.195	0.313	0.396	0.460	0.740	0.247
0.874	0.420	0.127	0.284	0.448	0.215	0.833	0.652	0.701	0.326
0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.876	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.777	0.491	0.523	0.665	0.919	0.146
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.281	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.454	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.659	0.463	0.994	0.307	0.631	0.422
0.116	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939
0.636	0.195	0.614	0.486	0.629	0.663	0.619	0.007	0.296	0.456
0.630	0.673	0.665	0.666	0.399	0.592	0.441	0.649	0.270	0.612
0.804	0.112	0.331	0.606	0.551	0.928	0.830	0.841	0.702	0.183
0.360	0.193	0.181	0.399	0.564	0.772	0.890	0.062	0.919	0.875
0.183	0.651	0.157	0.150	0.800	0.875	0.205	0.446	0.648	0.685

Note: Always select a new set of numbers in a systematic manner, either horizontally or vertically. Once used, the set should be crossed out.

Illinois Department of Transportation

Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling
Appendix E.4

Effective Date: April 1, 2008
Revised Date: December 1, 2021

PFP/QCP Jobsite Sampling Location Determination

Date: ______________ Contract #: ______________ Route: ______________
HMA Mix #: ______________ HMA Mix Code: ______________ HMA Desc.: ______________
Design G_{mb}: ______________ Pvt width(w): ______________ Pvt thickness(t): ______________

Lot #:		Sublot #:		Sampling Tonnage (st):	

Begin Truck Tons (b):		Longitudinal Distance(d): $(d)=[384.6(q)(rd)] / [G_{mb}(w)(t)]$	
End Truck Tons (e):		Starting Station(ss):	
Tons in Truck (q): *(q)=(e)-(b)*		Random sample location(rl): *(rl)=(ss)+/-(d)* *{add or subtract if up/down sta.}*	
Random Truck distance(rd): *(rd)=[(st)-(b)]/(q)*			

Lot #:		Sublot #:		Sampling Tonnage (st):	

Begin Truck Tons (b):		Longitudinal Distance(d): $(d)=[384.6(q)(rd)] / [G_{mb}(w)(t)]$	
End Truck Tons (e):		Starting Station(ss):	
Tons in Truck (q): *(q)=(e)-(b)*		Random sample location(rl): *(rl)=(ss)+/-(d)* *{add or subtract if up/down sta.}*	
Random Truck distance(rd): *(rd)=[(st)-(b)]/(q)*			

Lot #:		Sublot #:		Sampling Tonnage (st):	

Begin Truck Tons (b):		Longitudinal Distance(d): $(d)=[384.6(q)(rd)] / [G_{mb}(w)(t)]$	
End Truck Tons (e):		Starting Station(ss):	
Tons in Truck (q): *(q)=(e)-(b)*		Random sample location(rl): *(rl)=(ss)+/-(d)* *{add or subtract if up/down sta.}*	
Random Truck distance(rd): *(rd)=[(st)-(b)]/(q)*			

Lot #:		Sublot #:		Sampling Tonnage (st):	

Begin Truck Tons (b):		Longitudinal Distance(d): $(d)=[384.6(q)(rd)] / [G_{mb}(w)(t)]$	
End Truck Tons (e):		Starting Station(ss):	
Tons in Truck (q): *(q)=(e)-(b)*		Random sample location(rl): *(rl)=(ss)+/-(d)* *{add or subtract if up/down sta.}*	
Random Truck distance(rd): *(rd)=[(st)-(b)]/(q)*			

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Hot-Mix Asphalt PFP and QCP Random Plant Samples
Appendix E.2

Effective Date: May 1, 2008
Revised Date: December 1, 2021

Samples shall be obtained at the frequencies specified in the Standard Specification Articles 1030.07 and 1030.08 for PFP and QCP, respectively.

A. The samples shall be taken at the randomly selected tonnage within a sublot. The random tonnage will be determined by the Engineer using the “Random Numbers” table as specified herein or the Department’s Quality Management Program (QMP) Package software. The tonnage shall be calculated according to the following:

1. Unless otherwise known, determine the random locations for a tonnage in excess of five percent over plan quantity by multiplying the plan quantity tonnage by 1.05 to determine an over-projected final quantity. If the over-projected final quantity is not achieved, disregard the additional random values.

2. Determine the maximum number of sublots needed for the given mixture by dividing the over-projected tonnage calculated above by the sublot size in tons (metric tons) (typically 1,000 tons). Round this number to the next whole value. This will determine the maximum number of sublots for the given mixture.

3. Multiply the sublot tonnage by a three-digit random number, expressed as a decimal. The number obtained (rounded to a whole number) shall be the random sampling tonnage within the given sublot.

4. The individual sublot random tonnages shall then be converted to cumulative random tonnages. This is accomplished by using the following equation for each sublot.

$$\mathrm{CT}_n = [(ST) \text{ x } (n-1)] + \mathrm{RT}_n$$

Where: n = the sublot number
CT = Cumulative tonnage
RT = Random tonnage as determined in #3 above
ST = Sublot tonnage

B. If paving is completed for a particular mixture before the specified sampling tonnage for the last sublot is achieved, the last sublot shall be omitted.

C. Samples shall be taken out of trucks at the plant. The truck containing the random tonnages will be determined by the Engineer following the procedure described herein. Two sampling platforms (one on each side of the truck) shall be provided for sampling of the mix. In order to obtain a representative sample of the entire truck load, an equal amount of material shall be taken from each quarter point around the circumference of each pile in the truck to obtain a composite sample weighing approximately 200lb (95 kg). All material shall be obtained by using a "D"-handled, square-ended shovel with built-up sides and back (1 to 1.5 in. [25 to 38 mm]). The sample tonnage will be disclosed no more than 30 minutes prior to sampling. Sampling shall be performed by the Contractor under the supervision of the Engineer.

Illinois Department of Transportation

Hot-Mix Asphalt PFP and QCP Random Plant Samples
Appendix E.2

Effective Date: May 1, 2008
Revised Date: December 1, 2021

D. The truck sample shall be divided into three approximately equal size (split) samples by the use of an approved mechanical sample splitter. The Engineer will witness all splitting. Two split samples for Department testing shall be placed in Department-approved sample containers provided by the Contractor and identified as per the Engineer's direction. The Engineer will gain immediate possession of both Department split samples. The Contractor may store, discard, or test the remaining split sample as described in Section 1030 of the Standard Specifications. However, the Contractor must test and provide the sample results in order to initiate the dispute resolution process as described in the Hot-Mix Asphalt Pay for Performance Special Provision.

Example:

Given: Plan quantity = 10,000 tons for a given mixture. Sublot = 1,000 tons.

1. Determine the over-projected final tonnage.

   10,000 tons x 1.05 = 10,500 tons

2. Determine the maximum number of sublots needed for the project based on the over-projected tonnage.

   10,500 tons/1,000 tons = 10.5 (Note: Always round up)
   Therefore, a maximum of 11 sublots

3. Obtain random numbers from the table and apply a different random number to each sublot.

   1000 x 0.546 = 546
   1000 x 0.123 = 123

   Repeat for **each** sublot.

4. Convert **individual** tonnages to cumulative job tonnage.

   [1,000 x (1-1)] + 546 = 546
   [1,000 x (2-1)] + 123 = 1,123

   Repeat for each sublot.

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Hot-Mix Asphalt PFP and QCP Random Plant Samples
Appendix E.2

Effective Date: May 1, 2008
Revised Date: December 1, 2021

The following contains a completed table for the 11 plant random samples:

Lot Number	Sublot Number	Random Number	Tonnage within Sublot	Cumulative Job Tonnage
1	1	0.546	1000 x 0.546 = 546	[1000 x (1-1)] + 546 = 546
	2	0.123	1000 x 0.123 = 123	[1000 x (2-1)] + 123 = 1123
	3	0.789	1000 x 0.789 = 789	[1000 x (3-1)] + 789 = 2789
	4	0.372	1000 x 0.372 = 372	[1000 x (4-1)] + 372 = 3372
	5	0.865	1000 x 0.865 = 865	[1000 x (5-1)] + 865 = 4865
	6	0.921	1000 x 0.921 = 921	[1000 x (6-1)] + 921 = 5921
	7	0.037	1000 x 0.037 = 37	[1000 x (7-1)] + 37 = 6037
	8	0.405	1000 x 0.405 = 405	[1000 x (8-1)] + 405 = 7405
	9	0.214	1000 x 0.214 = 214	[1000 x (9-1)] + 214 = 8214
	10	0.698	1000 x 0.698 = 698	[1000 x (10-1)] + 698 = 9698
	11	0.711	1000 x 0.711 = 711	[1000 x (11-1)] + 711 = 10711

If paving is completed prior to production of the 10,711 ton of mixture, the 11th sublot is omitted.

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Hot-Mix Asphalt PFP and QCP Random Plant Samples
Appendix E.2

Effective Date: May 1, 2008
Revised Date: December 1, 2021

RANDOM NUMBERS

0.576	0.730	0.430	0.754	0.271	0.870	0.732	0.721	0.998	0.239
0.892	0.948	0.858	0.025	0.935	0.114	0.153	0.508	0.749	0.291
0.669	0.726	0.501	0.402	0.231	0.505	0.009	0.420	0.517	0.858
0.609	0.482	0.809	0.140	0.396	0.025	0.937	0.301	0.253	0.761
0.971	0.824	0.902	0.470	0.997	0.392	0.892	0.957	0.040	0.463
0.053	0.899	0.554	0.627	0.427	0.760	0.470	0.040	0.904	0.993
0.810	0.159	0.225	0.163	0.549	0.405	0.285	0.542	0.231	0.919
0.081	0.277	0.035	0.039	0.860	0.507	0.081	0.538	0.986	0.501
0.982	0.468	0.334	0.921	0.690	0.806	0.879	0.414	0.106	0.031
0.095	0.801	0.576	0.417	0.251	0.884	0.522	0.235	0.389	0.222
0.509	0.025	0.794	0.850	0.917	0.887	0.751	0.608	0.698	0.683
0.371	0.059	0.164	0.838	0.289	0.169	0.569	0.977	0.796	0.996
0.165	0.996	0.356	0.375	0.654	0.979	0.815	0.592	0.348	0.743
0.477	0.535	0.137	0.155	0.767	0.187	0.579	0.787	0.358	0.595
0.788	0.101	0.434	0.638	0.021	0.894	0.324	0.871	0.698	0.539
0.566	0.815	0.622	0.548	0.947	0.169	0.817	0.472	0.864	0.466
0.901	0.342	0.873	0.964	0.942	0.985	0.123	0.086	0.335	0.212
0.470	0.682	0.412	0.064	0.150	0.962	0.925	0.355	0.909	0.019
0.068	0.242	0.777	0.356	0.195	0.313	0.396	0.460	0.740	0.247
0.874	0.420	0.127	0.284	0.448	0.215	0.833	0.652	0.701	0.326
0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.876	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.777	0.491	0.523	0.665	0.919	0.146
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.281	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.454	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.659	0.463	0.994	0.307	0.631	0.422
0.116	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939
0.636	0.195	0.614	0.486	0.629	0.663	0.619	0.007	0.296	0.456
0.630	0.673	0.665	0.666	0.399	0.592	0.441	0.649	0.270	0.612
0.804	0.112	0.331	0.606	0.551	0.928	0.830	0.841	0.702	0.183
0.360	0.193	0.181	0.399	0.564	0.772	0.890	0.062	0.919	0.875
0.183	0.651	0.157	0.150	0.800	0.875	0.205	0.446	0.648	0.685

Note: Always select a new set of numbers in a systematic manner, either horizontally or vertically. Once used, the set should be crossed out.

BLENDING

After the sample has been obtained and prior to splitting into individual test portions, the mix must be blended together. The mix shall be blended by use of a sample splitter into two pans. The mix in the two pans must be reintroduced through the splitter, a minimum of five times for binder and 3 times for surface mixes. After each split, one of the pans must be turned end for end (180°) before being re-blended.

WD-40 should never be used for lubricating splitter and pans. Stuck asphalt can be *removed* using WD-40.

VISUAL OBSERVATION

It is the responsibility of the Contractors quality control personnel to conduct a periodic visual inspection of the hot-mix asphalt in the trucks prior to transit to the job site. The technician should inspect for the following:

Segregation in the truck beds

Uncoated material

Dry appearance and/or brownish in color

Mix temperature

Excessive moisture

For Quality Control, if any of the aforementioned are deemed to be excessive or out of specification, an immediate investigation is warranted. It will be the responsibility of the Quality Control Manager (Level II), to decide if the truck load(s) should be rejected.

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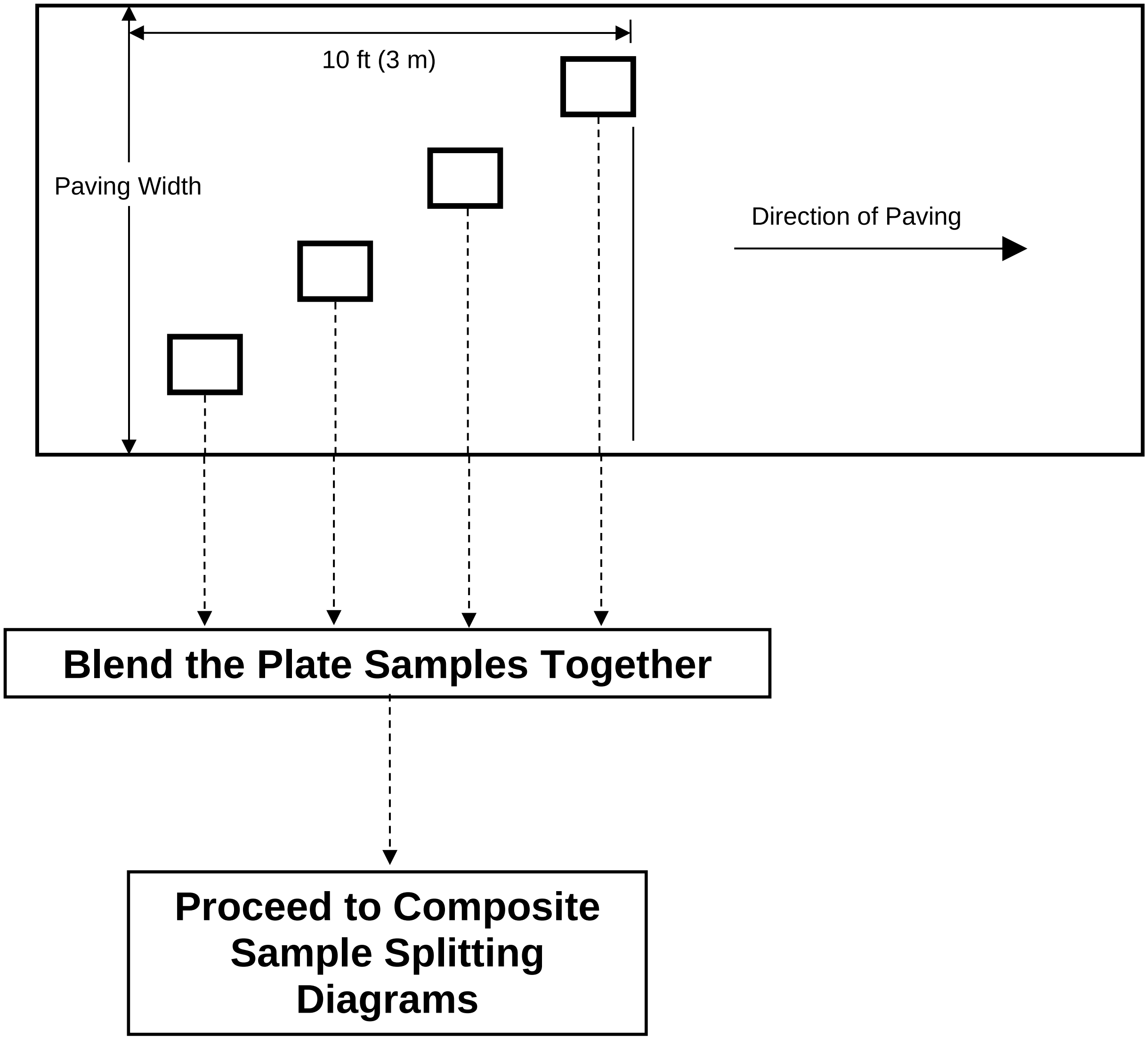
Hot-Mix Asphalt Composite Sample Blending and Splitting Diagrams
Appendix B.14

Effective Date: January 1, 2002
Revised Date: December 1, 2021

1. Plate Sample Blending

Minimum Total Weight Requirements

- *100 lb. (45 kg.) (QC/QA Verification)*
- *200 lb. (91 kg.) (QCP/PFP)*



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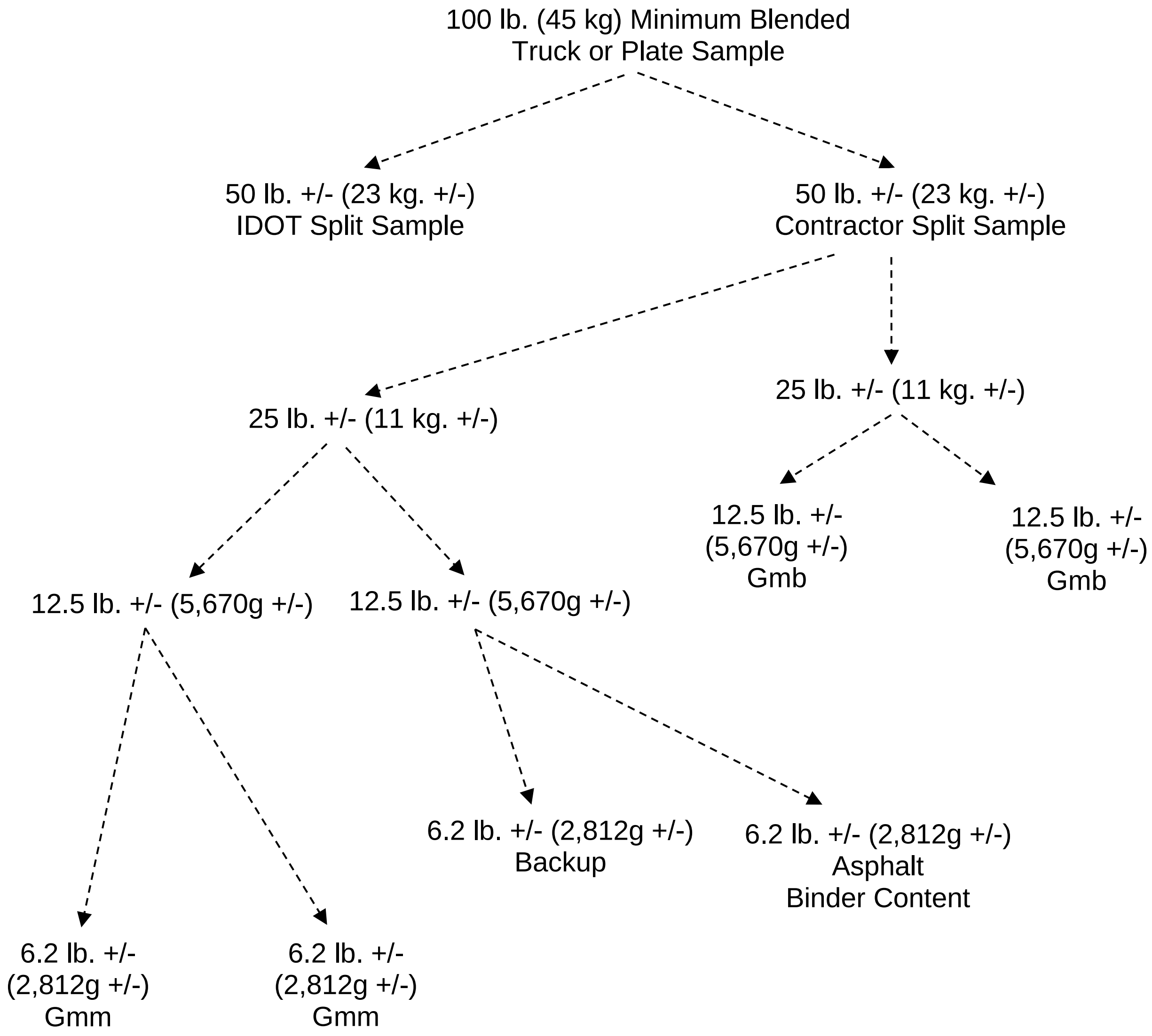
Hot-Mix Asphalt Composite Sample Blending and Splitting Diagrams
Appendix B.14

Effective Date: January 1, 2002
Revised Date: December 1, 2021

2. QC/QA Verification Composite Sample Splitting



<u>50 lb. (23 kg.) Sample Produces:</u>
2 – Bulk Specific Gravity (Gmb)
2 – Max. Specific Gravity (Gmm)
1 – Asphalt Binder Content (AB %)
1 – Backup

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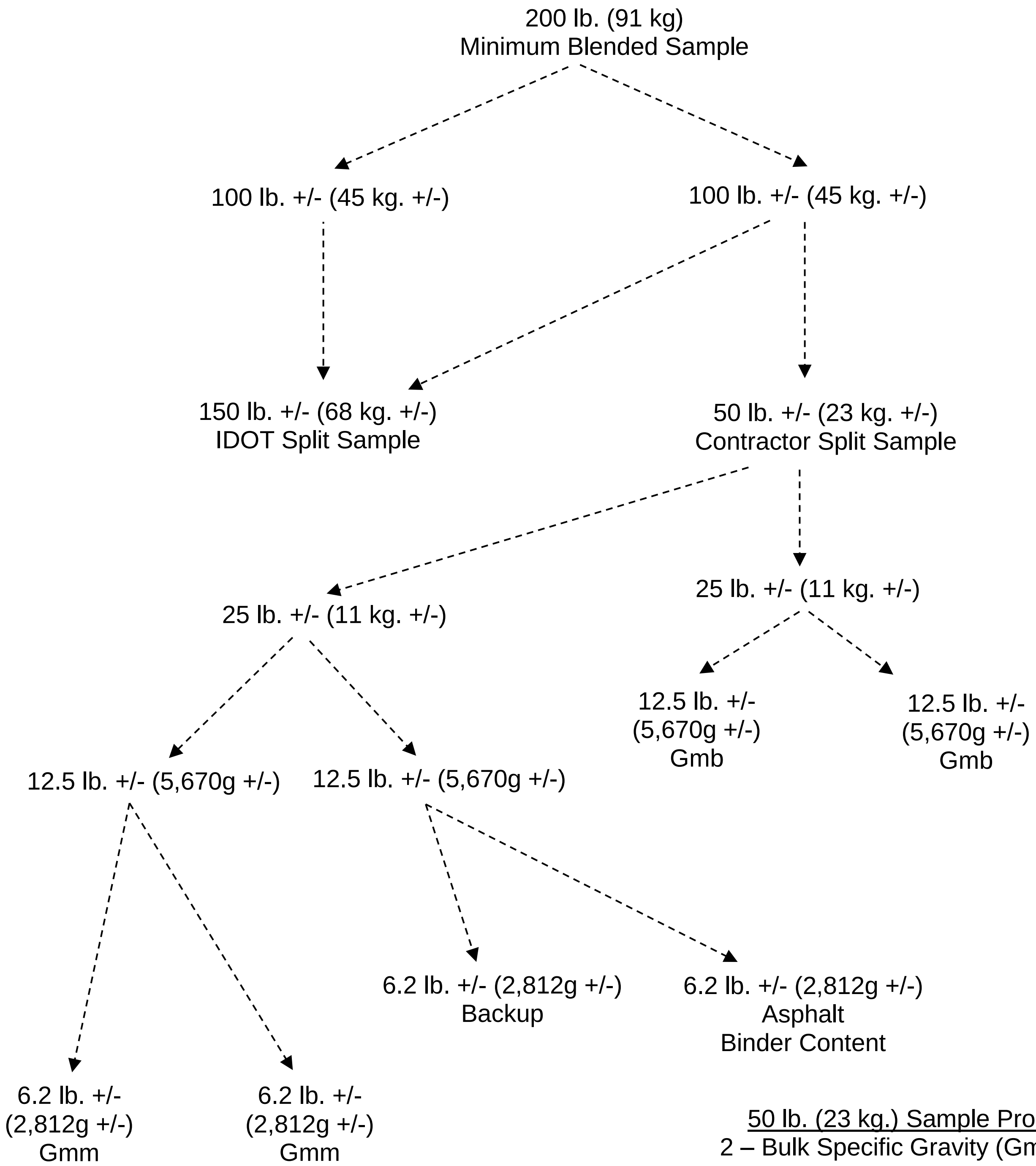
Hot-Mix Asphalt Composite Sample Blending and Splitting Diagrams
Appendix B.14

Effective Date: January 1, 2002
Revised Date: December 1, 2021

3. QCP/PFP Composite Sample Splitting



<u>50 lb. (23 kg.) Sample Produces:</u>
2 – Bulk Specific Gravity (Gmb)
2 – Max. Specific Gravity (Gmm)
1 – Asphalt Binder Content (AB %)
1 – Backup

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INITIAL DAILY AND RANDOM SAMPLES (QC/QA)

Illinois Department of Transportation

Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples
Appendix B6

Effective: May 1, 1993
Revised: December 1, 2022

Initial Daily Plant and Random Samples shall be obtained at the frequencies specified in Standard Specifications Article 1030.09. The initial daily quality control (QC) mixture sample shall be taken at the plant and the second QC daily sample, if required, shall also be collected at the plant. The Department's verification mixture samples will be taken at the jobsite, except for mixtures used in patching and paving less than 3 ft (1 m) wide where it will be taken at the plant.

A. The QC mixture sample shall be taken from a truck at the plant. Two sampling platforms (one on each side of the truck) shall be provided for sampling of the mix. In order to obtain a representative sample of the entire truck, an equal amount of material shall be taken from each quarter point around the circumference of each pile in the truck to obtain a composite sample weighing approximately 100 lb (45 kg). All truck samples shall be obtained by using a "D"-handled, square-ended shovel with built-up sides and back (1 to 1½ in. [25 to 37.5 mm]). The composite sample shall be blended and split to lab sample size using an IDOT approved HMA splitter. The blending and splitting shall be according to HMA Level I procedures.

B. Starting with the first day of production (excluding a test strip), the initial daily QC mixture sample shall be obtained between the first ½ to 1½ hours of daily production of a particular mixture according to Article 1030.09(a)(2).

C. The second daily QC mixture sample, if required, shall be taken at a randomly selected time within the third quarter of the anticipated production day as determined by the Contractor using the "Random Numbers" table on the following page or the Department's Quality Management Program (QMP) Package software. The anticipated full production day shall be the time from ½ hour after production begins to ½ hour before production ends. The following procedure shall be used to calculate the second daily QC mixture sampling time.

1. Multiply the quarter production day (in minutes) by a three-digit random number, expressed as a decimal, selected from the "Random Numbers" table or the Department's QMP Package software.

2. The number obtained (rounded to a whole number) shall be added to the starting time of the third quarter. The time represented by this addition is the randomly selected sampling time.

   If the plant is producing HMA mixtures intermittently, the samples shall be taken as close to the determined time as possible.

The tests completed by the Contractor on the second daily QC mixture sample shall be according to Article 1030.09(a)(2).

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Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples
Appendix B6

(continued)
Effective: May 1, 1993
Revised: December 1, 2022

D. Department Random Verification Mixture Sample Determination and Collection.

The verification mixture sample will be collected at a randomly selected tonnage as specified in Article 1030.09(h). The Engineer will determine the location of the random verification mixture sample using the “Random Numbers” table as specified herein or the Department’s QMP Package software. The plan quantities will be used for each mixture unless there is significant change during construction at which time the new quantity will be used in the calculation.

1. The Engineer will multiply the plan quantity by a three digit random number, expressed as a decimal, selected from the "Random Numbers" table or the Department's QMP Package software.

2. The number obtained (rounded to a whole number) is the randomly selected ton to be sampled.

3. This ton will be used to identify the truck containing the mixture to be sampled. For jobsite sampling, the Engineer will estimate the location this mixture will be placed to identify the location of plate sampling.

   The values are to be considered confidential and are not to be disclosed to anyone outside of the Department until after the truck containing the random verification mixture has been produced.

Mixtures used for patching, paving applications placed with a road widener, paving applications less than 1,320 ft (400 m) in length, and handwork shall be sampled from the truck at the plant by the Contractor following the same procedure used to collect QC mixture samples (section A). This process will be witnessed by the Engineer who will take custody of the verification sample.

For all other mixture applications, the Contractor may select either sampling behind the paver or sampling from the MTD discharge chute for jobsite sampling. The Contractor shall provide the necessary equipment and HMA Level I personnel to obtain the required samples, for whatever method is chosen, as specified herein. In the event the job site conditions pose a safety risk, the Engineer will adjust the random test location to the nearest safe location. Unsafe conditions include: intersections, narrow or restricted areas such as underpasses, on interchange ramps within 100 ft (30 m) of an access controlled highway, or any other situation deemed unsafe.

1. Behind Paver Sampling.

   This method covers the procedures for sampling HMA paving mixtures at the point of delivery immediately behind the paver and before initial compaction. This method is intended to provide a single composite sample that is representative of the mixture as produced (i.e. excludes paver effects).

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Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples
Appendix B6

(continued)
Effective: May 1, 1993
Revised: December 1, 2022

a. Equipment

1) IDOT Approved Sampling Shovel (Fig. 1).

2) Sample Containers - four (4) each. Metal sample buckets with a minimum capacity of 3.5 gal (13 L).

3) IDOT Approved HMA Sample Splitter.

4) Plate/Shovel Sampling. The following additional equipment is needed when sampling HMA placed directly over a milled surface, rubblized concrete or an aggregate base.

   i. Sampling Plates - four (4) each. The sampling plates shall be rectangular and have a minimum size of 14 x 28 in. (360 x 720 mm). Plates shall have a hole approximately 0.25 in. (6 mm) in diameter drilled through each of the four corners.

   ii. Lifting Handles and Wire Lead. A 24 in. (600 mm) length of wire shall be attached to the two holes on one side of the plate to serve as lifting handle. An additional wire lead shall be attached to one of the lifting handles for locating the buried plate in the pavement. This wire shall extend to the edge of the pavement.

   iii. Hammer and masonry nails for securing plates and wire lead.

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Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples
Appendix B6

(continued)
Effective: May 1, 1993
Revised: December 1, 2022

Overall Length = 5 ft (1.5 m)
Shovel Width = 10 in. (255 mm)
Shovel Length = 12 in. (305 mm)
Shovel Sides = 4 in. (100 mm)

Figure 1. Aluminum Sampling Shovel & Dimensions

b. Shovel Sample Sampling Procedure (Without Plates). This method shall be used when sampling over smooth HMA and concrete surfaces.

  1) The sampling shovel shall be used at each of the four offsets illustrated in Figure 2. to dig directly downward into the HMA behind the paver until it comes into contact with the previous pavement surface. When in contact, the shovel shall be pushed forward until it is full. The shovel shall be lifted up slowly. The mix shall be carefully placed into the sample container in order to prevent any loss of HMA.

c. Shovel/Plate Sampling Procedure (With Plates). This method shall be used when sampling HMA directly over aggregate base, stabilized subbase, rubblized concrete, or a milled surface. This method may not be appropriate for a 3/4 in. (19 mm) binder lift over a milled surface. In the case of IL-4.75 or IL-9.5 FG mixtures, if approved by the Engineer, these mixtures may be shovel sampled from the auger area at the designated random location. Intentions of sampling IL-4.75 or IL-9.5 FG mixtures in this manner shall be listed in the approved QC Plan.

  1) Each plate with the wire lead attached to handles shall be placed at four locations at the designated random location ahead of the paver according to Figure 2. If conditions on the project require restricting movement of the plate, a nail shall be driven through one of the holes in the plate and into the pavement.

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Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples
Appendix B6
(continued)
Effective: May 1, 1993
Revised: December 1, 2022

2) The wire lead shall be extended beyond the edge of the pavement. Trucks, pavers, and/or material transfer devices shall be allowed to cross over the plate and/or wire lead.

3) Immediately after the HMA is placed by the paver and before the initial roller compaction, the wire lead shall be used to locate the plate. Once located, the wire handles shall be lifted out of the pavement. This will locate the four corners of the plate.

4) Once the plate edges are defined, the shovel shall be used to dig downward through the thickness of the HMA behind the paver until it is in contact with the plate. The shovel shall be pushed forward until it is full. The shovel shall be lifted up slowly. The mix shall be carefully placed into the sample container in order to prevent any loss of HMA.

5) Remove the sampling plates from the pavement.

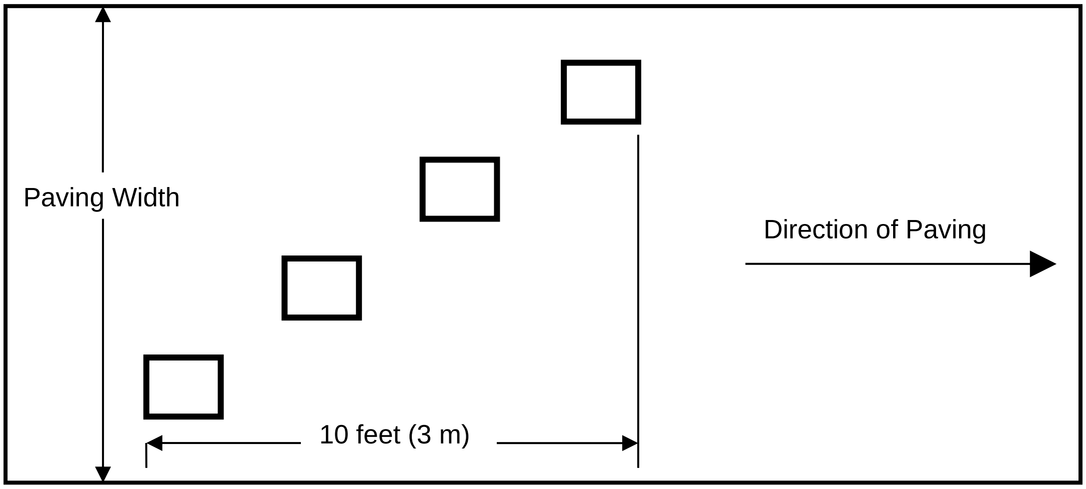

Figure 2. Behind the Paver Sampling Layout

d. Composite Sample.

1) The HMA samples in the containers shall be blended and split, using an IDOT approved HMA splitter, onsite by the Contractor and witnessed by the Engineer. One composite sample consists of four increments collected within 10 ft (3 m) longitudinally and diagonally across the width of the paving operation (Fig. 2). The four increments shall be blended according to HMA Level I procedures to provide a single composite sample.

Illinois Department of Transportation

Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples
Appendix B6

(continued)
Effective: May 1, 1993
Revised: December 1, 2022

2) Composite/Lab Samples.

   i. A composite sample size shall be approximately 150 lb (70 kg) and a minimum of 100 lb (45 kg), allowing 50 lb (23 kg) for District testing, and 50 lb (23 kg) for Contractor testing.

   ii. The minimum lab sample size of 50 lb (23 kg) shall be obtained by splitting the composite samples into two equal lab samples using an IDOT approved HMA splitter. The Engineer will secure the Department lab sample for the Contractor to transport to the District Materials Laboratory.

e. Sample Site Repair.

1) HMA from the paver auger system shall be used to fill the voids left in the pavement from sampling. To reduce segregation and low density in the finished mat, buckets shall be used to fill the voids left by the samples.

   i. HMA from the augers system shall be placed in clean metal buckets just prior to sampling the pavement.

   ii. The metal buckets shall be filled with approximately 25% more HMA than will be removed for the composite sample.

2) The buckets shall be dumped directly over the void.

3) The filled void shall have a thickness greater than the surrounding HMA to allow compaction of the mix by the roller(s).

4) Unacceptable site repair shall be removed and replaced at the Contractor’s expense.

2. MTD Sampling.

This method covers the procedures for sampling HMA paving mixtures at the point of delivery from a material transfer device (MTD).

1) Equipment.

   1) MTD Sampling Device. A portable device mounted either in the bed of a pickup truck or on a trailer. The device shall be equipped with a funnel

large enough to capture the full stream of HMA from the MTD discharge chute without spillage and shall be capable of capturing a minimum composite sample. See Figures 3, 4 and 5 for illustrations of various MTD sampling device configurations.

2) Sample Containers – Metal containers each capable of holding a minimum of 50 lb (23 kg) of HMA.

b. MTD Sampling Procedure.

The Engineer will identify the truck containing the sample tonnage. Immediately after the truck containing the random HMA tonnage has finished unloading, the MTD shall pull forward away from the paver far enough to allow the sampling device to be positioned under the MTD discharge chute. The sampling device shall be positioned as level as possible in a safe location readily accessible by the MTD. The MTD shall discharge without spillage approximately 150 lb (70 kg) and a minimum of 100 lb (45 kg) into the funnel of the sampling device.

c. Composite Sample.

1) Composite Sample. HMA from all four sample containers of the sampling device shall be blended into one composite sample and split to lab sample size by the Contractor onsite using an IDOT approved HMA splitter. The blending and splitting shall be according to HMA Level I procedures and will be witnessed by the Engineer. A composite sample size shall be approximately 150 lb (70 kg) and a minimum of 100 lb (45 kg), allowing 50 lb (23 kg) for District testing, and 50 lb (23 kg) for Contractor testing.

The minimum lab sample size of 50 lb (23 kg) shall be obtained by splitting the composite samples into two equal lab samples using an IDOT approved HMA splitter. The Engineer will secure the Department lab sample for the Contractor to transport to the District Materials Laboratory.

d. Documentation.

After the sample has been obtained, the following information shall be written on each sample bag or box with a felt tip marker.

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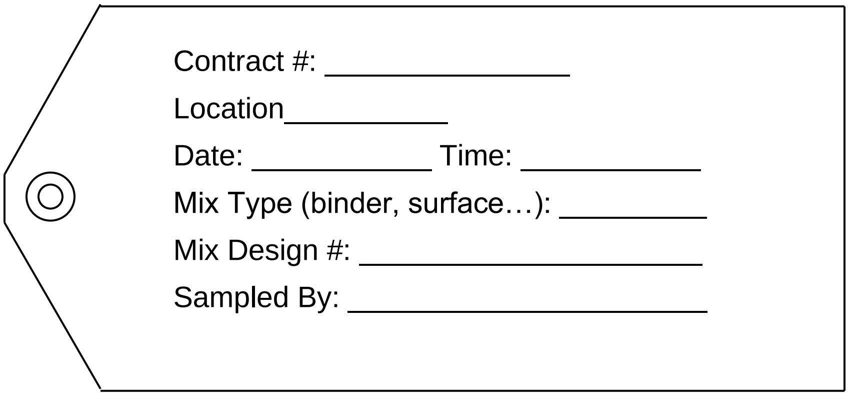

Contract #: ________________
Location___________
Date: ____________ Time: ____________
Mix Type (binder, surface…): __________
Mix Design #: _______________________
Sampled By: ________________________

e. Sample Security.

Each sample bag with a Department verification mixture sample will be secured by the Engineer using a locking ID tag.

Sample boxes containing the Department's verification mixture sample will be sealed/taped using a security ID label.

f. Sample Transportation.

The Contractor shall deliver the secured Department verification mixture samples to the district laboratory, during regular working hours, within two days of sampling.

g. Testing.

The Contractor shall and the Department will complete testing on the split verification mixture samples as described in 1030.09(g) and 1030.09(h).

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Figure 3. Example of MTD Sampling Device

Figure 4. Additional Examples of MTD Sampling Devices

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Figure 5. Additional Examples of MTD Sampling Devices

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(continued)
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Revised: December 1, 2022

RANDOM NUMBERS

0.576	0.730	0.430	0.754	0.271	0.870	0.732	0.721	0.998	0.239
0.892	0.948	0.858	0.025	0.935	0.114	0.153	0.508	0.749	0.291
0.669	0.726	0.501	0.402	0.231	0.505	0.009	0.420	0.517	0.858
0.609	0.482	0.809	0.140	0.396	0.025	0.937	0.301	0.253	0.761
0.971	0.824	0.902	0.470	0.997	0.392	0.892	0.957	0.040	0.463
0.053	0.899	0.554	0.627	0.427	0.760	0.470	0.040	0.904	0.993
0.810	0.159	0.225	0.163	0.549	0.405	0.285	0.542	0.231	0.919
0.081	0.277	0.035	0.039	0.860	0.507	0.081	0.538	0.986	0.501
0.982	0.468	0.334	0.921	0.690	0.806	0.879	0.414	0.106	0.031
0.095	0.801	0.576	0.417	0.251	0.884	0.522	0.235	0.389	0.222
0.509	0.025	0.794	0.850	0.917	0.887	0.751	0.608	0.698	0.683
0.371	0.059	0.164	0.838	0.289	0.169	0.569	0.977	0.796	0.996
0.165	0.996	0.356	0.375	0.654	0.979	0.815	0.592	0.348	0.743
0.477	0.535	0.137	0.155	0.767	0.187	0.579	0.787	0.358	0.595
0.788	0.101	0.434	0.638	0.021	0.894	0.324	0.871	0.698	0.539
0.566	0.815	0.622	0.548	0.947	0.169	0.817	0.472	0.864	0.466
0.901	0.342	0.873	0.964	0.942	0.985	0.123	0.086	0.335	0.212
0.470	0.682	0.412	0.064	0.150	0.962	0.925	0.355	0.909	0.019
0.068	0.242	0.777	0.356	0.195	0.313	0.396	0.460	0.740	0.247
0.874	0.420	0.127	0.284	0.448	0.215	0.833	0.652	0.701	0.326
0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.876	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.777	0.491	0.523	0.665	0.919	0.146
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.281	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.454	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.659	0.463	0.994	0.307	0.631	0.422
0.116	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939
0.636	0.195	0.614	0.486	0.629	0.663	0.619	0.007	0.296	0.456
0.630	0.673	0.665	0.666	0.399	0.592	0.441	0.649	0.270	0.612
0.804	0.112	0.331	0.606	0.551	0.928	0.830	0.841	0.702	0.183
0.360	0.193	0.181	0.399	0.564	0.772	0.890	0.062	0.919	0.875
0.183	0.651	0.157	0.150	0.800	0.875	0.205	0.446	0.648	0.685

Note: Always select a new set of numbers in a systematic manner, either horizontally or vertically. Once used, the set should be crossed out.

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HOT-MIX ASPHALT QC/QA
INITIAL DAILY and RANDOM SAMPLES

Example of initial daily plant and random sample:

The plant is expecting to produce mix from 5:30am to 5:00pm and **0.772** is the next random number.

Time frame for the initial daily sample of the day would be (first sample)? ________________

Steps for calculating random sampling time:

A. How many minutes in an anticipated day? ______________

B. How many minutes in each quarter of the anticipated day?

______min/day ÷ 4 quarters/day = ______min/quarter

______min is equal to ______hours______min

C. What would be the beginning and ending times for each quarter?

1st Quarter ________ to ________

2nd Quarter ________ to ________

3rd Quarter ________ to ________

4th Quarter ________ to ________

D. Number of min/quarter ______ x next random number ______ = ______min. into 3rd Quarter

E. The start time of the 3rd Quarter (from Section C) added to the calculated minutes into the 3rd Quarter (from Section D) gives you the random sample time.

________________ + _____________ = _____________________
(Start of 3rd Quarter) **(min)** **(Random Sample Time)**

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INGREDIENTS OF HOT-MIX ASPHALT MIXTURES (HMA)

Hot-Mix Asphalt (HMA) is typically comprised of approximately 95% aggregate and 5% asphalt cement By Total Weight of Mixture (BTWM). The aggregate, which is typically a continuous gradation, provides the load bearing capacity. The asphalt cement holds the aggregate particles in place while making the finished pavement flexible and impermeable to water.

This chapter provides information on origination, properties, and classifications of aggregates and asphalt cement used in Hot-Mix asphalt. Occasionally, Hot-Mix Asphalt may contain additives such as modifiers or anti-stripping agents, which are beyond the scope of this course.

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AGGREGATES

INTRODUCTION

Hot-Mix Asphalt (HMA) is typically made up of 90 - 95% aggregate by weight. Therefore, the success of a Hot-Mix asphalt pavement is highly dependent on the aggregate characteristics.

The intent of this section is not to reiterate the information presented in the Aggregate Technician Course, but rather to address specific aspects of aggregates as they relate to Hot-Mix asphalt used in Illinois Department of Transportation (IDOT) paving projects.

SOURCES

Aggregates used in IDOT Hot-Mix asphalt paving projects are classified as natural aggregates, processed aggregates, synthetic aggregates or recycled products.

A. Natural Aggregates

Natural Aggregates are aggregates that are used in their natural form, with little or no processing. They are made up of particles produced by a natural erosion and degradation process, such as the action of wind, water, moving ice, and chemicals. Glaciers, for example, often produce rounded boulders and pebbles. Similarly, flowing water produces smoothly rounded particles.

The two major types of natural aggregates used in pavement construction are gravel and sand. Gravel is usually defined as particles 4.75 mm (No. 4) or larger in size. Sand is defined as particles smaller than 4.75 mm (No. 4) but larger than 75µm (No. 200). Particles smaller than 75µm (No. 200) are considered fines, made up primarily of silt and clay.

B. Processed Aggregates

Processed aggregates are aggregates that have been crushed and screened in preparation for use. There are two basic sources of processed aggregates: natural gravels that are crushed to make them more suitable for use in asphalt pavement mixtures, and shot rock from a solid rock formation that must be crushed and reduced in size before being used for paving.

Rock is crushed for four reasons; to change the surface texture from smooth to rough, to change particle shape from round to angular, to improve quality, and to reduce and improve the distribution and range (gradation) of particle sizes.

C. Synthetic Aggregates

Synthetic or artificial aggregates do not exist in nature. They are the product of chemical or physical processing of materials. Some are by-products of industrial production processes such as ore refining; others are produced specifically for use as aggregate by raw materials. Some examples are:

(1) Air Cooled Blast-Furnace (ACBF) Slag

ACBF slag is a commonly used by-product aggregate. It is a non-metallic substance that rises to the surface of molten iron during the blast-furnace smelting process. When separated from the molten iron, the slag is reduced into small particles by either quenching it immediately in water or crushing it after it has cooled.

ACBF Slag has a low bulk specific gravity (approximately 2.0 - 2.2) and a high, variable absorption (2.0 - 6.0%).

(2) Steel Slag

Steel slag is also a commonly used by-product aggregate. It is a non-metallic substance that rises to the surface of molten steel during the smelting process in basic oxygen, open hearth, or electric arc furnaces. When separated from the molten steel, the slag is reduced into small particles either by quenching it immediately in water or crushing after it has cooled.

Steel slag has a high bulk specific gravity (approximately 2.9 - 3.4) and a high absorption (approximately 3.0 - 5.0%), that is less variable than ACBF slag. Steel slag also can be expansive due to the potential of having free Calcium Oxide (CaO) and Magnesium Oxide (MgO) present in the particles.

Both ACBF and steel slags have desirable friction properties and are, therefore, commonly used in Hot-Mix asphalt surface courses in high traffic areas.

D. Recycled Products

(1) Reclaimed Asphalt Pavement (RAP)

Reclaimed Asphalt Pavement (RAP). RAP is the material produced by cold milling or crushing an existing hot-mix asphalt (HMA) pavement. The Contractor shall supply written documentation that the RAP originated from roadways or airfields under federal, state, or local agency jurisdiction.

RAP Stockpiles. The Contractor shall construct individual RAP stockpiles meeting one of the following definitions. Stockpiles shall be sufficiently separated to prevent intermingling at the base. Stockpiles shall be identified by signs indicating the type as listed below (i.e.

"Homogeneous Surface"). Prior to milling, the Contractor shall request the Department provide documentation on the quality of the RAP to clarify the appropriate stockpile.

(a) Fractionated RAP (FRAP). FRAP shall consist of RAP from Class I, HMA (High and Low ESAL) mixtures. The coarse aggregate in FRAP shall be crushed aggregate and may represent more than one aggregate type and/or quality, but shall be at least C quality. FRAP shall be fractionated prior to testing by screening into a minimum of two size fractions with the separation occurring on or between the No. 4 (4.75 mm) and 1/2 in. (12.5 mm) sieves. Agglomerations shall be minimized such that 100 percent of the RAP in the coarse fraction shall pass the maximum sieve size specified for the mixture composition of the mix design.

(b) Homogeneous. Homogeneous RAP stockpiles shall consist of RAP from Class I, HMA (High and Low ESAL) mixtures and represent: 1) the same aggregate quality, but shall be at least C quality; 2) the same type of crushed aggregate (either crushed natural aggregate, ACBF slag, or steel slag); 3) similar gradation; and 4) similar asphalt binder content. If approved by the Engineer, combined single pass surface/binder millings may be considered "homogeneous" with a quality rating dictated by the lowest coarse aggregate quality present in the mixture.

(c) Conglomerate. Conglomerate RAP stockpiles shall consist of RAP from Class I, HMA (High and Low ESAL) mixtures. The coarse aggregate in this RAP shall be crushed aggregate and may represent more than oneaggregate type and/or quality, but shall be at least C quality. This RAP may have an inconsistent gradation and/or asphalt binder content prior to processing. Conglomerate RAP shall be processed prior to testing by crushing to where all RAP shall pass the 5/8 in. (16 mm) or smaller screen. Conglomerate RAP stockpiles shall not contain steel slag.

(d) Conglomerate "D" Quality (Conglomerate DQ). Conglomerate DQ RAP stockpiles shall be according to Articles 1031.02(a)(1) through 1031.02(a)(3), except they may also consist of RAP from HMA shoulders, bituminous stabilized subbases, or HMA (High or Low ESAL) binder mixture. The coarse aggregate in this RAP may be crushed or round but shall be at least D quality. This RAP may have an inconsistent gradation and/or asphalt binder content.

(e) Non-Quality. RAP stockpiles that do not meet the requirements of the stockpile categories listed above shall be classified as "Non-Quality".

RAP/FRAP containing contaminants, such as earth, brick, sand, concrete, sheet asphalt, non-bituminous surface treatment (i.e. high friction surface treatments), pavement fabric, joint sealants, plant cleanout, etc., will be unacceptable unless the contaminants are removed to the satisfaction of the Engineer. Sheet asphalt shall be stockpiled separately.

(2) Reclaimed Asphalt Shingles (RAS)

Reclaimed Asphalt Shingles (RAS). RAS is the material produced from the processing and grinding of preconsumer or post-consumer shingles. RAS shall be a clean and uniform material with a maximum of 0.5 percent unacceptable material by weight of RAS, as defined in Bureau of Materials Policy Memorandum, “Reclaimed Asphalt Shingle (RAS) Sources”. RAS shall come from a facility source on the Department’s “Qualified Producer List of Certified Sources for Reclaimed Asphalt Shingles” where it shall be ground and processed to 100 percent passing the 3/8 in. (9.5 mm) sieve and 93 percent passing the #4 (4.75 mm) sieve based on a dry shake gradation. RAS shall be uniform in gradation and asphalt binder content and shall meet the testing requirements specified herein. In addition, RAS shall meet the following Type 1 or Type 2 requirements

(a) Type 1. Type 1 RAS shall be processed, preconsumer asphalt shingles salvaged from the manufacture of residential asphalt roofing shingles.

(b) Type 2. Type 2 RAS shall be processed post-consumer shingles only, salvaged from residential, or four unit or less dwellings not subject to the National Emission Standards for Hazardous Air Pollutants (NESHAP).

PROPERTIES

A. Gradation

Hot-Mix asphalt specifications require aggregate particles to be within a certain range of sizes and for each size of particle to be present in a certain proportion. This distribution of various particle sizes within the aggregate used is called aggregate gradation or mix gradation. To determine whether an aggregate gradation meets specifications requires an understanding of how particle size and gradation are measured.

Mixture gradations must meet the gradations listed in Section 1030.04(a), Table 1, 2, 3 & 4 of the Standard Specifications for the various mixtures. Individual stockpile or shelf gradations must meet gradations listed in Sections 1003.01(c) and 1004.01(c) or as modified by the Aggregate Gradation Control System (QC/QA Masterband option).

Because specifications list a maximum particle size for each aggregate used, the size of the largest particles in the sample must be determined. There are two designations for maximum particle size:

- Maximum Size: One sieve larger than the nominal maximum size

- Nominal Maximum Size - One sieve larger than the first sieve to retain more than 10% cumulative.

Gradation is often considered to be the most important aggregate property because it affects many vital HMA properties. Gradation influences HMA stability, durability, permeability, and workability along with several other parameters which are beyond the scope of this course.

During the asphalt mixture design phase, a mix gradation is chosen which will provide a stable (typically dense graded) stone skeleton. This stone skeleton must have enough voids to allow room for a sufficient amount of liquid Asphalt Cement (AC) plus 4% air voids (to allow for expansion) after compaction using the gyratory compaction procedure. The total void space is referred to as Voids in the Mineral Aggregate (VMA). Minimum values of VMA are specified in Section 1030.04(b) 1, 2, 3 & 4 for the various mix types.

Changes in gradation can have significant effects on VMA. Therefore, it is of extreme importance to control the aggregate gradation during mix production. A gradation change, which lowers VMA, will result in a loss of air voids and cause the pavement to bleed and rut. Lowering the AC content to maintain the 4% air voids will cause an insufficient asphalt film thickness which results in oxidation and raveling.

B. Quality

Aggregates used in IDOT projects must meet various quality standards. Aggregates are tested to classify an aggregate as Class A, B, C, or D quality. “A” is the highest quality and “D” is the lowest. The quality requirements are listed in Sections 1003.01(b) and 1004.01(b) of the Standard Specifications. Some of the quality tests that are run are as follows:

Quality Tests:

- Sodium Sulfate (Na_2SO_4) Soundness (AASHTO T 104)
- Los Angeles Abrasion (AASHTO T 96)
- Minus 75µm (#200) Sieve Material (Illinois Modified AASHTO T11)
- Deleterious Materials
- Micro-Deval

(1) Sodium Sulfate (Na_2SO_4) Soundness Test is a measure of an aggregate's ability to resist disintegration caused by weathering.

(2) Los Angeles Abrasion Test is a procedure for testing various sizes of coarse aggregate for resistance to abrasion. Aggregates must be able to resist abrasion and degradation during manufacturing, placement, and compaction of the pavement mixture; and during the service life of the pavement under actual traffic. Aggregates at the pavement surface must be tougher (more abrasion resistant) than aggregates used in lower layers of the pavement structure.

(3) Minus 75µm (#200) Sieve Material is a washed gradation requirement.

(4) Deleterious Materials are unsuitable materials frequently found in aggregates in various amounts. Materials that are considered deleterious include vegetation, coal and lignite, soft and unsound particles, lumps of clay and shale. Excessive amounts of such material can have adverse effects on pavement performance.

(5) The Micro-Deval is used to test the resistance of fine/coarse aggregates to degradation by abrasion. This testing of fine/coarse aggregates determines their abrasion loss in the presence of water and an abrasive charge. Test results are helpful in judging the suitability of fine/coarse aggregates subject to weathering and abrasive action.

C. Absorption

All aggregates are porous, some more than others. How porous an aggregate is, determines how much liquid it absorbs when soaked in a bath.

The capacity of an aggregate to absorb water (or asphalt) is important information. If an aggregate is highly absorptive, it will continue to absorb asphalt after initial mixing at the plant, leaving less asphalt on its surface to bond aggregate particles together. Because of this, a porous aggregate requires significantly more asphalt to make a suitable mixture than a less porous aggregate does.

High porosity, highly absorptive aggregates are not used normally, unless they possess other characteristics that make them desirable despite their high absorptive capacity. Examples of such materials are blast-furnace slag, and other synthetic or manufactured aggregates, which are highly porous, but are also lightweight and abrasion-resistant.

D. Particle Shape

Particle shape influences the workability of the paving mix during placement, as well as the amount of force necessary to compact the mixture to the required density. During pavement life, particle shape also influences the strength of the pavement structure.

Because irregular, angular particles tend to interlock when compacted, they usually resist displacement (movement) in the final pavement. Effective interlocking is generally achieved with sharp-cornered, cubical-shaped particles, obtained by crushing. However, round particles such as those comprising most natural gravels and sands, are used successfully in asphalt paving mixtures, particularly dense-graded types.

Many asphalt pavement mixtures contain both angular and round particles. The coarse (large) aggregate particles are usually crushed stone or crushed gravel that give the pavement strength; the fine (small) aggregate particles are usually natural sand, which gives the mixture necessary workability.

E. Surface Texture/Friction

Surface texture of aggregate particles is another factor that determines not only the workability and final strength of a paving mixture, but also the skid resistant characteristics of the pavement surface. Some consider it more important than particle shape. A rough, sandpaper-like texture increases pavement strength because it prevents particles from moving easily past one another and provides a higher coefficient of surface friction for safer traffic operations.

In addition, asphalt films cling more readily to rough surfaces than to smooth ones. Because natural gravels usually have smooth surface textures, they are often crushed during processing. Crushing produces rough surface textures on the fractured faces, as well as changing particle shape.

There is no standard method for evaluating surface texture directly. Like particle shape, it is a characteristic reflected in mixture strength tests and in workability of the mixture during construction.

GENERAL

A. Coarse and Fine Aggregates

(1) Coarse Aggregate

Coarse aggregate refers to particles retained by the 2.36 mm (#8) sieve.

(2) Fine Aggregate

Fine aggregate refers to particles that pass through the 2.36 mm (#8) sieve.

(a) Mineral Filler is the portion of fine aggregate that passes the 600μm (#30) sieve.

(b) Mineral Dust is the portion of fine aggregate that passes the 75μm (#200) sieve.

B. Shelf Gradations

Shelf gradations are aggregate gradations which are routinely produced by an aggregate source. Shelf gradations used by IDOT are specified in Articles 1003.01(c) and 1004.01(c) of the Standard Specifications.

Commonly, several shelf gradation aggregates are combined in correct proportions to provide a desired asphalt mixture gradation (combined gradation).

C. AGCS Gradations with Band

Shelf gradations which are produced under the Department's Aggregate Gradation Control System (AGCS) include CA or CM 5, 7, 8, 11, 13, 14, & 16. Modifications, according to the Bureau of Materials & Physical Research Policy Memorandum "Aggregate Gradation Control System", may be made to the specified ranges for these aggregates when produced under AGCS. Under AGCS, these coarse aggregate shelf gradation have a specified critical sieve with a tighter tolerance requirement. Aggregate produced under the AGCS is a more uniform and an overall better product.

D. AGCS Gradations Without Band

Additional, Shelf gradations which are produced under the Department's Aggregate Gradation Control System (AGCS) include CA or CM 6, 10, 12 and FA 01, 02, 20, 21 & 22. These coarse and fine aggregate, shelf gradations **do not** have a specified critical sieve or tighter tolerance requirement.

MISTIC DESIGNATIONS

It is essential for the Level I Technician to understand the make-up of an aggregate material code. The aggregate material code is used repeatedly on various report forms. A thorough understanding of the MISTIC designations will enable the Level I Technician to glance at a material code and know immediately, the aggregate quality, type, classification, and gradation.

The following example illustrates how to read an aggregate material code.

Aggregate Material Codes						
Inspected Material	**Quality Level**	**Type of Material**	**Aggregate Type**	**Specification**	**Gradation Number**	**Superstructure Quality Concrete**
0 = Aggregates	0 = No Quality 1 = No Quality 2 = A quality 3 = B quality 4 = C quality 5 = D quality 6 = D Quality Stabilized	0 = Gravel 1 = Crushed Gravel 2 = Crushed Stone 3 = ACBF Slag 7 = Natural Sand 8 = Stone Sand 9 = Special Aggregate	C = Coarse Aggregate F = Fine Aggregate	A = Standard Specification M = Modified Specification	Standard Specifications Article 1003.01(C) or Article 1004.01(C)	01
Example: **032CM16**						
0 **Aggregate**	**3** **‘B’ Quality**	**2** **Crushed Stone**	**C** **Coarse Aggregate**	**M** **Modified Specification**	**16** **Gradation**	
A modified ‘B’ quality crushed stone coarse aggregate 16 gradation						
Class Example:						

DESCRIPTION OF MIXTURES

Bituminous mixtures used on IDOT projects are classified as Class A, Hot-Mix Asphalt Low ESAL, Hot-Mix Asphalt High ESAL, IL 4.75 and SMA.

A. Class A

Class A bituminous surface is typically used on low volume roads by local agencies.

Class A-1 consists of a bituminous seal coat on the roadway followed by an application of a seal coat aggregate.

Class A-2 consists of a prime coat, a bituminous cover coat and a cover aggregate, and a bituminous seal coat and seal coat aggregate.

Class A-3 consist of a prime coat, two separate applications of a bituminous cover coat and cover aggregate and a bituminous seal coat and seal coat aggregate.

B. Superpave

Superpave, the final product of the Strategic Highway Research Program (SHRP is a system which was developed for specifying asphalt materials. It stands for <u>Su</u>perior <u>Per</u>forming Asphalt <u>Pave</u>ments and represents a basis for specifying component materials, asphalt mixture design and anaylsis, and pavement performance prediction. Generically, it is an improvement to previous mixture design because Superpave designs the asphalt mixture for specific location, climate and traffic.

In the past, the laboratory compactive effort was defined by Class I and Type, i.e., Type 1, Type 2 or Type 3. In Superpave, the compactive effort is expressed as a Ndesign number, which is selected based on the estimated 20-year ESAL loading of the traffic lane. SuperPave mixes will now be classified as Low ESAL, High ESAL, or SMA.

N = Number of gyrations in the gyratory compactor.

1. Hot-Mix Asphalt Low ESAL

Hot-Mix Asphalt Low ESAL consists of IL 19.0L binder and IL-9.5L surface mixes. These mixes have a design compactive effort of 30 and an air void target of 4.0%. Low ESAL mixes are designed for lower volume roadways.

2. Hot-Mix Asphalt High ESAL

Hot-Mix Asphalt High ESAL consists of IL-19.0 binder mixes and IL-9.5, IL-9.5FG and IL 4.75 surface mixes. These mixes have a design compactive effort of Ndesign 50, 70 or 90 depending on the loading and traffic volume of the roadway. High ESAL mixes are designed at 4.0% air voids at the design number of gyrations. These mixes are designed for heavier loading and higher traffic volume.

3. SMA Mixture

SMA Mixtures have a design compactive effort of Ndesign 50 or 80 depending on the loading and traffic volume of the roadway. These mixes are designed at 4.0% air voids at the design number of gyrations

The following Ndesign table lists the compactive effort required for the different levels of traffic loading, as well as describes the typical roadway application.

Design ESAL's (millions) Based on 20-yr design	**N_{ini}[1]**	**N_{des}**	**N_{max}[21]**	**Typical Roadway Application**
< 0.3	5	30	42	Roadways with very light traffic volume such as local roads, county roads, and city streets where truck traffic is prohibited or at a very minimal level. (Considered local in nature; not regional, intrastate, or interstate.) Special purpose roadways serving recreational sites or areas may also be applicable.
0.3 to 3	6	50	74	Includes many collector roads or access streets. Medium-trafficked city streets and the majority of county roadways.
3 to 10	7	70	107	Includes many two-lane, multi-lane, divided, and partially or completely controlled access roadways. Among these are medium-to-highly trafficked streets, many state routes, US highways, and some rural interstates.
≥ 10	8	90	141	May include the previous class of roadways which have a high amount of truck traffic. Includes US Interstates, both urban and rural in nature. Special applications such as truck-weighing stations or truck-climbing lanes on two-lane roadways may also be applicable to this level.

FRICTION REQUIREMENTS OF COARSE AGGREGATE

1004.03 Coarse Aggregate for Hot-Mix Asphalt (HMA). The aggregate shall be according to Article 1004.01 and the following.

(a) Description. The coarse aggregate for HMA shall be according to the following table.

Coarse Aggregates Art. 1004.03

<table>
<tr><th>Use</th><th>Mixture</th><th colspan="2">Aggregates Allowed</th></tr>
<tr><td>Class A</td><td>Seal or Cover</td><td colspan="2">Allowed Alone or in Combination [5/]:
Gravel
Crushed Gravel
Carbonate Crushed Stone
Crystalline Crushed Stone
Crushed Sandstone
Crushed Slag (ACBF)
Crushed Steel Slag
Crushed Concrete</td></tr>
<tr><td>HMA
Low ESAL</td><td>Stabilized Subbase or Shoulders</td><td colspan="2">Allowed Alone or in Combination [5/]:
Gravel
Crushed Gravel
Carbonate Crushed Stone
Crystalline Crushed Stone
Crushed Sandstone
Crushed Slag (ACBF)
Crushed Steel Slag[1/]
Crushed Concrete</td></tr>
<tr><td>HMA
High ESAL
Low ESAL</td><td>Binder
IL-19.0
or IL-19.0L
SMA Binder</td><td colspan="2">Allowed Alone or in Combination [5/]:
Crushed Gravel
Carbonate Crushed Stone[2/]
Crystalline Crushed Stone
Crushed Sandstone
Crushed Slag (ACBF)
Crushed Concrete[3/]</td></tr>
<tr><td>HMA
High ESAL
Low ESAL</td><td>C Surface and Binder
IL-9.5
IL-9.5FG
or IL-9.5L
SMA
Ndesign 50 Surface</td><td colspan="2">Allowed Alone or in Combination [5/]:
Crushed Gravel
Carbonate Crushed Stone[2/]
Crystalline Crushed Stone
Crushed Sandstone
Crushed Slag (ACBF)
Crushed Steel Slag[4/]
Crushed Concrete[3/]</td></tr>
<tr><td rowspan="6">HMA
High ESAL</td><td rowspan="6">D Surface and Binder
IL-9.5
or IL-9.5FG
SMA
Ndesign 50
Surface</td><td colspan="2">Allowed Alone or in Combination [5/]:
Crushed Gravel
Carbonate Crushed Stone (other than Limestone)[2/]
Crystalline Crushed Stone
Crushed Sandstone
Crushed Slag (ACBF)
Crushed Steel Slag[4/]
Crushed Concrete[3/]</td></tr>
<tr><td colspan="2">Other Combinations Allowed:</td></tr>
<tr><td><i>Up to...</i></td><td><i>With...</i></td></tr>
<tr><td>25% Limestone</td><td>Dolomite</td></tr>
<tr><td>50% Limestone</td><td>Any Mixture D aggregate other than Dolomite</td></tr>
<tr><td>75% Limestone</td><td>Crushed Slag (ACBF) or Crushed Sandstone</td></tr>
</table>

Art. 1004.03 Coarse Aggregates

Use	Mixture	Aggregates Allowed	
HMA High ESAL	E Surface IL-9.5 or IL-9.5FG SMA Ndesign 80 Surface	Allowed Alone or in Combination [5/]: Crushed Gravel Crystalline Crushed Stone Crushed Sandstone Crushed Slag (ACBF) Crushed Steel Slag Crushed Concrete[3/] No Limestone.	
		Other Combinations Allowed:	
		Up to...	*With...*
		50% Dolomite[2/]	Any Mixture E aggregate
		75% Dolomite[2/]	Crushed Sandstone, Crushed Slag (ACBF), Crushed Steel Slag, or Crystalline Crushed Stone
		75% Crushed Gravel or Crushed Concrete[3/]	Crushed Sandstone, Crystalline Crushed Stone, Crushed Slag (ACBF), or Crushed Steel Slag
HMA High ESAL	F Surface IL-9.5 or IL-9.5FG SMA Ndesign 80 Surface	Allowed Alone or in Combination [5/]: Crystalline Crushed Stone Crushed Sandstone Crushed Slag (ACBF) Crushed Steel Slag No Limestone.	
		Other Combinations Allowed:	
		Up to...	*With...*
		50% Crushed Gravel, Crushed Concrete[3/], or Dolomite[2/]	Crushed Sandstone, Crushed Slag (ACBF), Crushed Steel Slag, or Crystalline Crushed Stone

1/ Crushed steel slag allowed in shoulder surface only.

2/ Carbonate crushed stone shall not be used in SMA Ndesign 80. In SMA Ndesign 50, carbonate crushed stone shall not be blended with any of the other aggregates allowed alone in Ndesign 50 SMA binder or Ndesign 50 SMA surface.

3/ Crushed concrete will not be permitted in SMA mixes.

4/ Crushed steel slag shall not be used as binder.

5/ When combinations of aggregates are used, the blend percent measurements shall be by volume.

(b) Quality. For surface courses, the coarse aggregate shall be Class B quality or better. For SMA surface and binder courses the coarse aggregate shall be Class B Quality or better. For Class A (seal or cover coat), and other binder courses, the coarse aggregate shall be Class C quality or better.

(c) Gradation. The coarse aggregate gradations shall be as listed in the following table.

Use	Size/Application	Gradation No.
Class A-1, A-2, & A-3	3/8 in. (10 mm) Seal	CA 16 or CA 20
Class A-1	1/2 in. (13 mm) Seal	CA 15
Class A-2 & A-3	Cover Coat	CA 14
HMA High ESAL	IL-19.0	CA 11 1/
	SMA 12.5 2/	CA 13, CA 14, or CA 16 3/
	SMA 9.5 2/	CA 13, CA 14, or CA 16 3/
	IL-9.5	CA 16
	IL-9.5FG	CA 16
HMA Low ESAL	IL-19.0L	CA 11 1/
	IL-9.5L	CA 16

1/ CA 16 or CA 13 may be blended with CA 11.

2/ The coarse aggregates shall be capable of being combined with the fine aggregates and mineral filler to meet the approved mix design and the mix requirements noted herein.

3/ The specified coarse aggregate gradations may be blended.

(d) Flat and Elongated Particles. For SMA the coarse aggregate shall meet the criteria for Flat and Elongated Particles listed in Illinois Modified AASHTO M 325.

(e) Absorption. For SMA the coarse aggregate shall also have water absorption ≤ 2.5 percent.

1004.04 Coarse Aggregate for Granular Embankment Special; Granular Subbase; and Aggregate Base, Surface, and Shoulder Courses. The aggregate shall be according to Article 1004.01 and the following.

(a) Description. The coarse aggregate shall be gravel, crushed gravel, crushed stone, crushed concrete, crushed slag, or crushed sandstone, except gravel shall not be used for subbase granular material, Type C.

The coarse aggregate for aggregate base course and aggregate shoulders, if approved by the Engineer, may be produced by blending aggregates from

SPECIFIC REQUIREMENTS

A. Dust/AC Ratio

Hot-Mix Asphalt requires the use of minus 75µm (#200) sieve material. However, too much or too little minus 75µm (#200) sieve material can have adverse effects on the mixture performance. Illinois has adopted a nationally accepted specification of dust [minus 75µm (#200) sieve material] to Asphalt Binder ratio in the field of 0.6 to 1.2 and the moisture content of the mixture at discharge from the mixer shall not exceed 0.3 percent. This requirement is stated in Article 1030.05 under “Plant Tests” of the Standard Specifications.

During the design stage the dust to asphalt binder ratio cannot exceed 1.0 for both High ESAL, Low ESAL & IL-4.75 mixtures. This requirement is stated in Article 1030.04(a) in Tables 1 of the Standard Specifications.

PERFORMANCE GRADED BINDERS

INTRODUCTION

During 1999 and 2000, the Illinois Department of Transportation will be following a national program to convert its asphalt cement grades to the Superpave Performance Graded (PG) Binder System. The biggest challenge is grasping the new terminology. First, one must become accustomed to the term “binder” to describe what used to be called asphalt cement (AC). This will require changing the IDOT term for lower lifts of the Hot-Mix asphalt (HMA) since the lower lifts have traditionally been called “binders”. Second, one will need to understand the nomenclature associated with the PG Binder grading system.

AN AC GRADED SYSTEM

In the past, asphalt cements were either “penetration” or “viscosity” graded. IDOT used the “penetration” system until the mid-1970’s. Since that time, IDOT has used a “viscosity” AC grading system. One problem with AC graded systems was they are based on empirical tests. Empirical specifications rely solely on practical experience and observations without regard for pavement performance theory. Therefore, the specification is based on the results from a given situation. Once the conditions change the results may no longer be the same. The penetration test is a measure of asphalt stiffness, but the stiffness requirements were gained through experience. If the conditions change, the stiffness requirements may no longer be accurate. The accuracy will not be known until results are obtained under new conditions.

Another drawback of the AC graded system is the long-term asphalt aging is not taken into consideration. Current tests are performed on unaged or “tank” asphalt and on artificially short-term aged asphalt to simulate construction aging. No tests are performed to simulate in-service aging. Aging occurs when the asphalt reacts with the oxygen in the atmosphere by oxidation. Asphalt undergoes a significant amount of oxidation during production.

Oxidation increases the stiffness of the asphalt, making it more brittle or “hard”, causing premature cracking. Since oxidation occurs more rapidly at higher temperatures, warmer climates are more susceptible to greater amounts of in-service aging.

The AC graded systems testing did not cover the temperature extremes that the pavement endured. Asphalts that produce similar results at the temperatures used for the penetration and viscosity testing may have very different results at other temperatures experienced by the pavement.

CHANGING TIMES

Penetration and viscosity tests were developed in an era of significantly lower pavement loading. In the past, truck weights were around 72,000 lbs. with tires at 75 psi. Today, truck weights exceed 80,000 lbs. with 125 psi radial tires. The 10% increase in truck weights produce a 40% increase in the stresses applied to the pavement, not to mention the increase in the number of trucks on the road. With such changes in traffic conditions, past experience is no longer sufficient to establish asphalt grading.

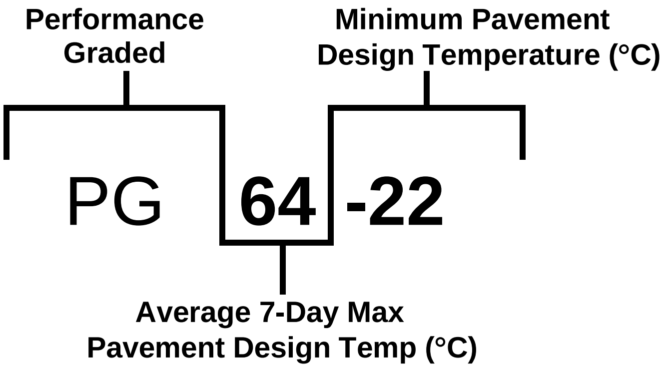
PERFORMANCE DRIVEN BINDERS

Today, we have a new asphalt binder specification in place. Grading based on viscosity and penetration has been replaced with a performance graded (PG) system. No longer are the tests empirical. The PG specification uses tests to measure physical properties that can be directly related to field performance by engineering principles.

PG binders are tested under conditions that are similar to the three critical stages of a binder’s life. The binder is tested for the first stage of transport, storage, and handling. A rolling thin film oven is used to process the binder for the second stage, mix production and construction, by exposing binder films to heat and air that approximate exposure during mixing and laydown conditions. For the third stage, long term aging, binder is aged using a pressure aging vessel. The pressure aging vessel exposes samples to heat and pressure to simulate years of in-service aging of a pavement.

WHAT DOES PG 64-22 MEAN?

PG means performance graded and may not contain polymers. The PG grade is selected largely based on the temperature where it is to be used. The nomenclature is fairly simple. The first number (64 in the illustration) represents the maximum 7 day pavement design temperature in Celsius (°C) for which the binder is tested. The higher the first number is, the warmer the climate. The second number (-22) represents the minimum temperature in (°C) for which low temperature cracking should not occur. Both numbers change in 6°C (11°F) increments.



Thus, the above grade would be for a pavement with an operating temperature range between 64 and -22°C (147 to -8°F).

Some PG binders may require modifiers, such as polymers, to meet low and high temperature requirements. Although modifiers may affect many properties, the majority of modifiers attempt to decrease the temperature dependency and oxidation hardening of asphalt mixtures. The rule of thumb to determine whether a given grade will typically require some type of modifier is based on the working temperature range. For example, a PG 64-22 has a working temperature of 86°C (64+22=86). Higher quality crude oils can achieve a maximum working temperature of approximately 92°C; whereas average crude oils have a maximum working temperature of approximately 90°C. Anything beyond a working temperature of 86°C may be polymer modified in Illinois. Unmodified PG binders should cost about the same as their AC equivalents. Modifiers may increase the cost of the HMA. Any decision to specify modified binders should be well thought out.

PG CERTIFIED PROGRAM

The Central Bureau of Materials (CBM) will perform all testing on PG binders. An approved list of PG binders is distributed by CBM.

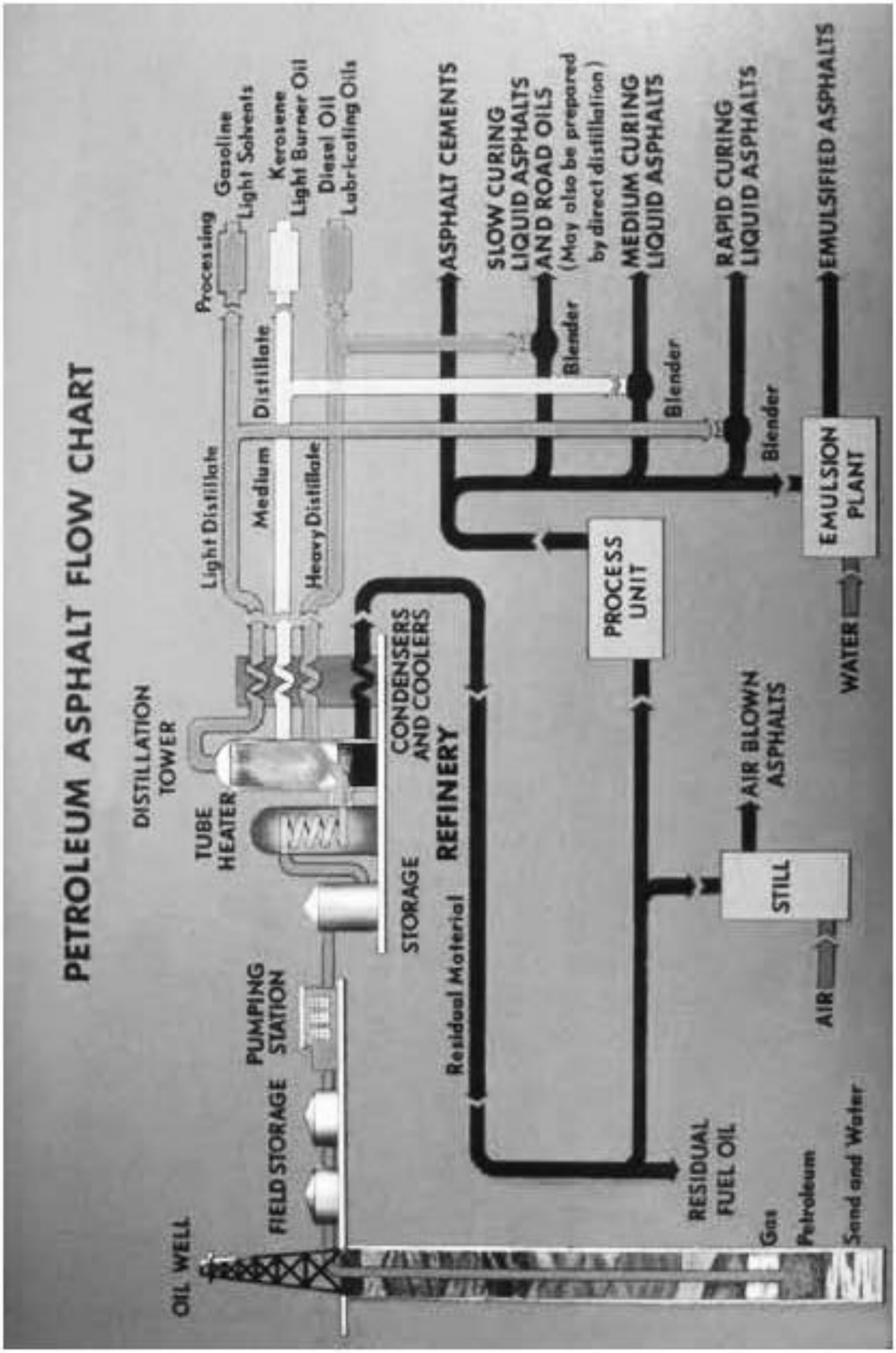
CONCLUSION

The new PG systems are tied to actual pavement performance. New grades are available to handle higher temperatures and heavier truck loading. Benefits may include better rut resistance and reduced low temperature cracking. PG graded asphalts are a new tool to help insure that asphalt pavements last longer.

TIPS ON HANDLING ASPHALT BINDERS

Other than contamination, excessive temperature is the biggest cause of asphalt mishandling. Asphalt should never be heated above 177° C (350° F), except when a reaction with rubber is required. It is also important not to incorporate air into the hot asphalt. Exposure to air and/or high temperature will oxidize the asphalt causing it to harden. This shortens the life of the asphalt, and therefore, the asphalt concrete mixture. Asphalt is a good insulator and consequently requires considerable time to heat up. It is, therefore, important to allow enough heat-up time prior to mix production.

Since asphalt is a good insulator, it retains heat longer than less viscous fluids such as water, and can therefore cause more severe burns.


PETROLEUM ASPHALT FLOW CHART
OIL WELL
FIELD STORAGE
PUMPING STATION
STORAGE
TUBE HEATER
DISTILLATION TOWER
CONDENSERS AND COOLERS
STORAGE
REFINERY
Light Distillate
Medium
Heavy Distillate
Processing
Distillate
Gasoline
Light Solvents
Kerosene
Light Burner Oil
Diesel Oil
Lubricating Oils
ASPHALT CEMENTS
SLOW CURING LIQUID ASPHALTS AND ROAD OILS
(May also be prepared by direct distillation)
Blender
MEDIUM CURING LIQUID ASPHALTS
Blender
RAPID CURING LIQUID ASPHALTS
Blender
EMULSIFIED ASPHALTS
EMULSION PLANT
PROCESS UNIT
WATER
Residual Material
STILL
AIR
AIR BLOWN ASPHALTS
RESIDUAL FUEL OIL
Gas
Petroleum
Sand and Water

]

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NUCLEAR DENSITY TEST

INTRODUCTION

Density of Hot-Mix asphalt is most commonly determined using a nuclear density gauge. The nuclear density gauge is easy to use and provides density readings in a matter of minutes. However, a nuclear density gauge can only give test results as accurate as the data input. In order for the nuclear density gauge to provide accurate densities, it must be correlated with the densities of cored Hot-Mix asphalt specimens taken from the roadway.

This section provides information on the proper use of a nuclear density gauge, how to determine test locations, and how to perform a nuclear core correlation.

This section also provides general information on how to determine density using the nuclear density gauge. For specific information and requirements, refer to the Department's "Illinois-Modified ASTM D 2950 Standard Test Method for Determination of Density of Bituminous Concrete In-Place by Nuclear Methods (Density Modified)".

NUCLEAR GAUGE OPERATION

A. General:

In order to obtain meaningful test data, it is essential to understand the operation of the gauge and its limitations. The best way to accomplish this is to read the operators manual for the gauge being used. It is recommended that this manual be kept with the gauge at all times and referenced whenever problems arise.

B. Standard Count

(1) Turn Gauge On - Once the gauge is turned on it will automatically go into a 300 second self-test on the electronics. Allow the gauge to warm up for 20 minutes (from time gauge is turned on) prior to running the *standard count*.

(2) Position Gauge - Prior to running a *standard count* the gauge shall be positioned at least 5 m (15 ft.) from any mass (building, vehicle, rollers, etc.), and at least 10m (30 ft.) from another nuclear gauge.

The gauge is positioned on the reference block, which is placed on a flat surface 1,510 kg/m^3 (100 pcf) or greater, with 15% or less moisture. The bottom of the gauge and the top of the reference block must be clean. The gauge must be situated between the raised edges, and with the control panel end of the gauge firmly against the metal butt plate.

(3) Run Standard Count - Once gauge is in position on reference block, remove padlock from the handle and ensure the handle is in the safe (top) position. Pressing STANDARD will cause the gauge to display the current *standard count*. At this point, the gauge will ask the user if a new count is needed. Press YES, the gauge will then ask if the gauge is on the reference block with the handle in the safe position. Pressing YES again will start the *standard count*. Step back 2m (6 ft.) from the gauge while the *standard count* is in progress (this should be done whenever the gauge is running, i.e., *standard counts and test counts*).

Newer gauges will indicate whether the new *standard count* passed or failed the allowable daily drift limits. The daily drift limits are 1% for density and 2% for moisture and are compared to the average of the 4 previous *standard counts*.

If the *new standard* count is within the allowable limits press YES. If the new *standard count* fails, press NO/CE to discard, and try again. If an acceptable count cannot be obtained in two tries, notify the Radiation Safety Officer (RSO). This may be an indication that there is a problem with the gauge. However, if the gauge has not been used for an extended period of time (i.e., several months) the source may have deteriorated enough to make the previous counts invalid. If this is the case, run four new *standard counts* to establish a new base for future comparison, and monitor the gauges performance.

C. Test Count

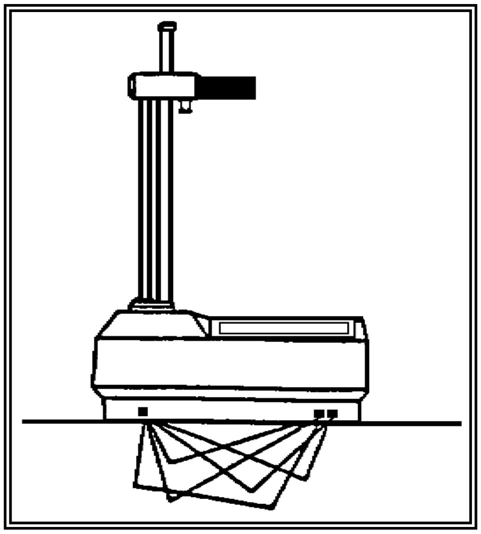
(1) Selecting Count Time - Most nuclear density gauges will allow the time for *test counts* to be set for 15 seconds, 1 minute, or 4 minutes. The confidence level of the gauge is affected by the length of time a *test count* is run. A 15 second *test count* will only provide a 37% confidence level. Increasing the *test count* time to 1 minute will increase the confidence level to 64%. A 4-minute *test count* will provide a 95% confidence level. The Department allows 1 minute as minimum time to run a *test count*, however a 4 minute *test count* is encouraged if time permits.

(2) Test Mode - Since nuclear density gauges can be used to determine either the density of asphalt, or soil, it is important to make sure the gauge is in the “Asphalt” mode. This can be accomplished by pressing SHIFT and MODE. The gauge will then display the current mode and ask if the user would like to change modes. With the “Asphalt” mode selected the gauge can be set to display “Wet Density” and “% Marshall” or “Wet Density” and “% Voids”.

The nuclear density gauge can measure density by either the ***backscatter*** **or** ***direct transmission*** **mode**.

Backscatter is used for layers of asphalt less than 4 inches (100 mm) thick.

This method involves placing the density gauge on the surface and lowering the probe so that is resting on the material to be tested. The probe does not penetrate the surface of the material.



BACKSCATTER GEOMETRY

(3) Inputting or Changing Marshall Values - From the "Gauge Ready" display press PROCTOR/MARSHALL. The display will then show the current values and ask if a change is desired. If so, press YES. Next select "Marshall" and the gauge will allow the user to enter the desired value for the maximum specific gravity [G_{mm} (D)] of the asphalt mixture. Take the maximum specific gravity [G_{mm} (D)] X 1000 kg/m^3 (62.4 lbs/ft^3) and enter this value into the gauge.

After entering this value press ENTER. If a mistake is made, press "CE" to clear the entry. Pressing CE twice, followed by ENTER, will cause the entry process to abort, and the old value will not be changed.

D. Test Procedure

(1) Determine Test Location - Determine the test location according to the Department's "Determination of Random Density Test Site Locations" stand alone document.

(2) Prepare Test Area - Since the measured value of density by backscatter is affected by the surface texture of the material under the gauge, a smoothly rolled surface should be tested for best results. A filler of limestone fines or similar material maybe desirable to fill surface pores of the rolled surface. The filler should be spread out to an area larger than the bottom of the gauge. Excess filler is to be removed, so the tops of the aggregate particles become visible through the filler.

(3) Position Gauge - The gauge should be placed in a manner such that the gauge is tipped to one side so that one edge of the gauge touches the pavement first. Once the one edge makes contact, allow the gauge to gently tilt into the upright position with the base centered in the filler. Make sure the gauge is sitting firmly and flatly on the pavement. This can be determined by attempting to rock the gauge by pressing each of the four corners of the gauge, one at a time. If gauge rocks, it must be resituated.

(4) Lower Source Rod - Once the gauge is positioned correctly lower the source rod to the correct position and lock in place.

(5) Start Test - Once the correct information is entered and gauge is positioned, a *test count* may be run. This can be accomplished by pressing START, standing back [approximately 6 ft (2 m.)], and allowing gauge to complete *test count*. One *test count* is referred to as “one determination”. See page 4-47 for layout of random density test site locations with a nuclear gauge or cores on Hot-Mix Asphalt, which requires different configurations based on confined/unconfined longitudinal joints. Refer to the Standard for Road and Bridge Construction, Revised January 1, 2022, Article1030.09 Section (b)(1), Required Density Tests.

When testing is completed, record all information, tip gauge up onto one edge*, retract source rod into safe position, and lift gauge (retract source rod into safe position before tipping gauge, if using direct transmission method).

*****Tipping gauge before retracting source rod prevents filler from being sucked up into gauge.

E. Clean Gauge

It is important, to keep the gauge clean at all times. Asphalt stuck to the bottom of the gauge may result in erroneous density readings. The gauge may be cleaned with Trichloroethane or Solvent 140. Do not use oil based cleaners such as gasoline, kerosene, and diesel fuel. Contact gauge manufacturer for specific cleaning procedures.

It is important, to use proper safety equipment and procedures to minimize exposure to toxic cleaning solvents, and radiation. Begin by tipping the gauge on its side with the bottom facing away. Reach around with one hand and wipe the bottom of the gauge clean with a cleaning rag and solvent. Remove the bottom plate with a screwdriver.***** Wipe plate and scraper ring (mounted in the plate) clean. Remove the sliding tungsten shield (spring loaded block)*. With tungsten shield removed, clean the open cavity, and inspect the tip of the source rod.***** If the tip of the source rod is contaminated, with anything other than grease, lower the source rod into the cavity just far enough to allow the tip to be cleaned.

*****It is recommended to use a mirror to minimize exposure to radiation, when cleaning bottom plate, the open cavity, or the tip of the source rod.
To reassemble gauge, make sure the source rod is retracted into the safe position. Install the sliding tungsten block with angled side up. Replace bottom plate.
Caution: Do not over-tighten screws in the aluminum base.

CORRELATION

Density results from a nuclear gauge are relative. If an approximation of core densities is required, a correlation must be developed to convert nuclear density to core density. Refer to the Department’s “Standard Test Method For Correlating Nuclear Gauge Densities With Core Densities” for correlation requirements and procedure for correlating nuclear gauge densities with core densities.

TEST SITES

Density tests must be performed at random locations according to the Department’s “Determination of Random Density Test Site Locations”.

REPORT FORM AND INSTRUCTIONS

Upon the completion of a nuclear density test, complete the Quality Assurance Nuclear Density Report QC/QA form herein.

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MATERIAL CODES

CODE	MIX TYPE	GRADATION/ FRICTION	# GYRATIONS	INDIVIDUAL SPECIFICATION
19504	BINDER	19.0L	N30	93.0 [1/]- 97.4 %-
19504R	BINDER	19.0L (REC)	N30	93.0 [1/]- 97.4 %-
19505	SURFACE	C - 9.5L	N30	92.5 – 97.4 %
19505R	SURFACE	C - 9.5L (Rec)	N30	92.5 – 97.4 %
19510		4.75	N50	93.0 - 97.4 %
19510R		4.75 (Rec)	N50	93.0 - 97.4 %
19512	BINDER	19.0	N50	93.0 [1/]- 97.4 %-
19512R	BINDER	19.0 (Rec)	N50	93.0 [1/]- 97.4 %-
19513	SURFACE	C	N50	92.5 – 97.4 %
19513F	SURFACE	C FG	N50	93.0 – 97.4 %
19513FR	SURFACE	C FG (Rec)	N50	93.0 – 97.4 %
19513R	SURFACE	C (Rec)	N50	92.5 – 97.4 %
19514	SURFACE	D	N50	92.5 – 97.4 %
19514F	SURFACE	D - FG	N50	93.0 – 97.4 %
19514FR	SURFACE	D - FG (Rec)	N50	93.0 – 97.4 %
19514R	SURFACE	D (Rec)	N50	92.5 – 97.4 %
19515	SURFACE	E	N50	92.5 – 97.4 %
19515R	SURFACE	E (Rec)	N50	92.5 – 97.4 %
19516	SURFACE	F	N50	92.5 – 97.4 %
19516R	SURFACE	F (Rec)	N50	92.5 – 97.4 %
19522	BINDER	19.0	N70	93.0 [1/]- 97.4 %-
19522R	BINDER	19.0 (Rec)	N70	93.0 [1/]- 97.4 %-
19523	SURFACE,	C	N70	92.5 – 97.4 %
19523F	SURFACE	C-FG	N70	93.0 – 97.4 %
19523FR	SURFACE,	C-FG (Rec)	N70	93.0 – 97.4 %
19523R	SURFACE	C (Rec)	N70	92.5 – 97.4 %
19524	SURFACE,	D	N70	92.5 – 97.4 %
19524F	SURFACE	D-FG	N70	93.0 – 97.4 %
19524FR	SURFACE	D FG (Rec)	N70	93.0 – 97.4 %
19524R	SURFACE	D (Rec)	N70	92.5 – 97.4 %
19525	SURFACE	E	N70	92.5 – 97.4 %
19525R	SURFACE	E (Rec)	N70	92.5 – 97.4 %
19526	SURFACE	F	N70	92.5 – 97.4 %
19526R	SURFACE	F (Rec)	N70	92.5 – 97.4 %
19532	BINDER	19.0	N90	93.0 – 96.0 %
19532R	BINDER	19.0 (Rec)	N90	93.0 – 96.0 %
19533	SURFACE	C	N90	92.0 – 96.0 %
19533R	SURFACE	C (Rec)	N90	92.0 – 96.0 %
19534	SURFACE	D	N90	92.0 – 96.0 %
19534F	SURFACE	D-FG	N90	92.0 – 96.0 %

[1/] 92.0 percent when placed as first lift on an unimproved subgrade

MATERIAL CODES (Continued)

CODE	MIX TYPE	GRADATION/ FRICTION	# GYRATIONS	INDIVIDUAL SPECIFICATION
19534FR	SURFACE	D-FG (Rec)	N90	93.0 – 97.4 %
19534R	SURFACE	D (Rec)	N90	92.0 – 96.0 %
19535	SURFACE	E	N90	92.0 – 96.0 %
19535R	SURFACE	E (Rec)	N90	92.0 – 96.0 %
19536	SURFACE	F	N90	92.0 – 96.0 %
19536R	SURFACE	F (Rec)	N90	92.0 – 96.0 %
19604	BINDER	9.5	N50	92.5 – 97.4 %
19604F	BINDER	9.5-FG	N50	93.0 – 97.4 %
19604FR	BINDER	9.5-FG (Rec)	N50	93.0 – 97.4 %
19604R	BINDER	9.5 (Rec)	N50	92.5 – 97.4 %
19605	BINDER	9.5	N70	92.5 – 97.4 %
19605F	BINDER	9.5-FG	N70	93.0 – 97.4 %
19605FR	BINDER	9.5-FG (Rec)	N70	93.0 – 97.4 %
19605R	BINDER	9.5-(Rec)	N70	92.5 – 97.4 %
19606	BINDER	9.5	N90	92.0 – 96.0 %
19606F	BINDER	9.5-FG	N90	93.0 – 97.4 %
19606FR	BINDER	9.5-FG (Rec)	N90	93.0 – 97.4 %
19606R	BINDER	9.5 R	N90	92.0 – 96.0 %
19647	SMA SURFACE	9.5 D	N50	93.5 -97.4 %
19647R	SMA SURFACE	9.5-D (Rec)	N50	93.5 -97.4 %
19650	SMA BINDER	12.5	N50	93.5 -97.4 %
19650R	SMA BINDER	12.5 (Rec)	N50	93.5 -97.4 %
19651	SMA SURFACE	12.5 C	N50	93.5 -97.4 %
19651R	SMA SURFACE	12.5-C (Rec)	N50	93.5 -97.4 %
19652	SMA SURFACE	12.5 D	N50	93.5 -97.4 %
19652R	SMA SURFACE	12.5-D (Rec)	N50	93.5 -97.4 %
19653	SMA BINDER	12.5	N80	93.5 -97.4 %
19653R	SMA BINDER	12.5 (Rec)	N80	93.5 -97.4 %
19654	SMA SURFACE	12.5 E	N80	93.5 -97.4 %
19654R	SMA SURFACE	12.5-E (Rec)	N80	93.5 -97.4 %
19655	SMA SURFACE	12.5-F	N80	93.5 -97.4 %
19655R	SMA SURFACE	12.5-F (Rec)	N80	93.5 -97.4 %
19664	SMA SURFACE	9.5-E	N80	93.5 -97.4 %
19664R	SMA SURFACE	9.5-E (Rec)	N80	93.5 -97.4 %
19665	SMA SURFACE	9.5-F	N80	93.5 -97.4 %
19665R	SMA SURFACE	9.5-F (Rec)	N80	93.5 -97.4 %

Notes:
For recycled mixes add an "R" after 5-digit code. - Example: 19534R
For Fine Graded Recycled mixes add an “FR” after 5-digit code – Example: 19534FR

HMA – Hot-Mix Asphalt
SMA – Stone Matrix Asphalt

Gauge No.	28769

m =	1.026
b =	-117.9

Formula Y = mX+b

Material Code:	19523
Material Desc:	BIT CONC SCS N70 C REC
Field Mix #:	87BIT1023
Lift Number:	.1

Route:	IL 32
Section:	(1,2) RS-3
County:	Moultrie
Job No:	C9701223
Contract No.:	74226
RE:	M. Weidner

Actual Nuclear Reading	Adjusted Nuclear Reading
2251	2192
2252	2193
2253	2194
2254	2195
2255	2196
2256	2197
2257	2198
2258	2199
2259	2200
2260	2201
2261	2202
2262	2203
2263	2204
2264	2205
2265	2206
2266	2207
2267	2208
2268	2209
2269	2210
2270	2211
2271	2212
2272	2213
2273	2214
2274	2215
2275	2216
2276	2217
2277	2218
2278	2219
2279	2220
2280	2221
2281	2222
2282	2223
2283	2224
2284	2225
2285	2227
2286	2228
2287	2229
2288	2230
2289	2231
2290	2232
2291	2233
2292	2234
2293	2235
2294	2236
2295	2237
2296	2238
2297	2239
2298	2240
2299	2241
2300	2242

Actual Nuclear Reading	Adjusted Nuclear Reading
2301	2243
2302	2244
2303	2245
2304	2246
2305	2247
2306	2248
2307	2249
2308	2250
2309	2251
2310	2252
2311	2253
2312	2254
2313	2255
2314	2256
2315	2257
2316	2258
2317	2259
2318	2260
2319	2261
2320	2262
2321	2263
2322	2264
2323	2265
2324	2267
2325	2268
2326	2269
2327	2270
2328	2271
2329	2272
2330	2273
2331	2274
2332	2275
2333	2276
2334	2277
2335	2278
2336	2279
2337	2280
2338	2281
2339	2282
2340	2283
2341	2284
2342	2285
2343	2286
2344	2287
2345	2288
2346	2289
2347	2290
2348	2291
2349	2292
2350	2293

Actual Nuclear Reading	Adjusted Nuclear Reading
2351	2294
2352	2295
2353	2296
2354	2297
2355	2298
2356	2299
2357	2300
2358	2301
2359	2302
2360	2303
2361	2304
2362	2306
2363	2307
2364	2308
2365	2309
2366	2310
2367	2311
2368	2312
2369	2313
2370	2314
2371	2315
2372	2316
2373	2317
2374	2318
2375	2319
2376	2320
2377	2321
2378	2322
2379	2323
2380	2324
2381	2325
2382	2326
2383	2327
2384	2328
2385	2329
2386	2330
2387	2331
2388	2332
2389	2333
2390	2334
2391	2335
2392	2336
2393	2337
2394	2338
2395	2339
2396	2340
2397	2341
2398	2342
2399	2343
2400	2345

Actual Nuclear Reading	Adjusted Nuclear Reading
2401	2346
2402	2347
2403	2348
2404	2349
2405	2350
2406	2351
2407	2352
2408	2353
2409	2354
2410	2355
2411	2356
2412	2357
2413	2358
2414	2359
2415	2360
2416	2361
2417	2362
2418	2363
2419	2364
2420	2365
2421	2366
2422	2367
2423	2368
2424	2369
2425	2370
2426	2371
2427	2372
2428	2373
2429	2374
2430	2375
2431	2376
2432	2377
2433	2378
2434	2379
2435	2380
2436	2381
2437	2382
2438	2383
2439	2385
2440	2386
2441	2387
2442	2388
2443	2389
2444	2390
2445	2391
2446	2392
2447	2393
2448	2394
2449	2395
2450	2396

Field Worksheet

DATE: **August 1, 2023**
CONTRACT: **74226**
JOB #: **C9701223**
ROUTE: **IL 32**
BASE MATERIAL: **Milled Surface** (milled, binder, aggregate)
MIX #: **87BIT1023**
MIX CODE: **19523**
USE: **Surface** (surf., 1st lift binder...)

Gauge # **28769**
Layer Thickness **2.5”**
Gmm **2.444**

Nuclear Densities

Reading 1

STATION: **15+20**

1)	**2295**				
2)	**2300**				
3)	**2307**				
4)	**2305**				
5)	**2299**				

Illinois Department of Transportation

Quality Assurance
Nuclear Density Report QC/QA

I.D. No. ____

Inspector No. ____ Date Sampled ____ Seq. No. ____ County ____

Bit Mix Plant ____ Bit Mix Code ____ Equip. ____ QA Y Section ____

Contract No. ____ Job No. ____ Target Dens. ____ Route ____

Respons. Loc. ____ Lab ____ Standard Count ____ Project ____

Start Date ____ Complete Date ____

Gauge # ____ Calib. Date ____

Mode ____ Probe Depth ____

Correlation Data

M= ____

B= ____

	Date Laid	Station	Ref	Lift No. (Thick)	Lit d (Gmb)	Big D (Gmm)	% Den	Result	Type Insp	Den Kg/m^3	Lot
1											
2											
3											
4											
5											

REMARKS

1 ____

2 ____

3 ____

4 ____

5 ____

Test No.	1			2			3			4			5		
Offset	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3
Average															

CC: ____ Tester ____ Agency ____

____ Inspector ____ Agency ____

MISTIC INPUT

Date Entered ____

Initials ____

'FOR DTY03303'

Printed 11/30/2011

BMPR MI303N (Rev. 07/02/09)
Formerly MI 303N

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Illinois Department of Transportation

Quality Assurance
Nuclear Density Report QC/QA

I.D. No. ____

Inspector No. ____ Date Sampled ____ Seq. No. ____

Bit Mix Plant ____ Bit Mix Code ____ Equip. ____ QA Y

Contract No. ____ Job No. ____ Target Dens. ____

Respons. Loc. ____ Lab ____ Standard Count ____

County ____

Section ____

Route ____

Project ____

Start Date ____ Complete Date ____

Gauge # ____ Calib. Date ____

Mode ____ Probe Depth ____

Correlation Data

M= ____

B= ____

	Date Laid	Station	Ref	Lift No. (Thick)	Lit d (Gmb)	Big D (Gmm)	% Den	Result	Type Insp	Den Kg/m^3	Lot
1											
2											
3											
4											
5											

REMARKS

1 ____

2 ____

3 ____

4 ____

5 ____

Test No.	1			2			3			4			5		
Offset	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3
Average															

CC: ____ Tester ____ Agency ____

____ Inspector ____ Agency ____

MISTIC INPUT

Date Entered ____

Initials ____

'FOR DTY03303'

Printed 11/30/2011

BMPR MI303N (Rev. 07/02/09)
Formerly MI 303N

This Page Is Reserved

Quality Assurance
Nuclear Density Report QC/QA

I.D. No. 1

Inspector No. 3 Date Sampled 4 Seq. No. 5 County 2

Bit Mix Plant 6 Bit Mix Code 7 Equip. 8 QA Y Section

Contract No. 9 Job No. 10 Target Dens. 11 Route

Responsible Loc. 12 Lab 13 Standard Court 14 Project

Start Date 15 Complete Date 16

Gauge # 17 Calib. Date 18

Mode 19 Probe Depth 20

Correlation Data

M=

B= 21

	Date Laid	Station	Ref	Lift No. (Thick)	Lit d (Gmb)	Big D (Gmm)	% Den	Result	Type Insp	Den Kg/m^3	Lot
1	22	23	24	25	26	27	28	29	30	31	32
2											
3											
4											
5											

REMARKS

1 33

2

3

4

5

34

Test No.	1			2			3			4			5		
Offset	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3
Average															

CC: 35 Tester 36 Agency 37

Inspector 38 Agency 39

MISTIC INPUT

Date Entered

Initials

'FOR DTY03303'
MI 303N QC/QA (Rev. 2/99)

This Page Is Reserved

QC/QA
IDOT HOT-MIX ASPHALT NUCLEAR DENSITY TESTING REPORT FORM INSTRUCTIONS MI303N FORM

1. **ID NO:** Leave blank MISTIC system will generate Test ID Number.

2. **PROJECT IDENTIFICATION:** Job stamp may be used

3. **SAMPLED BY:** Enter the identification number of the person taking the sample.

   A. **IDOT personnel** are to use their Social Security No. or assigned I.D. No. (Only applicable when sample taken by IDOT)

   B. **Producers** are to use the District designation followed by 0's until the field is filled.

      EXAMPLE: District 3 designation is 93; then "930000000" would designate a District 3 producer.

   C. **Consultant personnel** are to use their tax number.
      Left justified and right filled with zeroes.
      EXAMPLE: (123450000) for tax number 12345.

   D. **Local agency personnel** are to use a "9" followed by the District number repeated until the field is filled.
      EXAMPLE: (966666666) for District six.

4. **DATE SAMPLED:** Enter date (MMDDYY) mix was produced
   Example: 040891 for April 8, 1991

5. **SEQ NO:** May be numerical or alphabetical up to 6 characters in length.

6. **BIT MIX PLANT:** MISTIC Producer/Supplier number

7. **MIX CODE:** MISTIC code number for the bituminous mix being produced

8. **EQUIP:** Enter type equipment used: "A" for an adjusted nuclear determination, or "N" if the reading was not adjusted (correlated)

9. **CONTRACT NO:** Use Contract Number (usually 5 digits)

10. **JOB NO:** Use Job Number that corresponds with the Contract Number

QC/QA
IDOT HOT-MIX ASPHALT NUCLEAR DENSITY TESTING REPORT FORM INSTRUCTIONS MI303N FORM

11. **TARGET DENS:** Enter the minimum required density in Kg/Cu m for the mix being tested. This will be based on the minimum % density for type
For example, take G_{mm} * 1000 * 0.920 for a 19534 D-Surface Mix with an Ndesign of 90.
For example, take G_{mm} * 1000 * 0.925 for a 19515 E-Surface Mix with an Ndesign of 50.

12. **RESPonsible LOC:** Enter District responsible location (e.g.: District 9 = 99

13. **LAB:** Enter the correct lab designation from the "MISTIC CODE REFERENCE SHEET" shown in ATTACHMENT A.

14. **STANDARD COUNT:** Enter the standard count used in the calculations

15. **START DATE:** N/A

16. **COMPLETE DATE:** N/A

17. **GAUGE #:** Enter the number of the gauge being used

18. **CALIB DATE:** Enter the last date the gauge was calibrated

19. **MODE:** Enter the mode of transmission: Direct or Backscatter

20. **DEPTH OF PROBE:** Enter the depth of the probe in inches

21. **CORRELATION DATA:** Enter the nuclear/core correlation data (m & b)used to determine the adjusted nuclear density.

22. **DATE LAID:** Enter the date the material was placed

23. **STATION:** Enter station number where test was taken

24. **REF:** Use direction of pavement (NBP, SBD, EBL, etc.)

(NBP = North Bound Passing)
(SBD = South Bound Driving)
(EBL = East Bound Lane)

QC/QA
IDOT HOT-MIX ASPHALT NUCLEAR DENSITY TESTING REPORT FORM INSTRUCTIONS MI303N FORM

25. **THICK(Lift number):** Designations in terms of lifts should be denoted from the bottom (including Bam or Poz lifts) in the following format. ".1" would designate 1st (lowest) lift, ".2" then would indicate the next lift (of the same mixture type) placed. Each mixture type will have its own set of lift numbers.

26. **G_{mb} (LIT "d"):** Record G_{mb} (Bulk Specific Gravity) determined during testing to the nearest .001.

27. **G_{mm} (BIG "D"):** Record G_{mm} (Maximum Specific Gravity) used in calculations to the nearest .001

28. **% DENS:** Record the calculated % density (nearest tenth)

29. **RESULTS:** Enter (APPR) for passing test or (FAIL) for failing test (see 34. **REMARKS**)

30. **TYPE TEST:** Enter the correct type test designation from the "MISTIC CODE REFERENCE SHEET" shown in ATTACHMENT A.

31. **DENS Kg/Cu m:** Record the calculated density (Kg/Cu m) to the nearest tenth.

32. **LOT NO:** Used to identify both the day's production (format of 999-99 and the random field density sample location.

    EXAMPLE: Lot number 001-01 represents the 1st day of production & first random sample location. Lot 001-02 identifies the 1st day’s production & the second random sample location.

    Retests are identified as follows: The first retest would be designated by using an 8 as the first digit in the suffix (Example: 001-82 would indicate the first retest of the second sample of lot 001.) Subsequent resamples would use descending numbers as indication of additional resamples.
    (Example: The second resample of sample number 2 in lot 001 would be 001-72)

    The field density LOT Prefix correlates with the plant LOT Prefix.

    However, the field density LOT Suffix identifies each random sample while the plant Lot Suffix is always "-01"

    For Start-Ups use LOT 000-01 for the first Growth Curve.

    For the second Growth Curve the Lot Number would be 000-02

    On Start-Ups, Plant Hot Bin/Cold Feed Gradation test must correlate to field density tests (as much as possible).

QC/QA
IDOT HOT-MIX ASPHALT NUCLEAR DENSITY TESTING REPORT FORM INSTRUCTIONS MI303N FORM

33. **REMARKS:** Make any comments regarding test results. State personnel must put a **C-mmddyy** for compared or a **X-mmddyy** for failed comparison. The date must be the date that the data was analyzed. Remarks must be filled out for any failed test.

34. **WORKSHEET:** This sheet may be used to do the required calculations; otherwise, actual calculations must accompany completed form.

35. **COPIES:** Distribution of copies: District, Resident Engineer, Contractor

36. **TESTER:** Producer and IDOT use signature of the person doing the testing

37. **AGENCY:** Tester's employer (contractor/consultant/IDOT).

38. **INSPECTOR:** Producer use signature of the person responsible for quality control. IDOT use tester's supervisors signature, or leave blank.

39. **AGENCY:** Producer use inspectors employer (contractors or consultant name)
IDOT leave blank

ATTACHMENT “A”
MISTIC CODE REFERENCE SHEET

LABORATORY LOCATIONS	LAB CODES
PRODUCER PLANT SITE LABORATORY	PP
PRODUCER NON-PLANT SITE LABORATORY	PL
PRODUCER CONSTRUCTION SITE	PC **(Nuclear Density)**
PRODUCER QUARRY LABORATORY	PQ
INDEPENDENT PLANT SITE LABORATORY	IP
INDEPENDENT NON-PLANT SITE LABORATORY	IL
INDEPENDENT CONSTRUCTION SITE	IC **(Nuclear Density)**
INDEPENDENT QUARRY LABORATORY	IQ
IDOT PLANT SITE LABORATORY	FP
IDOT CONSTRUCTION SITE	FC **(Nuclear Density)**
IDOT QUARRY LABORATORY	FQ
DISTRICT LABORATORY	DI
DISTRICT SATELLITE LABORATORY	DS
CENTRAL BUREAU MIXTURE LABORATORY	BM (50 RESP LOC ONLY)
CENTRAL BUREAU CHEMICAL LABORATORY	BC (50 RESP LOC ONLY)
CENTRAL BUREAU AGGREGATE LABORATORY	AG (50 RESP LOC ONLY)

“TYPE TEST”

PRELIMINARY (PRIOR TO PRODUCTION) TEST (To be used on start-up nuclear density [use type equipment code N] and core test results that are used for correlation.)	**PRE**
CONTRACTOR/CONSULTANT PROCESS CONTROL TEST	**PRO**
IDOT ASSURANCE TEST	**IND**
CONSULTANT PERFORMING IDOT ASSURANCE TEST	**IND**
SPECIAL IDOT INVESTIGATIVE TEST	**INV**

RESAMPLE OF FAILED TEST SAME AS ORIGINAL (PRO, IND)

DO NOT USE “RES”

“SAMPLED BY”

PRODUCERS: USE DISTRICT DESIGNATION THEN 0000000
EXAMPLE: DISTRICT 4 PRODUCER = 940000000

IDOT: USE SOCIAL SECURITY NUMBER

LOCAL AGENCY: USE 9 PLUS DISTRICT NUMBER FILLED
EXAMPLE: DISTRICT 3 LOCAL AGENCY = 933333333

CONSULTANTS: USE TAX NUMBER (left justified, right filled with zeros)
EXAMPLE: 123450000 FOR TAX NUMBER 12345

“TYPE EQUIPMENT”

FOR DENSITY:	**CORES**	**C**
	NUCLEAR GAUGE DETERMINATION	**N**
	ADJUSTED NUCLEAR DETERMINATINO	**A**
MARSHALL/AC	**REFLEX EXTRACTION**	**R**
	VACUUM EXTRACTION	**V**
	MARSHALL AND NUCLEAR AC OR NUCLEAR AC ONLY	**N**
	MARSHALL TESTS ONLY	**X**

“SAMPLED FROM”

STOCKPILE	**SP**	**PRODUCTION**	**PR**
COLD FEED	**CF**	**ON BELT (STOPPED)**	**OB**
HOT BIN	**HB**	**BELT STREAM**	**BE**
TRUCK	**TK**	**RAIL CAR**	**CR**
ROAD	**RD**	**BARGE**	**BR**
TRUCK DUMP	**TD**	**BIN/SILO**	**SI**

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Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised Date: December 1, 2023

Standard Method of Test
for
Density of Asphalt Mixtures in Place by Nuclear Methods

Reference ASTM D 2950-22

ASTM Section	***Illinois Modification***
2.1	Replace the individual Standards as follows: IL Modified ASTM Standards in the Illinois Department of Transportation *Manual of Test Procedures for Materials* (current edition)
4.5	Replace with the following: The density results obtained by this test method are relative. If an approximation of core density results is required, a correlation factor will be developed to convert nuclear density to core density by obtaining nuclear density measurements and core densities at the same locations. The Department's "Procedure for Correlating Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt" shall be used to determine the appropriate correlation. It may be desirable to check this factor at intervals during the course of the paving project. A new correlation factor should be determined when there is a change in the job mix formula (outside the allowable adjustments); a change in the source of materials or in the materials from the same source; a significant change in the underlying material; a change from one gauge to another; or a reason to believe the factor is in error.
4.6 New Section	All projects containing 2750 metric tons (3000 tons) or more of a given mixture will require a correlation factor be determined and applied for measurement of density testing.
4.7 New Section	<u>Definitions:</u> Density Test Location: The random station location used for density testing. Density Reading: A single, one-minute nuclear density reading. Individual Test Result: An individual test result is the average of three to five nuclear density readings obtained at each random density test location. One to three “individual test results” will be required per “density test location” depending on the following conditions: • If two confined edges are present, one “individual test” result representing all five density readings across the mat shall be reported. (Confined edge density readings are included in the average.)

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised Date: December 1, 2023

Standard Method of Test
for
Density of Asphalt Mixtures in Place by Nuclear Methods

Reference ASTM D 2950-22

ASTM Section	***Illinois Modification***
4.7 New Section Cont'd	• If one confined and one unconfined edge is present, two "individual test results" shall be reported for each density test location. ○ One "individual test result" representing the average of four density readings across the mat, including the one confined edge and excluding the unconfined edge density readings. ○ One "individual test result" representing the average of three density readings on the unconfined edge. ○ For HMA mixes placed under QC/QA criteria, the Department density verification test result will be equal to the average of the four density readings across the mat, including the one confined edge density reading, and the quantity 2.0% plus the average of three unconfined edge density readings (See Figure 1). • If two unconfined edges are present, three "individual test" results shall be reported for each density test location. ○ One "individual test result" representing the average of three density readings across the mat, excluding the unconfined edge density readings. ○ One "individual test result" representing the average of three density readings on the unconfined edge. ○ One "individual test result" representing the average of three density readings on the opposite unconfined edge. ○ For HMA mixes placed under QC/QA criteria, the Department density verification test result will be equal to the average of the three density readings across the mat and the quantity 2.0% plus the average of three unconfined edge density readings for each unconfined edge (see Figure 2). Daily Average Density Value: The "daily average density" is the average of the "density readings" of a given offset for the given day's production. Density Test Site: Correlation term use to describe each physical location the nuclear density gauge is placed where a density value is determined. Density Value: Correlation term used to describe the density determined at a given density test site from the average of two or potentially three readings.

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised Date: December 1, 2023

Standard Method of Test
for
Density of Asphalt Mixtures in Place by Nuclear Methods

Reference ASTM D 2950-22

5.2.1	Add the following at the end: The user should recognize that density readings obtained on the surface of thin layers of hot-mix asphalt (HMA) may be erroneous if the density of the underlying material differs significantly from that of the surface course.
5.2.2	Add the following at the end: Accuracy of the nuclear density test is affected by the surface texture and thickness of the mixture and most significantly affected by the underlying material. The number of tests required to determine a satisfactory factor are dependent on the conditions stated above.
5.5	Replace with the following: If samples of the measured material are to be taken for purposes of correlation with other test methods, the procedures described in the Department's "Procedure for Correlating Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt" shall be used.
6.5 New Section	*Readout Instrument,* such as scaler or direct readout meter.
8.1	Add the following at the end: Dated inspection reports shall be kept and be made available to the Engineer upon request.
8.1.1 New Section	The calibration check shall provide proof of five-block calibration. Calibration standards shall consist of magnesium, magnesium/aluminum, limestone, granite, and aluminum. All calibration standards should be traceable to the U.S. Bureau of Standards. Proof shall consist of documented and dated calibration counts accompanied by copies of an invoice from the calibrating facility.
8.1.2 New Section	At least once a year and after all major repairs which may affect the instrument geometry, the calibration curves, tables, or equation coefficients shall be verified or reestablished.
9.2.1	Replace with the following: The reference standard count shall be taken a minimum of 10 m (30 ft.) from another gauge and a minimum of 5 m (15 ft.) away from any other masses or other items which may affect the reference count rate. In addition, the reference count shall be taken on material 1510 kg/m^3 (100 lbs./ft.^{3}) or greater.

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised Date: December 1, 2023

Standard Method of Test
for
Density of Asphalt Mixtures in Place by Nuclear Methods

Reference ASTM D 2950-22

ASTM Section	***Illinois Modification***
9.2.2	Revise the first sentence as follows: Turn on the apparatus prior to standardization and allow it to stabilize, a minimum of 20 minutes.
9.2.3	Replace with the following: All reference standard counts shall consist of a 4-minute count.
9.2.4	Replace with the following: The density reference standard count shall be within 1 percent of the average of the last four daily reference standard counts.
9.2.5 New Section	If four reference standard counts have not been established, then the reference standard count shall be within 2 percent of the standard count shown in the count ratio book.
9.2.6 New Section	If the reference standard count fails the established limits, the count may be repeated. If the second count fails also, the gauge shall not be used. The gauge shall be adjusted or repaired as recommended by the manufacturer.
9.2.7 New Section	Record all daily reference standard counts in a permanent-type book for a gauge historical record. This also applies to direct readout gauges.
9.3	Delete the first sentence.
10.1	Revise as follows: In order to provide more stable and consistent results: (1) turn on the instrument prior to use to allow it to stabilize, a minimum of 20 minutes; and (2) leave the power on during the day's testing.

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised Date: December 1, 2023

Standard Method of Test
for
Density of Asphalt Mixtures in Place by Nuclear Methods

Reference ASTM D 2950-22

ASTM Section	***Illinois Modification***
10.3	Replace with the following: Select a test location, using the Department's "Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations". Each random density test site location shall consist of five equally spaced nuclear density offsets across the mat. These density offsets shall be positioned to provide a diagonal configuration across the mat. The outer density offsets shall be located at a distance equal to 4 in. (100 mm) from the edge of the mat. • If the edge is unconfined, an "individual test result" shall represent the average of three "density readings" spaced 10 feet apart longitudinally along the unconfined edge. • If the edge is confined, the density reading will be averaged with the remaining offset "density readings" to provide an "individual test result" representing everything except unconfined edges.
10.4	Replace with the following: Maximum contact between the base of the instrument and the surface of the material under test is critical. Since the measured value of density by backscatter is affected by the surface texture of the material immediately under the gauge, a smoothly rolled surface should be tested for best results. A filler of limestone fines or similar material, leveled with the guide/scraper plate, shall be used to fill open surface pores of the rolled surface.
10.5	Replace with the following: Place the source in the proper position. All other radioactive sources shall be kept at least 10 m (30 ft.) from the gauge so the readings will not be affected.
Note 7	Delete
10.6	Delete
10.7	Delete
10.8	Delete
Note 8	Delete
Note 9	Delete

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for
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Reference ASTM D 2950-22

ASTM Section	***Illinois Modification***
11.1	Replace with the following: Determine the in-place density according to the methods stated herein.
11.1.1	Delete.
11.2	Delete.
12.1.1	Replace with the following: Gauge number,
12.1.2	Revise as follows: Date of calibration data,
12.1.5	Revise as follows: Density test site description as follows: (1) project identification number, (2) location, including station and reference to centerline, (3) mixture type(s), including mix design number and surface texture, e.g., open, smooth, roller-tracked, etc., and (4) number and type of rollers
12.1.6	Replace with the following: Layer (bottom lift = .1, second lift = .2, etc.) and thickness of layer,

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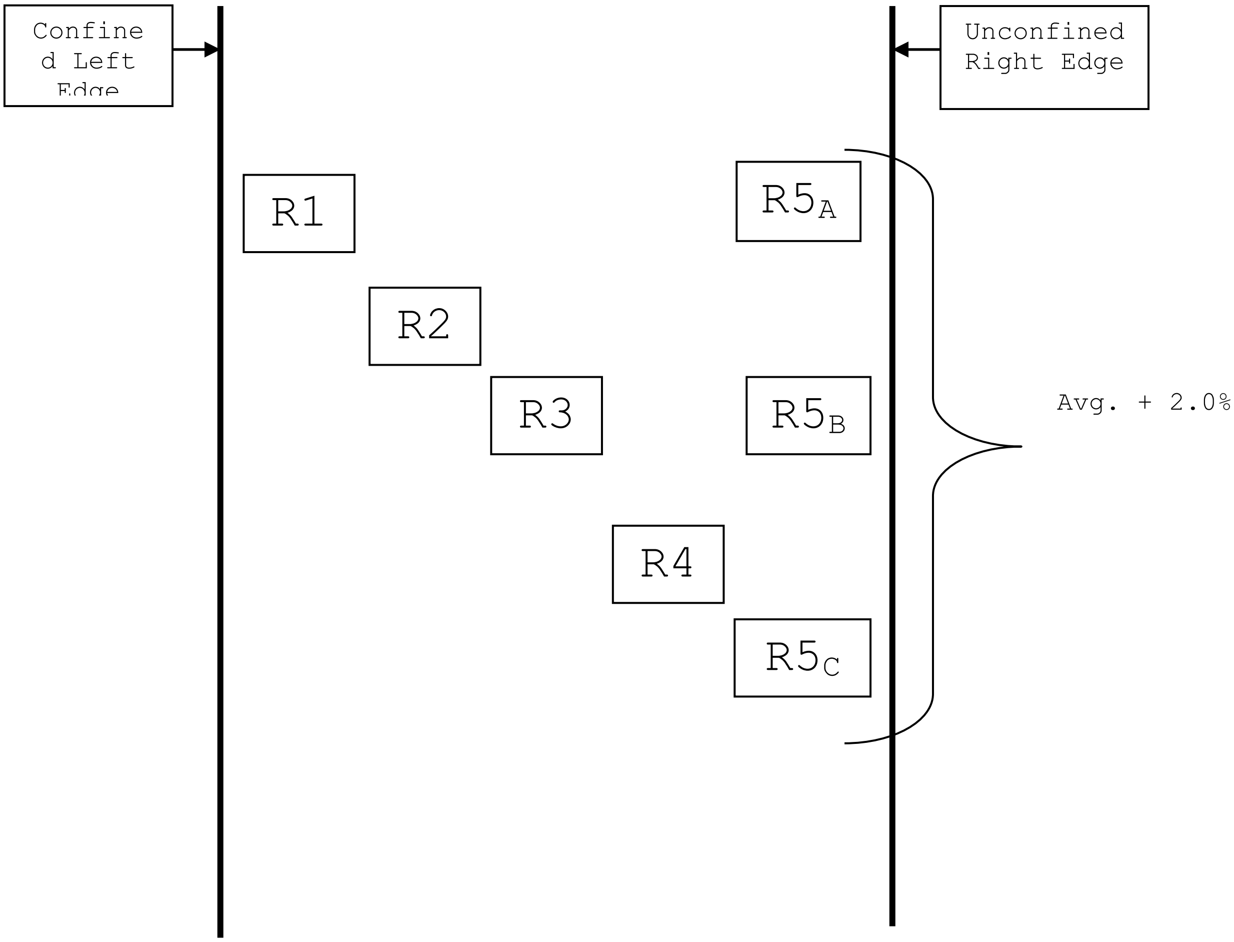
Figure 1.



$$\text{Department Density Verification Test (\%)} = \frac{R1 + R2 + R3 + R4 + \left(\left(\frac{R5_A + R5_B + R5_C}{3}\right) + 2.0\right)}{5}$$

Where R1, R2, R3, R4, $R5_A$, $R5_B$, and $R5_C$ represent nuclear density readings.

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for
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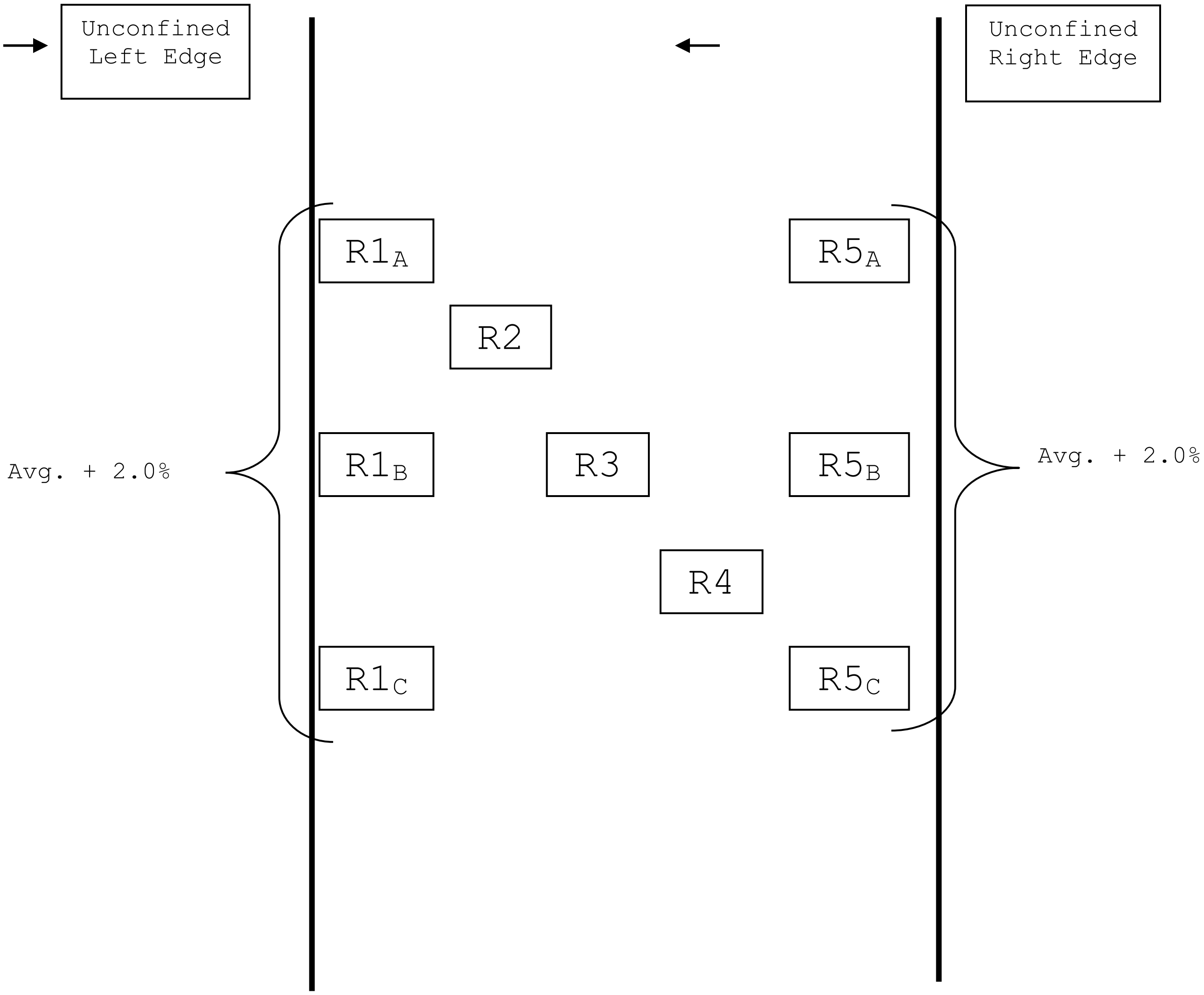
Figure 2.



$$\text{Department Density Verification Test (\%)} = \frac{\left(\left(\frac{R1_A + R1_B + R1_C}{3}\right) + 2.0\right) + R2 + R3 + R4 + \left(\left(\frac{R5_A + R5_B + R5_C}{3}\right) + 2.0\right)}{5}$$

Where $R1_A$, $R1_B$, $R1_C$, R2, R3, R4, $R5_A$, $R5_B$, and $R5_C$ represent nuclear density

Designation: D2950/D2950M – 22

Standard Test Method for Density of Asphalt Mixtures in Place by Nuclear Methods[1]

This standard is issued under the fixed designation D2950/D2950M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method describes a test procedure for determining the density of asphalt mixtures by the attenuation of gamma radiation, where the source and detector(s) remain on the surface (backscatter method) or the source or detector is placed at a known depth up to 300 mm [12 in.] while the detector or source remains on the surface (direct transmission method).

1.2 The density, in mass per unit volume of the material under test, is determined by comparing the detected rate of gamma emissions with previously established calibration data.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.4 All observed and calculated values shall conform to the guide for significant digits and rounding established in Practice D6026.

1.5 For limitations, see Section 5 on Interferences.

1.6 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard. It is the recommendation of Committee D04 that the following note be added to the end of the Significance and Use section of all applicable standards. Applicable standards are those in which measurement or calibration are made, sample are procured, or products are selected. The subcommittee shall determine the appropriateness of adding the note throughout the consensus process.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific warning statements, see Section 7.

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

D8 Terminology Relating to Materials for Roads and Pavements

D1188/D1188M Test Method for Bulk Specific Gravity and Density of Compacted Asphalt Mixtures Using Coated Samples

D2041/D2041M Test Method for Theoretical Maximum Specific Gravity and Density of Asphalt Mixtures

D2726/D2726M Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Asphalt Mixtures

D3665 Practice for Random Sampling of Construction Materials

D3666 Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials

D6026 Practice for Using Significant Digits and Data Records in Geotechnical Data

D6752/D6752M Test Method for Bulk Specific Gravity and Density of Compacted Asphalt Mixtures Using Automatic Vacuum Sealing Method

D6926 Practice for Preparation of Asphalt Mixture Specimens Using Marshall Apparatus

D7013/D7013M Guide for Calibration Facility Setup for Nuclear Surface Gauges

D7759/D7759M Guide for Nuclear Surface Moisture and Density Gauge Calibration

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[1] This test method is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.21 on Specific Gravity and Density of Asphalt Mixtures.

Current edition approved Dec. 15, 2022. Published January 2023. Originally approved in 1971. Last previous edition approved in 2014 as D2950/D2950M – 14. DOI: 10.1520/D2950_D2950M-22.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3. Terminology

3.1 *Definitions*—See Terminology D8 for general definitions.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *detector, n*—a device to detect and measure radiation.

3.2.2 *gamma (radiation) source, n*—a sealed source of radioactive material that emits gamma radiation as it decays.

3.2.3 *nuclear gauge, n*—a device containing one or more radioactive sources used to measure certain properties of asphalt mixtures.

3.2.4 *test count, n*—the measured output of a detector for a specific type of radiation for a given test.

4. Significance and Use

4.1 The test method described is useful as a rapid, nondestructive technique for determining the in-place density of compacted asphalt mixtures.

4.2 With proper calibration and confirmation testing, the test method is suitable for quality control and acceptance testing of compacted asphalt mixtures.

4.3 The test method can be used to establish the proper rolling effort and pattern to achieve the required density.

4.4 The nondestructive nature of the test allows repetitive measurements to be made at a single test location between roller passes and to monitor changes in density.

4.5 The density results obtained by this test method are relative. Correlation with other test methods such as D1188/D1188M, D2726/D2726M, or D6752/D6752M is required to convert the results obtained using this method to actual density. It is recommended that at least seven core densities and seven nuclear densities be used to establish a conversion factor. A new factor must be established at any time a change is made in the paving mixture or in the construction process.

NOTE 1—The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of Specification D3666 are generally considered capable of competent and objective testing, sampling, inspection, etc. Users of this standard are cautioned that compliance with Specification D3666 alone does not completely ensure reliable results. Reliable results depend on many factors; following the suggestions of Specification D3666 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.

5. Interferences

5.1 The chemical composition of the material being tested may significantly affect the measurement, and adjustments may be necessary. Certain elements with atomic numbers greater than 20 may cause erroneously high test values.

5.2 The test method exhibits spatial bias in that the instrument is most sensitive to the density of the material in closest proximity to the nuclear source.

5.2.1 When measuring the density of an overlay, it may be necessary to employ a correction factor if the underlying material varies in thickness, mineral composition, or degree of consolidation at different points within the project. (See Annex A1.)

5.2.2 The surface roughness of the material being tested may cause lower than actual density determination.

5.3 Oversize aggregate particles in the source-detector path may cause higher than actual density determination.

5.4 The sample volume being tested is approximately 0.0028 m^3 [0.0989 ft^3] for the backscatter method and 0.0056 m^3 [0.198 ft^3] for the direct transmission method. The actual sample volume varies with the apparatus and the density of the material.

NOTE 2—The volume of field-compacted material represented by a test can be effectively increased by repeating the test at adjacent locations and averaging the results.

5.5 If samples of the measured material are to be taken for purposes of correlation with other test methods such as D1188/D1188M, D2726/D2726M, or D6752/D6752M, the volume measured can be approximated by a 200 mm [8 in.] diameter cylinder located directly under the center line of the radioactive source and detector(s). The height of the cylinder to be excavated will be the depth setting of the source rod when using the direct transmission method or approximately 75 mm [3 in.] when using the backscatter method (Note 3).

NOTE 3—If the layer of an asphalt mixture to be measured is less than the depth of measurement of the instrument, corrections must be made to the measurements to obtain accurate results due to the influence of the density of the underlying material. (See Annex A1 for the method used.)

6. Apparatus

6.1 *Nuclear Device*—An electronic counting instrument, capable of being seated on the surface of the material under test, and which contains:

6.1.1 *Gamma Source*—A sealed high-energy gamma source such as cesium or radium, and

6.1.2 *Gamma Detector*—Any type of gamma detector such as a Geiger-Mueller tube(s).

6.2 *Reference Standard*—A block of dense material used for checking instrument operation and to establish conditions for a reproducible reference-count rate.

6.3 *Scraper Plate*—A metal plate, straightedge, or other suitable leveling tool which may be used to level the test site to the required smoothness using fine sand or similar material.

6.4 *Drive Pin*—A steel rod of slightly larger diameter than the rod in the direct transmission instrument, to prepare a perpendicular hole in the material under test for inserting the rod. A drill may also be used.

7. Hazards

7.1 This equipment utilizes radioactive materials which may be hazardous to the health of the users unless proper precautions are taken. Users of this equipment must become familiar with applicable safety procedures and government regulations.

7.2 Effective user instructions together with routine safety procedures, such as source leak tests, recording and evaluation of film badge data, etc. are a recommended part of the operational guidelines for the use of this instrument.

7.3 A regulatory agency radioactive materials license may be required to possess this equipment.

8. Calibration

8.1 Calibrate the instrument in accordance to Guides D7759/D7759M and D7013/D7013M.

8.2 *Calibration Adjustments*—The calibration response shall be checked by the user prior to performing tests on materials that are distinctly different from the material types used in establishing the calibration curve. The calibration response shall also be checked on newly acquired or repaired apparatus. Take a sufficient number of measurements and compare them to other accepted methods (such as Test Method D1188/D1188M, D2726/D2726M, or D6752/D6752M) to establish a correlation.

9. Standardization and Reference Check

9.1 Nuclear test devices are subject to long-term aging of the radioactive source, detectors, and electronic systems, which may change the relationship between count rate and material density. To offset this aging, the apparatus may be standardized as the ratio of the measured count rate to a count rate made on a reference standard. The reference count rate should be of the same order of magnitude as the measured count rate over the useful density range of the apparatus.

9.2 Standardization of equipment should be performed at the start of each day's work, and a permanent record of this data retained.

9.2.1 Perform the standardization with the apparatus located at least 10 m [33 ft] away from other sources of radioactivity and clear of large masses or other items which may affect the reference count rate.

NOTE 4—The user is advised that the value given in 9.2.1 is intended as a minimum distance for nuclear sources typical in surface moisture/density gauges. The user should consider requiring a greater distance if other nuclear sources of greater activity are present.

9.2.2 Turn on the apparatus prior to standardization and allow it to stabilize. Follow the manufacturer's recommendations in order to provide the most stable and consistent results.

9.2.3 Using the reference standard, take at least four repetitive readings at the normal measurement period and determine the mean. If available on the apparatus, one measurement period of four or more times the normal period is acceptable. This constitutes one standardization check.

9.2.4 If the value obtained in 9.2.3 is within the following stated limits, the apparatus is considered to be in satisfactory operating condition and the value may be used to determine the count ratios for the day of use. If the value is outside these limits, allow additional time for the apparatus to stabilize, make sure the area is clear of sources of interference, and then conduct another standardization check. If the second standardization check is within the limits, the apparatus may be used, but if it also fails the test, the apparatus shall be adjusted or repaired as recommended by the manufacturer. The limits are as follows:

$$|N_s - N_o| \leq 2.0\sqrt{N_o/F} \qquad (1)$$

where:

N_s = value of current standardization count,
N_o = average of the past four values of N_s taken previously, and
F = value of any prescale.

NOTE 5—The count per measurement periods shall be the total number of gammas detected during the timed period. The displayed value must be corrected for any prescaling which is built into the instrument. The prescale value (F) is a divisor which reduces the actual value for the purpose of display. The manufacturer will supply this value if other than 1.0.

9.3 Use the value of N_s to determine the count ratios for the current day's use of the instrument. If for any reason the measured density becomes suspect during the day's use, perform another standardization check.

NOTE 6—See Annex A2 for more information on evaluating gauge standardization.

10. Procedure

10.1 In order to provide more stable and consistent results: (*1*) turn the instrument on prior to use to allow it to stabilize, and (*2*) leave the power on during the day's testing.

10.2 Standardize the apparatus.

10.3 Select a test location in accordance with the project specifications, or, if not otherwise specified, in accordance with Practice D3665. If the instrument will be closer than 1 m [3 ft] to any vertical mass that may influence the result, follow the instrument manufacturer's correction procedure.

10.4 Maximum contact between the base of the instrument and the surface of the material under test is critical. The maximum void shall not exceed 6 mm [¼ in.]. Use native fines or fine sand to fill the voids and level with the guide/scraper plate.

10.5 For the direct transmission method, use the guide/scraper plate and drive the drive pin to a depth of at least 25 mm [1 in.] deeper than the desired measurement depth.

NOTE 7—Extreme care must be taken when driving the drive pin into a compacted asphalt mixture, as it may cause a disturbance of the material which could cause errors in the measurement. Drilling may be more suitable.

10.6 Place the source in the proper position. For the direct transmission method measurements, move the instrument so that the rod is firmly against the side of the hole in the gamma measurement path.

10.7 Take a count for the normal measurement period. If the backscatter method using the air gap technique is used, take an additional measurement in the air-gap position as recommended by the manufacturer. (See Note 3.)

10.8 Determine the ratio of the reading to the standard count or the air-gap count. From this ratio and the calibration and adjustment data, determine the in-place density. (See Note 8 and Note 9.)

NOTE 8—Some instruments have built-in provisions to compute the ratio, bulk (or wet) density, and allow an adjustment bias.

NOTE 9—If the depth of an asphalt mixture layer under test is less than the depth of measurement of the instrument, the value obtained in 10.8 must be adjusted. (See Annex A1.)

NOTE 10—Do not leave the gauge on a hot surface for more than 1 min after completion of a measurement. Prolonged high temperatures may adversely affect the instrument's electronics. The gauge should be allowed to cool between measurements.

11. Calculation of Results

11.1 Using the calibration chart, calibration tables, or equation and coefficients, or instrument direct readout feature with appropriate calibration adjustments, determine the in-place density. This is the bulk (or wet) density.

11.1.1 An adjustment bias can be calculated by comparing the results from a number of instrument measurements to the results obtained using Test Method D1188/D1188M, D2726/D2726M, or D6752/D6752M.

11.2 Compare the results obtained to samples compacted by Test Method D6926 or with the results of test methods such as D2041/D2041M to determine acceptability (percentage of compaction).

12. Report

12.1 Report the following information:

12.1.1 Make, model, and serial number of the test apparatus,

12.1.2 Date and source of calibration data,

12.1.3 Date of test,

12.1.4 Standard count for the day of the test,

12.1.5 Test site description including project identification number, location, and mixture type(s),

12.1.6 Thickness of layer tested and any adjustment bias,

12.1.7 Method of measurement (backscatter or direct transmission), depth, count rate, calculated density of each measurement and any adjustment data, and

12.1.8 Percentage of compaction, if required.

13. Precision and Bias[3]

13.1 *Precision:*

13.1.1 Precision is based on a field experiment in 2008 that used six gauges from five manufacturers. Materials included Superpave 9.5, 12.5, 19.0, and 37.5 HMA used on a construction project sponsored by the New York DOT. Density varied from 127.8 to 149.1 lb/ft^3 [2047.16 to 2388.35 kg/m^3] with mean of 138.07 lb/ft^3 [2211.68 kg/m^3] and standard deviation 3.9 lb/ft^3 [62.47 kg/m^3]. Each test with a single gauge was conducted by the same operator, therefore, single-operator precision for this statement is also considered to be single-gauge precision if conducted by the same operator.

13.1.2 *Single-Operator Precision*—The single-operator standard deviation has been found to be 1.57 lb/ft^3 [25.15 kg/m^3].[4] Therefore, results of two properly conducted tests by the same operator on the same material should not differ by more than 4.4 lb/ft^3 [70.48 kg/m^3].[4]

13.1.3 *Multilaboratory Precision*—The multilaboratory standard deviation has been found to be 1.75 lb/ft^3 [20.03 kg/m^3].[4] Therefore, results of two properly conducted tests from two different laboratories on the same material should not differ by more than 4.9 lb/ft^3 [78.49 kg/m^3].[4]

13.2 *Bias:*

13.2.1 No information can be presented on the bias of the procedure in Standard Test Method for Density of Asphalt Mixtures in Place by Nuclear Methods for measuring density as no material having an accepted reference value is available.

NOTE 11—With regards to the bias statement above, any user may elect to conduct a comparison of these gauges related to the laboratory measured value from core samples. Gauge measurements should be taken directly on the location of the pavement where cores will be cut.

14. Keywords

14.1 asphalt mixture density; density; in-place density; nuclear test method

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[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D04-1032. Contact ASTM Customer Service at service@astm.org.

[4] These numbers represent, respectively, the (1s) and (d2s) limits as described in Practice C670.

ANNEXES

(Mandatory Information)

A1. DETERMINATION OF DEPTH OF MEASUREMENT

A1.1 The depth of measurement is characteristic of a particular instrument design and may be defined as that depth, measured from the surface, at which a significant change in density will not result in change in the measurement.

A1.1.1 Determine the depth by measuring the apparent density of top layers of uniform density but varying thicknesses placed over a base layer having a highly different density. Vary the thickness of the top layer until a constant density as determined by the instrument is reached (Note A1.2).

NOTE A1.1—For lift thicknesses of 51 mm [2 in.] or less, the backscatter mode is suggested; for lift thicknesses greater than 51 mm [2 in.] the direct transmission mode is suggested. Thin lift gauges can be used for lift thicknesses up to 102 mm [4 in.].

NOTE A1.2—Materials such as magnesium and aluminum in sheet form have proven to be satisfactory for the top layer. Blocks of magnesium and aluminum used as calibration standards are useful as the base material.

A1.1.2 Plot the results on graph paper and determine the depth at which the apparent measured density is equal to the calculated density. This determination should be made for both a lower density material and a higher density material as the top layer. The depth of measurement is the average of the two results.

A2. EVALUATING GAUGE STANDARDIZATION

A2.1 The Poisson distribution of nuclear decay events, the half-life of the isotope used for the measurements, and other electronic and mechanical sources of variance all contribute to the variability and change in gauge standardization counts over time.

A2.2 The purpose of the daily standardization count is twofold: to compensate for the temporal effects on the gauge count rate, and to aid in identifying unacceptable levels of change in gauge response.

A2.3 In-place density properties of the asphalt under test are determined by first dividing the measurement count by the standardization count. The resulting ratio is then used as the dependent variable in the calibration equation to determine the in-place density of the asphalt.

A2.4 Because the ratio described in A2.3 is used to evaluate the aforementioned properties of the asphalt, any sources of multiplicative changes to the nuclear counting properties of the gauge, such as source strength decay over time, are canceled and have little to no effect on gauge measurements.

A2.5 Other phenomena can have additive or subtractive effects on the count rate, however, which can bias the counts and can result in inaccurate measurements by the gauge.

A2.6 Daily standardization counts are initially evaluated as follows:

A2.6.1 The density count taken on a given day is compared to the respective average of the four preceding standardization counts.

A2.6.2 If the density standardization count falls within ±1 % of the average density counts, then the density standardization count is acceptable.

A2.6.3 If the standardization count fails to meet these limits, it is typically because an excessive amount of time has passed between consecutive standardization counts and natural source decay prevents meeting this criteria. Evaluate the density standardization count in the following manner:

A2.7 If the standardization count is outside the limits set by Eq A2.1 and Eq A2.2, repeat the standardization check. If the second standardization check satisfies Eq A2.1, the gauge is considered to be in satisfactory operating condition.

$$0.98(N_{dc})e\frac{-t(\ln(2))}{T_{d(1/2)}} < N_{d0} < 1.02(N_{dc})e\frac{-t(\ln(2))}{T_{d(1/2)}} \quad \text{(A2.1)}$$

where:

$T_{d(1/2)}$ = half-life of the isotope that is used for the density determination in the gauge. For example, for ^{137}Cs, the radioactive isotope most commonly used for density determination in these gauges, $T_{d(1/2)}$, is 11 023 days,
N_{dc} = density system standardization count acquired at the time of the last calibration or verification,
N_{d0} = current density system standardization count,
t = time that has elapsed between the current standardization test and the date of the last calibration or verification. The units selected for t, $T_{d(1/2)}$, and $T_{m(1/2)}$ should be consistent, that is, if $T_{d(1/2)}$ is expressed in days, then t should also be expressed in days,
$ln(2)$ = the natural logarithm of 2, which has a value of approximately 0.69315, and
e = the inverse of the natural logarithm function, which has a value of approximately 2.71828.

A2.7.1 The limits for Eq A2.1 are based on the exponential decay equation for isotopes of a known half-life. They provide a ±2 % range around the theoretical standardization count at the time of the reading based on the standardization count at the time of calibration. This range is based on the expanded uncertainty of the gauge count response for a properly functioning gauge.

A2.7.2 Calibration reports for these gauges typically come with a table that indicates the ±2 % range of density standardization counts for a period of approximately one year after the time of calibration.

A2.7.3 *Example*—A nuclear gauge containing a ^{137}Cs source for density determination (half-life = 11 023 days) is calibrated on March 1 of a specific year. At the time of calibration, the density standard count was 2800 counts per minute (prescaled). According to Eq A2.1, what is the allowed range of standard counts for November 1 of the same year?

A2.7.3.1 For this example, a total of 245 days have elapsed between the date of calibration or verification (March 1) and the date of the gauge standardization (November 1). Therefore:

t = 245 days,
$T_{d(1/2)}$ = 11 023 days,
$T_{m(1/2)}$ = 157 788 days,
N_{dc} = 2800 counts, and
N_{mc} = 720 counts.

A2.7.3.2 According to Eq A2.1, therefore, the lower limit for the density standard count taken on November 1, denoted by N_{d0}, is:

$$0.98(N_{dc})e\frac{-t(\ln(2))}{T_{d(1/2)}} = 0.98(2800)e\frac{-245(\ln(2))}{11\ 023} = 2744e^{-0.01541} = 2702 \text{ counts} \qquad (A2.2)$$

A2.7.3.3 Likewise, the upper limit for the density standard count taken on November 1, denoted by N_{d0}, is:

$$1.02(N_{dc})e\frac{-t(\ln(2))}{T_{d(1/2)}} = 1.02(2800)e\frac{-245(\ln(2))}{11\ 023} = 2856e^{-0.01541} = 2812 \text{ counts} \qquad (A2.3)$$

A2.7.3.4 Therefore, the density standardization count acquired on November 1 should lie somewhere between 2702 and 2812 counts, or $2702 \leq N_{d0} \leq 2812$.

A2.8 If the standardization count fails to meet the limits described in A2.6.2, and additionally the standardization count fails to meet the limits described in A2.7, the functionality of the gauge or the accuracy of the calibration, or both, may be compromised. Under these circumstances, the gauge should be removed from service until the source of the discrepancy can be identified and corrected. Repairs or modifications to the gauge will require verification of the existing calibration of the gauge, or a calibration of the gauge, as described in Guide D7759/D7759M.

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Illinois Department of Transportation

Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations
Appendix B.7

Effective: May 1, 1993
Revised: December 1, 2021

Density quality control and verification tests shall be performed at random test locations based on the frequency specified in Article 1030.09 of the Standard Specifications. The random test locations shall be determined as follows:

1. By the Contractor for quality control using a nuclear density gauge at intervals as specified in 1030.09(b).

   A) The beginning station number shall be established daily and the estimated paving distance computed for the day's production. The total distance to be paved shall then be subdivided into density testing intervals. A minimum of one interval is required for each half day’s production.

   For patching, estimate the number of patches to be completed for each half of the day’s production.

   B) The length of each paving interval shall be multiplied by the three digit random number expressed as a decimal from the "Random Numbers" table on the following page or from the Department's Quality Management Program (QMP) Package. The number obtained shall be added to the beginning station number for the interval to determine the longitudinal test location. This process shall be repeated for the subsequent intervals for the day's production using new random numbers to identify each test location.

   The remaining partial length of paving at the end of each day shall be treated as an interval with the test location determined by multiplying the partial distance by the next random number.

   For patching, multiply each of the estimated half day’s production of patches by the three digit random number. If necessary, round these numbers up to the next whole number. The numbers obtained shall be the patches that shall be tested, starting the count over at each half day’s production.

   C) Nuclear density test sites shall be equally positioned five (5) across all paved mat widths. The outer test sites shall be 4 in. (100 mm) from the edges of the mat. When LJS has been used, the outer test site shall be adjusted in 1 ft (300 mm).

   For patching, only a single test site centered in the randomly selected patch shall be tested.

   D) The average of all nuclear density readings at each location shall be reported on the Department’s MI 303N QC Nuclear Density Report form.

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Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations
Appendix B.7

Effective: May 1, 1993
Revised: December 1, 2021

2. By the Engineer for verification testing using cores or a nuclear density gauge as specified in 1030.09(h). The test location will be the center of the core or nuclear density gauge.

   A) Prior to paving or patching, the random test locations for density will be determined by the Engineer using the random numbers. The values are to be considered confidential and are not to be disclosed to anyone outside of the Department until finish rolling is complete. Once random test locations are determined by the Engineer, it may be necessary to alter the random test locations due to quantity adjustments, sequencing changes, or other alterations made by the Department or Contractor. The Engineer will document any changes to the random test locations.

   B) For all paving, each test location will be randomly determined longitudinally. For paving less than 3 ft (1 m) wide, the transverse location will be centered in the paving width. For paving wider than or equal to 3 ft (1 m), each test location will also be randomly determined transversely within each density testing interval. Each test location will be determined with two random numbers. The first random number is used to determine the longitudinal distance to the nearest 1.0 ft (300 mm) into the density testing interval. The second random number is used to determine the transverse offset to the nearest 0.1 ft (30 mm) from the left edge of the paving. The direction of the paving lane will be the same as the direction of the traffic.

      1) Longitudinal Location: Determine the random longitudinal location by multiplying the length of the prescribed density interval by the random number selected.

      2) Transverse Offset to Center of Core: For paving wider than or equal to 3 ft (1 m), determine the random transverse location by multiplying the width of the paving by the random number selected from the Random Numbers table or the Department’s QMP Package. The effective lane width of the paving lane will be used in calculating the transverse offset. The effective lane width is determined by first subtracting 1.0 ft (300 mm) for each longitudinal joint with LJS from the entire lane width. The effective lane width is then reduced 4.0 in. (100 mm) for each joint that does not have LJS. The effective lane width is further reduced by 4.0 in. (100 mm) for the diameter of the core barrel.

         Effective lane width of pavement = pavement lane width – 1.0 ft (300 mm) for each edge with LJS – 4.0 in. (100 mm) for each edge without LJS – 4.0 in. (100 mm) for core barrel

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The transverse offset is determined by first multiplying the effective lane width by the selected random number. If the left edge is located immediately above LJS, 1.0 ft (300 mm) will be added to the calculated transverse offset measurement. If the left edge is confined but without LJS, 4.0 in. (100 mm) will be added to the calculated transverse offset measurement. An additional 2 in. (50 mm) will be added to the calculated transverse offset measurement to account for the distance from the edge of the core barrel to the center of core. The transverse offset is measured from the left physical edge of the paved lane to locate the center of the core on the pavement.

Transverse Offset to Center of Core = effective lane width x random number + 1.0 ft (300 mm) if left edge has LJS + 4.0 in. (100 mm) if left edge does not have LJS + 2.0 in. (50 mm) for core barrel

Density taken within 1.0 ft (300 mm) from an unconfined edge without LJS will have 2.0% added.

For patching, the random density locations will be determined based on the number of patches estimated for the project multiplied by a random number. If necessary, round any calculated fraction up to the next whole number. The test location will be centered in the patch.

C) The intervals used to determine the random locations for density verification are dependent on mixture use as specified in 1030.09(h).

D) This process shall be repeated for all density intervals on a given project.

E) Moving test locations.

There are two scenarios in which a random test location may be moved longitudinally using the same random transverse offset. The first scenario is to avoid only the obstacles listed in Case 1 below. The second scenario is to avoid pavement defects in the surface being overlaid as described in Case 2 below.

1) Case 1. In the event the random test location has an obstruction that will not allow the necessary compactive effort to be applied, the Engineer will adjust the longitudinal location of the density test in order to avoid the obstacle. Using the same random transverse offset, the test location will be moved longitudinally, ± 15 ft (5 m) to avoid the following obstacles only:

   a) Structures or Bridge Decks
   b) Detection loop or other pavement sensors
   c) Manholes or other utility appurtenances

2) Case 2. In the event there are pavement defects in the surface being overlaid, the Contractor may place temporary markings on the shoulder to identify longitudinal locations where a defect is present. In the case of an asphalt scab (i.e. thin layer of less than 0.5 in. (12 mm) of asphalt pavement remaining after milling) the temporary markings shall show the extent or length of the defect. These pavement defect locations will be approved by the Engineer. If a random test location lands at the same longitudinal location as a temporary mark, the test location will be moved 5 ft (1.5 m) in the direction toward the paver at the same transverse offset.

F) Example Calculations for Identifying Density Verification Test Locations for QC/QA Paving and Patching Projects.

Example 1.

This example illustrates the determination of density verification test locations for a QC/QA overlay project.

Given: A mixture is to be paved as a 6.0 ft wide shoulder 3.5 in. thick for 1 mile with LJS placed at the pavement/shoulder joint.

This paving thickness will require a density testing interval of 0.2 miles. The shoulder consists of a 6.0 ft-wide mat with the left edge confined with LJS and the right edge unconfined without LJS. The random numbers selected for the longitudinal direction are: 0.904, 0.231, 0.517, 0.253, and 0.040. The random numbers for the transverse direction are: 0.003, 0.052, 0.998, 0.510 and 0.109.

The individual longitudinal density test interval distances can be converted to the cumulative random distance using the following equation:

$$CD_n = [D \times (n-1)] + R_n$$

Where:

n = the density interval number
CD = cumulative distance
D = density testing interval length (typically 1056 ft (0.2 mile))
R = random distance within the given density testing interval

The longitudinal locations are determined by multiplying the longitudinal random numbers by 1056 ft (0.2 mile). The transverse offsets are determined by multiplying the transverse random number by the width of the paving minus 1.0 ft for the left edge confined with LJS (5.0 ft).

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Determine the effective shoulder width by subtracting 1.0 ft for each edge with LJS and 4.0 in. (0.33 ft) for each edge without LJS from the 6.0 ft paved shoulder width. In this case the right edge of the shoulder is unconfined without LJS, so subtract 4.0 in. (0.33 ft), and the left edge is confined with LJS so subtract 1.0 ft. Then subtract 4.0 in. (0.33 ft) for the width of the core barrel.

Effective Shoulder Width = 6.0 ft - 1.0 ft - 0.33 ft – 0.33 ft = 4.34 ft

The calculated transverse offset distances are determined by multiplying the effective shoulder width of 4.34 ft by the random numbers and adding 1.0 ft for the left confined edge with LJS plus 2.0 in. (0.17 ft) for the core barrel (1.0 ft + 0.17 ft = 1.17 ft). The random locations for the first mile measured from the beginning of the lot and the left edge of the paved shoulder to the center of the core barrel are as follows:

Test Site #	Random Distance	Cumulative Distance	Center of Core Transverse Location [1/]
1	1056 x 0.904 = 955 ft	1056 x (1-1) + 955 = 955 ft	(4.34 x 0.003) + 1.17 = 1.2 ft
2	1056 x 0.231 = 244 ft	1056 x (2-1) + 244 = 1300 ft	(4.34 x 0.052) + 1.17 = 1.4 ft
3	1056 x 0.517 = 546 ft	1056 x (3-1) + 546 = 2658 ft	(4.34 x 0.998) + 1.17 = 5.5 ft
4	1056 x 0.253 = 267 ft	1056 x (4-1) + 267 = 3435 ft	(4.34 x 0.510) + 1.17 = 3.4 ft
5	1056 x 0.040 = 42 ft	1056 x (5-1) + 42 = 4266 ft	(4.34 x 0.109) + 1.17 = 1.6 ft

1/ Transverse location of the center of the core measured from the left physical edge of the shoulder.

Example 2.

This example illustrates the determination of density verification test locations for a QC/QA widening project.

Given: A mixture is to be paved as a 2.0 ft wide shoulder 1.5 in. thick for 4 miles.

This paving width will require a density testing interval of 1 mile. The shoulder consists of a 2.0 ft wide mat with the left edge confined and the right edge unconfined. No LJS was used. The random numbers for the longitudinal direction are: 0.821, 0.345, 0.623 and 0.140. As the paving is less than 3 ft, the transverse location will be centered.

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Effective: May 1, 1993
Revised: December 1, 2021

The individual density test interval distances can be converted to the cumulative random distance using the following equation:

$$CD_n = [D \times (n-1)] + R_n$$

Where:

n = the density interval number
CD = cumulative distance
D = density testing interval length (1 mile)
R = random distance within the given density testing interval

The longitudinal locations are determined by multiplying the longitudinal random numbers by 5,280 ft (1 mile). The transverse offsets are determined by dividing the width of the paving in half (by 2).

The random locations measured from the beginning of shoulder paving and the left (confined) edge of the paved mat to the center of the nuclear gauge are as follows:

Test Site #	Random Distance	Cumulative Distance	Transverse Location
1	5280 x 0.821 = 4,335 ft	5280 x (1-1) + 4,335 = 4,335 ft	2.0 / 2 = 1.0 ft
2	5280 x 0.345 = 1,822 ft	5280 x (2-1) + 1,882 = 7,162 ft	2.0 / 2 = 1.0 ft
3	5280 x 0.623 = 3,289 ft	5280 x (3-1) + 3,289 = 13,849 ft	2.0 / 2 = 1.0 ft
4	5280 x 0.140 = 739 ft	5280 x (4-1) + 739 = 16,579 ft	2.0 / 2 = 1.0 ft

Example 3.

This example illustrates the determination of density verification test locations for a QC/QA patching project.

Given: On an 8 mile full-depth patching project it is estimated that 140 patches will be constructed.

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Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations
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Effective: May 1, 1993
Revised: December 1, 2021

Patching projects require 1 nuclear density test for every 50 patches. The first random number is 0.289. The second is 0.760 and the third 0.444. The individual density test interval distance can be converted to the cumulative random patch using the following equation:

$$CP_n = [D \times (n-1)] + P_n$$

Where:

n = the density interval number
CP = cumulative patch
D = density testing interval (typically 50 patches)
P = random patch within the given density testing interval

The longitudinal locations are determined by multiplying the longitudinal random numbers by 50 patches or when less than 50 patches remain, the number of remaining patches. The test location is then centered in the identified patch.

Nuclear #	Random Patch[1]	Cumulative Patch	Transverse Location
1	50 x 0.289 = 15	50 x (1-1) + 15 = 15	Center of patch
2	50 x 0.760 = 38	50 x (2-1) + 38 = 88	Center of patch
3	40 x 0.444 = 18	50 x (3-1) + 18 = 118	Center of patch

1/ If necessary, round any calculated fraction up to the next whole number.

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Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations
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RANDOM NUMBERS

0.576	0.730	0.430	0.754	0.271	0.870	0.732	0.721	0.998	0.239
0.892	0.948	0.858	0.025	0.935	0.114	0.153	0.508	0.749	0.291
0.669	0.726	0.501	0.402	0.231	0.505	0.009	0.420	0.517	0.858
0.609	0.482	0.809	0.140	0.396	0.025	0.937	0.301	0.253	0.761
0.971	0.824	0.902	0.470	0.997	0.392	0.892	0.957	0.040	0.463
0.053	0.899	0.554	0.627	0.427	0.760	0.470	0.040	0.904	0.993
0.810	0.159	0.225	0.163	0.549	0.405	0.285	0.542	0.231	0.919
0.081	0.277	0.035	0.039	0.860	0.507	0.081	0.538	0.986	0.501
0.982	0.468	0.334	0.921	0.690	0.806	0.879	0.414	0.106	0.031
0.095	0.801	0.576	0.417	0.251	0.884	0.522	0.235	0.389	0.222
0.509	0.025	0.794	0.850	0.917	0.887	0.751	0.608	0.698	0.683
0.371	0.059	0.164	0.838	0.289	0.169	0.569	0.977	0.796	0.996
0.165	0.996	0.356	0.375	0.654	0.979	0.815	0.592	0.348	0.743
0.477	0.535	0.137	0.155	0.767	0.187	0.579	0.787	0.358	0.595
0.788	0.101	0.434	0.638	0.021	0.894	0.324	0.871	0.698	0.539
0.566	0.815	0.622	0.548	0.947	0.169	0.817	0.472	0.864	0.466
0.901	0.342	0.873	0.964	0.942	0.985	0.123	0.086	0.335	0.212
0.470	0.682	0.412	0.064	0.150	0.962	0.925	0.355	0.909	0.019
0.068	0.242	0.777	0.356	0.195	0.313	0.396	0.460	0.740	0.247
0.874	0.420	0.127	0.284	0.448	0.215	0.833	0.652	0.701	0.326
0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.876	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.777	0.491	0.523	0.665	0.919	0.146
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.281	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.454	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.659	0.463	0.994	0.307	0.631	0.422
0.116	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939
0.636	0.195	0.614	0.486	0.629	0.663	0.619	0.007	0.296	0.456
0.630	0.673	0.665	0.666	0.399	0.592	0.441	0.649	0.270	0.612
0.804	0.112	0.331	0.606	0.551	0.928	0.830	0.841	0.702	0.183
0.360	0.193	0.181	0.399	0.564	0.772	0.890	0.062	0.919	0.875
0.183	0.651	0.157	0.150	0.800	0.875	0.205	0.446	0.648	0.685

Note: Always select a new set of numbers in a systematic manner, either horizontally or vertically. Once used, the set should be crossed out.

HOT-MIX ASPHALT QC/QA RANDOM DENSITY LOCATIONS

Example: The Contractor is paving a distance of 1.9 miles today at a thickness of 2 inches.

1. **At what frequency will the Contractor take random tests?** ___________ ft.

Calculation to determine the number of station locations

- _________________ miles X 5280 ft/mile = _______________ feet.
  (distance to be paved) (distance to be paved in feet.)
- ________________ ÷ _________________ = ________________
  (dist. to be paved in feet) (frequency of tests in feet) (number of tests needed to the nearest tenth.)
- How many total tests will be needed? ________________

Calculate the length of the partial unit

- ________________ X _________________ = ________________ feet.
  (partial unit length in decimal form) (frequency of tests in feet) (length of partial unit)

2. Calculate the stations for the required tests.

1 mile =________ feet ½ mile = _________ feet 1 Station = 100 feet = 1 +00

If the beginning station is 2+00 for the days paving, calculate the beginning and ending stations for each area.

____________ (Length of Area 1)	____________ (Length of Area 2)	____________ (Length of Area 3)	____________ (Length of Area 4)
Area 1	Area 2	Area 3	Area 4

_____+_____ _____+______ ______+_____ ______+_____ ______+_____

Area 1 __________ × ______feet = _________feet
(Random) (Length) (Dist into Area)

_________feet +____________feet =_____________=Sta____________
(Dist into Area) (Beg Sta of Area in feet) (Total feet)

Area 2 __________ × ______feet = _________feet
(Random) (Length) (Dist into Area)

_________feet +____________feet =_____________= Sta____________
(Dist into Area) (Beg Sta of Area in feet) (Total feet)

Area 3 __________ × ______feet = _________feet
(Random) (Length) (Dist into Area)

_________fee t+ ____________feet =_____________= Sta____________
(Dist into Area) (Beg Sta of Area in feet) (Total feet)

Area 4 __________ × ______feet = _________feet
(Random) (Length) (Dist into Area)

_________feet +____________feet =_____________= Sta____________
(Dist into Area) (Beg Sta of Area in feet) (Total feet)

Notes:

1) See page 4-51 for layout of random density test site locations with a nuclear gauge or cores on Hot-Mix Asphalt, which requires different configurations based on confined/unconfined longitudinal joints. Refer to Article 1030.09 Section (b) (1) Required Density Tests, Paving.

2) A failing nuclear density test requires a resample half way between the failed test and finish roller location.

3) IDOT QC/QA software package will calculate the station locations or your random densities for you if you wish it to do so.

New Nuclear Density Test Site Locations Specification

Random Test Determination Layout

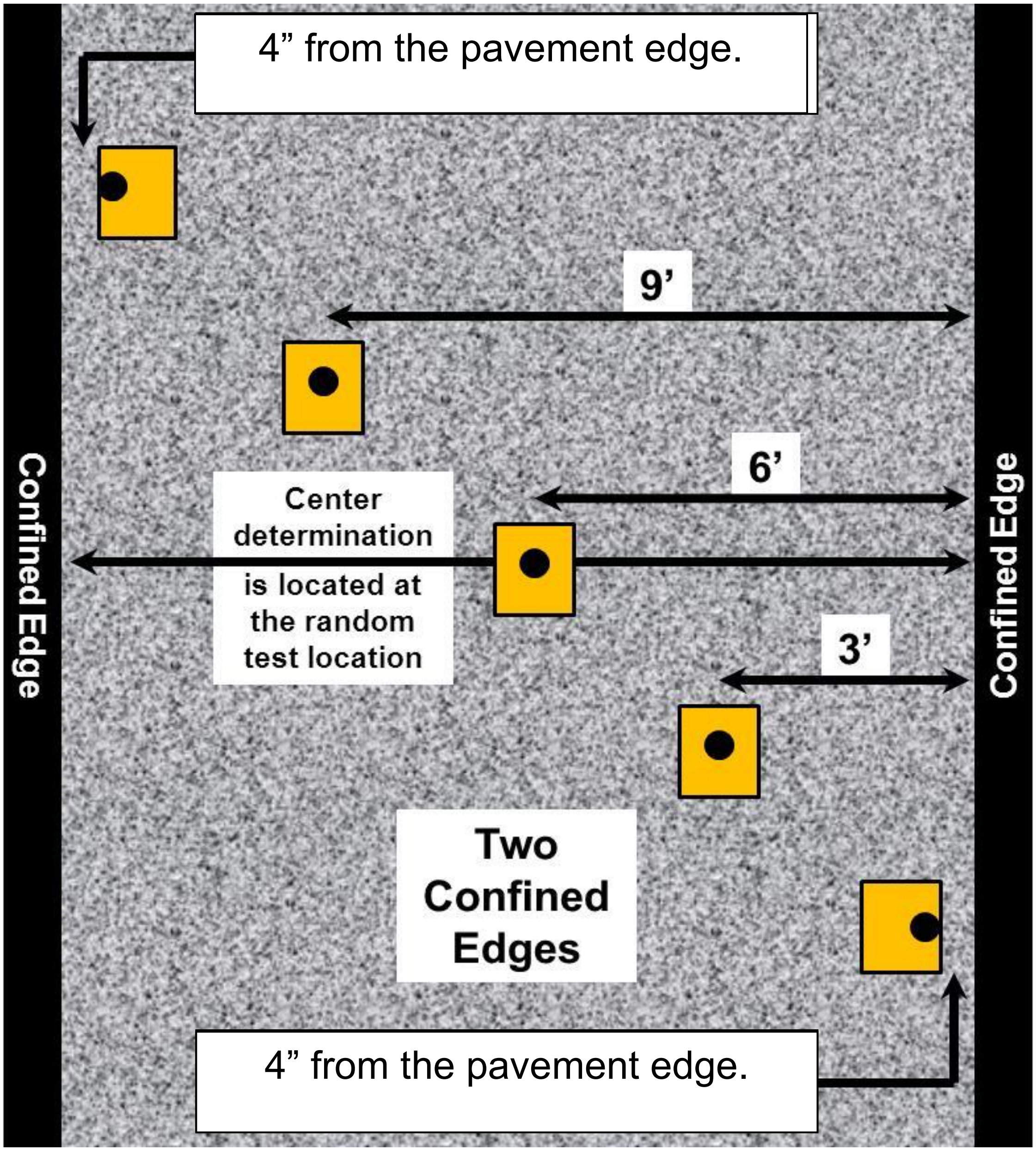
Nuclear density testing will be completed by cutting cores or using a correlated nuclear density gauge at random locations provided by the contractor or IDOT inspector. Density testing will include determinations diagonally across the center of the mat and longitudinally on the outside edges. The layout configuration and density control limits at each test location is dependent upon whether the lifts of HMA being placed have confined (typically an inlay) or unconfined edges.

All nuclear density longitudinal test determinations, confined or unconfined, will be located at 4 in. (100 mm), from the edge of the nuclear density gauge or edge of the core from the pavement edge.

Random Test Determination Layout for Two Confined Edges (Inlay)

When testing a random test location located in an inlay or in an area with two confined edges, a total of five determinations will be taken or five cores will be cut diagonally across the mat at the required layout locations. The results of all five determinations or cores are averaged to achieve one individual test which is required to meet the Density Control Limits for the mixture being tested.

A total of five nuclear density determinations will be taken or five cores will cut at this location. One density requirement is to be met in this situation.



Random Test Determination Layout for One Confined Edge

When testing a mat with one confined edge:

1. Either four determinations will be taken or four cores will be cut, diagonally across the mat, at the required layout locations on the side nearest to the confined edge.

   The results of these four nuclear density determinations or cut cores will be averaged to achieve one individual test result which is required to meet the Density Control Limits for the mixture being tested as an “Individual Test (includes confined edges)” specification.

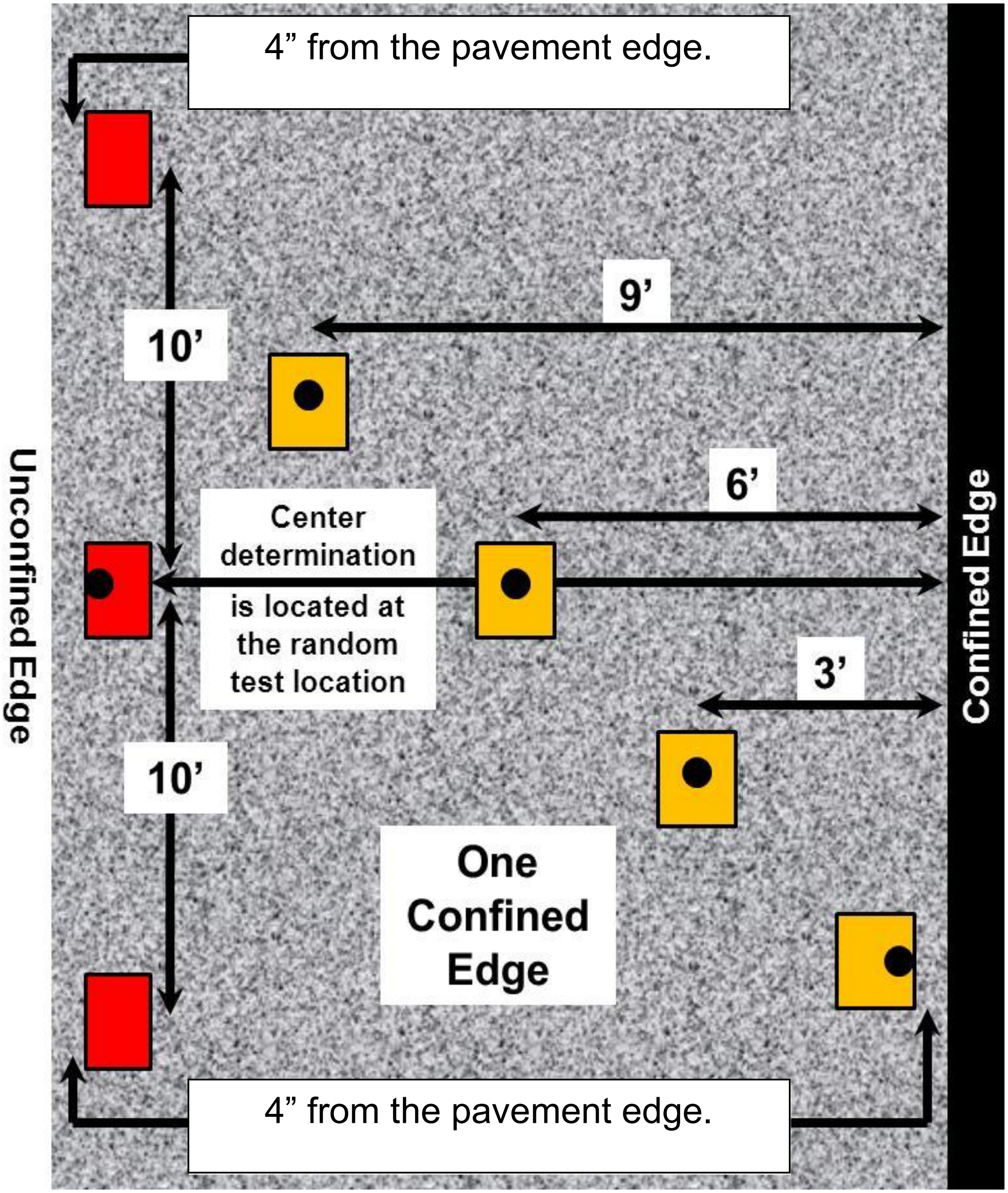
2. When testing with a nuclear density gauge, a total of three determinations will be taken longitudinally along the unconfined edge of the pavement at the required layout locations.

   The middle determination will be located at the random test location and the other two determinations will be spaced longitudinally apart in line with the middle determination at the required layout locations.

   The results of the three determinations will be averaged to achieve one individual test which is required to meet the Density Control Limits for the mixture being tested for as an “Unconfined Edge Joint Density Minimum” specification.

3. When cutting cores, a single core (the middle determination from #2) will be cut at the required layout location. This single core will be required to meet the Density Control Limits for the mixture being tested for as an “Unconfined Edge Joint Density Minimum” specification.

A total of seven nuclear density determinations or five cores will be taken at this location. Two separate density requirements are to be met in this situation, one for the four confined locations and one the unconfined edge.


4” from the pavement edge.
10’
9’
Unconfined Edge
6’
Center determination is located at the random test location
Confined Edge
3’
10’
One Confined Edge
4” from the pavement edge.

Random Test Determination Layout for Two Unconfined Edges

When testing a mat with two unconfined edges:

1. Either three nuclear density determinations will be taken or three cores will be cut, diagonally, at the required layout locations in the center of the mat.

   The results of these three nuclear density determinations or cut cores will be averaged to achieve one individual test result which is required to meet the Density Control Limits for the mixture being tested as an “Individual Test (includes confined edges)” specification.

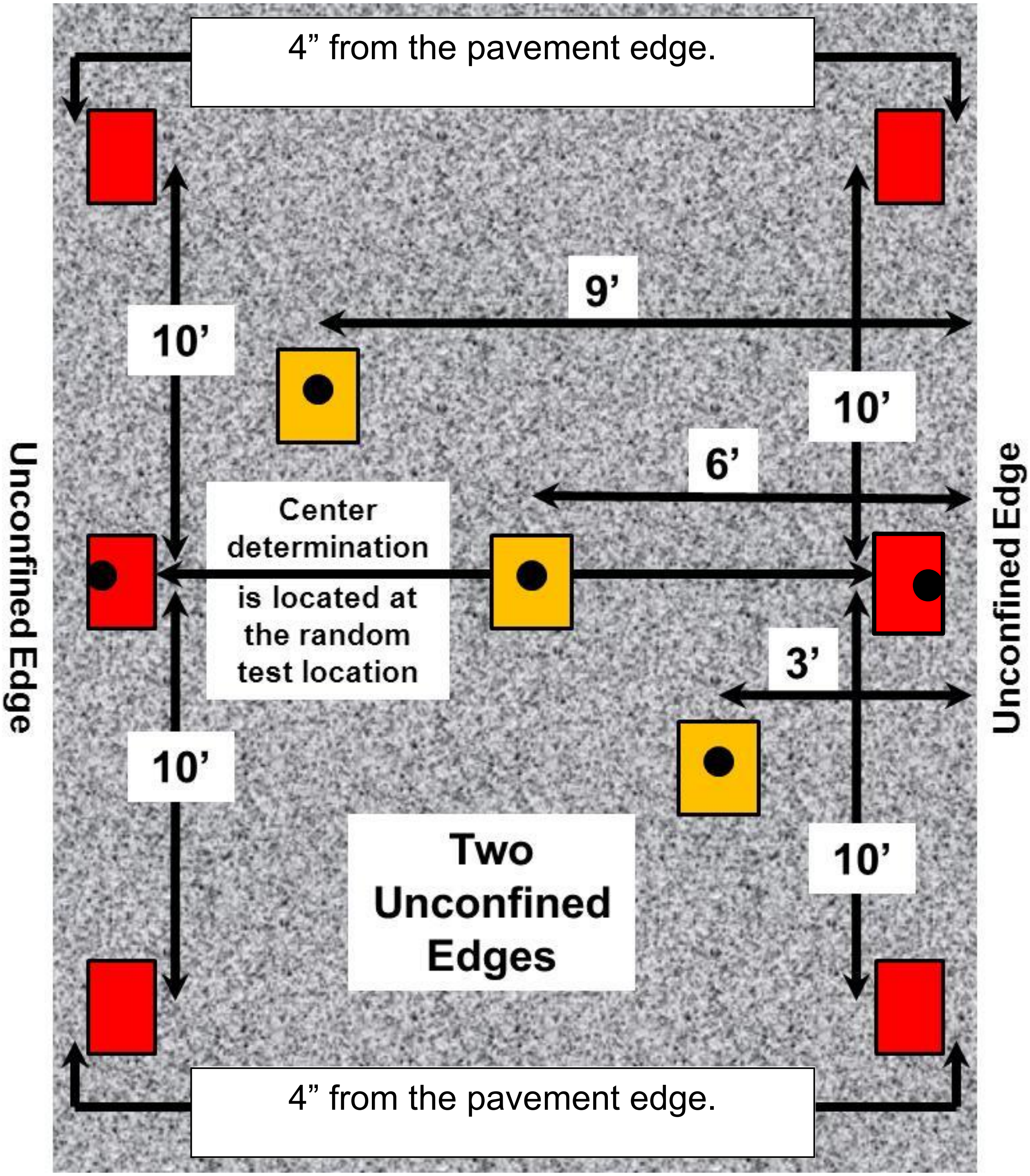
2. When testing with a nuclear density gauge, a total of three determinations will be taken longitudinally along each unconfined edge of the pavement at the required layout locations.

   The middle determination will be located at the random test location and the other two determinations will be spaced longitudinally apart in line with the middle determination at the required layout locations on the pavement edges.

   The results of the three determinations, on one side of the pavement, will be averaged to achieve one individual test which is required to meet the Density Control Limits for the mixture being tested for as an “Unconfined Edge Joint Density Minimum” specification. Each unconfined edge has its own requirement to meet.

3. When cutting cores, a single core (the middle determination) will be cut at the required layout location on each pavement edge. Each single core will be required to meet the Density Control Limits for the mixture being tested for as an “Unconfined Edge Joint Density Minimum” specification separately for each pavement edge.

A total of nine nuclear density determinations or five cores will be taken at this location. Three separate density requirements are to be met in this situation, one for the center pavement location and one on each of the unconfined edges.


4” from the pavement edge.
9’
10’
10’
6’
Center determination is located at the random test location
3’
10’
10’
Two Unconfined Edges
Unconfined Edge
Unconfined Edge
4” from the pavement edge.

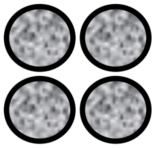
This Page Is Reserved

Density Requirements for cores for PFP and QCP

PFP (> 8000 tons) – Density Requirements

- Lift thickness equal to or less than 3 in. every 0.2 miles (320 m) or 1056 ft.
- Lift thickness greater than 3 in. every 0.1 miles (160 m) or 528 ft.

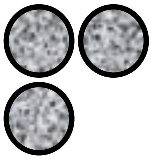
Four cores are taken at the designated random site determined by the Engineer. (1 for District, 1 for Contractor, 1 for backup and 1 for dispute)



QCP (1200 - 8000 tons) – Density Requirements

- Lift thickness equal to or less than 3 in. every 0.2 miles (320 m) or 1056 ft.
- Lift thickness greater than 3 in. every 0.1 miles (160 m) or 528 ft.

Three cores are taken at the designated random site determined by the Engineer. (1 for District, 1 for Contractor, 1 for backup)



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Hot-Mix Asphalt PFP and QCP Procedure for Determining Random Density Locations
Appendix E.3

Effective Date: April 1, 2009
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Random density test locations will be determined at the frequency specified in the Standard Specification Articles 1030.07 and 1030.08. Cores shall be collected by the Contractor at these locations and secured by the Department for testing. The test locations will be determined as follows:

F) Prior to paving, the test locations will be determined by the Engineer using the “Random Numbers” table as specified herein or the Department’s Quality Management Program (QMP) Package software. The values are to be considered confidential and are not to be disclosed to anyone outside of the Department until finish rolling is complete. Disclosing the information prior to finish rolling would be in direct violation of federal regulations. Once random test locations are determined by the Engineer, it may be necessary to alter these locations due to quantity adjustments, sequencing changes, or other alterations made by the Department or Contractor. The Engineer will document any changes to the random test locations and provide documentation to the Contractor upon completion of the project.

Each test location will be randomly located both longitudinally and transversely within each density interval by using two random numbers. The first random number is used to determine the longitudinal distance to the nearest 1 ft (300 mm) into the density testing interval. The second random number is used to determine the transverse offset to the nearest 0.1 ft (30 mm) from the left edge of the **paving lane**. The direction of the **paving lane** will be the same as the direction of traffic.

Longitudinal Location: Determine the random longitudinal location by multiplying the length of the prescribed density interval by the random number selected from the Random Numbers table.

Transverse Offset to Center of Core: Determine the random transverse offset as follows:

1. PFP. The effective lane width of the paving lane will be used in calculating the transverse offset. The effective lane width is determined by first subtracting 1.0 ft (300 mm) for each unconfined edge from the entire paved lane width (i.e. If a 12.0 ft (3.7 m) wide paved lane has two unconfined edges, the effective lane width would be 10.0 ft (3.0 m).) The effective lane width is reduced by 1.0 ft (300 mm) for each confined longitudinal joint with longitudinal joint sealant (LJS) (i.e. If a 12.0 ft (3.7 m) wide paved lane has one unconfined edge without LJS and one confined edge with LJS, the effective lane width would be 10.0 ft (3.0 m).) The effective lane width is reduced by 4.0 in. (100 mm) for each confined edge without LJS. The effective lane width is further reduced 4.0 in. (100 mm) for the diameter of the core barrel.

> Effective lane width of PFP pavement = pavement lane width – 1.0 ft (300 mm) for each unconfined/LJS edge – 4.0 in. (100 mm) for each confined non LJS edge – 4.0 in. (100 mm) for core barrel

The transverse offset is determined by first multiplying the effective lane width by the selected random number. If the left edge is unconfined or located immediately above LJS, 1.0 ft (300 mm) will be added to the calculated transverse offset measurement. If the left edge is confined but without LJS, 4.0 in. (100 mm) will be added to the calculated transverse offset measurement. An additional 2 in. (50 mm) will be added to the calculated transverse offset measurement to account for the distance from the edge of the core barrel to the center of core. The transverse offset is measured from the left physical edge of the paved lane to locate the center of the core on the pavement.

> Transverse Offset to Center of Core = effective lane width x random number + 1.0 ft (300 mm) if left edge is unconfined/LJS edge + 4.0 in. (100 mm) if left edge is confined non LJS edge + 2.0 in. (50 mm) for core barrel

Areas outside the mainline pavement that are paved concurrently with the mainline pavement (i.e. 3 ft (1 m) wide shoulders, driveways, etc.) are not considered part of the paved mainline mat. See the PFP example calculation herein.

Additionally, the longitudinal joint density test locations of a paved lane with one or both unconfined edges without LJS will be determined by multiplying each sublot length for each unconfined, non-LJS edge by a random number. The transverse locations of the longitudinal joint density coring will be centered at a distance of 4.0 in. (150 mm) plus 2.0 in. (50 mm) (to account for the distance from the edge of the core barrel to the center of core) from each unconfined, non-LJS edge. See the PFP example calculation herein.

2. QCP. The effective lane width of the paving lane will be used in calculating the transverse offset. The effective lane width is determined by first subtracting 1.0 ft (300 mm) for each longitudinal joint with LJS from the entire lane width. The effective lane width is then reduced 4.0 in. (100 mm) for each joint that does not have LJS. The effective lane width is further reduced by 4.0 in. (100 mm) for the diameter of the core barrel.

> Effective lane width of QCP pavement = pavement lane width – 1.0 ft (300 mm) for each edge with LJS – 4.0 in. (100 mm) for each edge without LJS – 4.0 in. (100 mm) for core barrel

The transverse offset is determined by first multiplying the effective lane width by the selected random number. If the left edge is located immediately above LJS, 1.0 ft (300 mm) will be added to the calculated transverse offset measurement. If the left edge is confined but without LJS, 4.0 in. (100 mm) will be added to the calculated transverse offset measurement. An additional 2 in. (50 mm) will be added to the calculated transverse offset measurement to account for the distance from the edge of the core barrel to the center of core. The transverse offset is measured from the left physical edge of the paved lane to locate the center of the core on the pavement.

Transverse Offset to Center of Core = effective lane width x random number + 1.0 ft (300 mm) if left edge has LJS + 4.0 in. (100 mm) if left edge does not have LJS + 2.0 in. (50 mm) for core barrel

Cores taken within 1.0 ft (300 mm) of an unconfined edge without LJS will have 2.0% density added for pay adjustment calculation purposes. See the QCP example calculation herein.

G) This process will be repeated for all density intervals on a given project.

H) Moving Test Locations.

There are two scenarios in which random test locations may be moved longitudinally using the same random transverse offset. The first scenario is to avoid only the obstacles listed under Case 1 below. The second scenario is to avoid pavement defects in the surface being overlaid as described in Case 2 below.

1) Case 1. In the event the random test location will not allow the necessary compactive effort to be applied, the Engineer will adjust the longitudinal location of the test location in order to avoid the obstacle. Using the same random transverse offset, the test location will be moved longitudinally, ± 15 ft (4.6 m) to avoid the following obstacles only:

   a) Structures or Bridge Decks
   b) Detection loop or other pavement sensors
   c) Manholes or other utility appurtenances

2) Case 2. In the event there are pavement defects in the surface being overlaid, the Contractor may place temporary markings on the shoulder prior to paving to represent longitudinal locations where a defect is present. These pavement defect locations will be approved by the Engineer. If a random test location lands at the same longitudinal location as a temporary mark, the test location will be moved 5 ft (1.5 m) past the temporary mark in the direction toward the paver at the same transverse offset. In the case of an asphalt scab (i.e. thin layer of less than 0.5 in. (13 mm) of asphalt pavement remaining after milling) the temporary markings shall show the extent or length of the defect. The test location will then be moved to a longitudinal distance 5 ft (1.5 m) past the end of the defect toward the paver.

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I) Example Calculations.

PFP Example.

This **PFP** example illustrates the determination of the random test locations within the first mile of a lot.

Given: The HMA pavement consists of a 13.0 ft wide mat 1.5 in. thick with the left edge confined without LJS and the right edge unconfined without LJS.

This will require a density testing interval of 0.2 miles. The random numbers for the longitudinal direction are: 0.917, 0.289, 0.654, 0.347, and 0.777. The random numbers for the transverse direction are: 0.890, 0.317, 0.428, 0.998, and 0.003.

The individual longitudinal density test interval distances can be converted to the cumulative random distance using the following equation:

$$CD_n = [D \times (n-1)] + R_n$$

Where:

n = the density interval number
CD = cumulative distance
D = density testing interval length (typically 1056 ft (0.2 mile))
R = random distance within the given density testing interval

The longitudinal test locations are determined by multiplying the longitudinal random numbers by 1056 ft (0.2 mile). The transverse core locations are determined by multiplying the transverse random number by the effective width of the paved mat.

Determine the effective lane width by subtracting 1.0 ft for each unconfined edge and 4.0 in. (0.33 ft) for each confined edge without LJS from the 13.0 ft paved lane width. In this case the right edge is unconfined, so subtract 1.0 ft (1.0 ft), and the left edge is confined without LJS so subtract 4.0 in. (0.33 ft). Then subtract 4.0 in. (0.33 ft) for the width of the core barrel.

Effective Lane Width = 13.0 ft - 1.0 ft - 0.33 ft – 0.33 ft = 11.34 ft

The calculated transverse offset distances are determined by multiplying the effective lane width of 11.34 ft by the random numbers and adding 4.0 in. (0.33 ft) for the left confined edge plus 2.0 in. (0.17 ft) for the core barrel (0.33 ft + 0.17 ft = 0.5 ft). The random locations for the first mile measured from the beginning of the lot and the left (confined) edge of the paved mat to the center of the core barrel are as follows (See Figure 1):

Core #	Longitudinal Location	Cumulative Distance	Center of Core Transverse Location[1/]
1	1056 x 0.917 = 968 ft	1056 x (1-1) + 968 = 968 ft	(11.34 x 0.890) + 0.5 = 10.6 ft
2	1056 x 0.289 = 305 ft	1056 x (2-1) + 305 = 1361 ft	(11.34 x 0.317) + 0.5 = 4.1 ft
3	1056 x 0.654 = 691 ft	1056 x (3-1) + 691 = 2803 ft	(11.34 x 0.428) + 0.5 = 5.4 ft
4	1056 x 0.347 = 366 ft	1056 x (4-1) + 366 = 3534 ft	(11.34 x 0.998) + 0.5 = 11.8 ft
5	1056 x 0.777 = 821 ft	1056 x (5-1) + 821 = 5045 ft	(11.34 x 0.003) + 0.5 = 0.5 ft

1/ Transverse location of the center of the core measured from the left physical edge of the paved lane.

Additionally, there will be two longitudinal joint density sublots in the unconfined right edge within the mile section, each sublot 0.5 mile (2640 ft). The random numbers to determine the locations for coring are: 0.822 and 0.317.

Sublot #	Core #	Longitudinal Location	Cumulative Distance	Center of Core Transverse Location[1/]
1	1	2640 x 0.822 = 2170 ft	2640 x (1-1) + 2170 = 2170 ft	6.0 in.
2	2	2640 x 0.317 = 837 ft	2640 x (2-1) + 837 = 3477 ft	6.0 in.

1/ Transverse location of the center of the core measured from the right physical edge of the paved lane.

QCP Example.

This **QCP** example illustrates the determination of the core locations within the first mile of a project.

Given: The pavement consists of a 13.0 ft wide mat 1.5 in. thick with the left edge confined with LJS and the right edge unconfined without LJS.

This will require a density testing interval of 0.2 miles. The random numbers for the longitudinal direction are: 0.904, 0.231, 0.517, 0.253, and 0.040. The random numbers for the transverse direction are: 0.007, 0.059, 0.996, 0.515, and 0.101.

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The individual density test interval distances can be converted to the cumulative random distance using the following equation:

$$CD_n = [D \times (n-1)] + R_n$$

Where:

n = the density interval number
CD = cumulative distance
D = density testing interval length (typically 1056 ft (0.2 mile))
R = Random distance within the given density testing interval

The longitudinal core locations are determined by multiplying the longitudinal random numbers by 1056 ft (0.2 mile).

The transverse core locations are determined by multiplying the transverse random numbers by the effective lane width. The effective lane width is the width of the paved lane minus 1.0 ft for the left edge confined with LJS, 4.0 in (0.33 ft) for the right edge without LJS, and 4.0 in. (0.33 ft) for the core barrel.

Effective Lane Width = 13.0 ft - 1.0 ft - 0.33 ft – 0.33 ft = 11.34 ft

The calculated transverse offset distances are determined by multiplying the effective lane width by the random numbers and adding 1.0 ft for the left confined edge with LJS plus 2.0 in. (0.17 ft) for the core barrel (1.0 ft + 0.17 ft = 1.17 ft). The random locations for the first mile measured from the beginning of the lot and the left (confined) edge of the paved mat to the center of the core barrel are as follows:

Core #	Longitudinal Location	Cumulative Distance	Center of Core Transverse Location[1/]
1	1056 x 0.904 = 955 ft	1056 x (1-1) + 955 = 955 ft	(11.34 x 0.007) + 1.17 = 1.2 ft
2	1056 x 0.231 = 244 ft	1056 x (2-1) + 244 = 1300 ft	(11.34 x 0.059) + 1.17 = 1.8 ft
3	1056 x 0.517 = 546 ft	1056 x (3-1) + 546 = 2658 ft	(11.34 x 0.996) + 1.17 = 12.5 ft
4	1056 x 0.253 = 267 ft	1056 x (4-1) + 267 = 3435 ft	(11.34 x 0.515) + 1.17 = 7.0 ft
5	1056 x 0.040 = 42 ft	1056 x (5-1) + 42 = 4266 ft	(11.34 x 0.101) + 1.17 = 2.3 ft

1/ Transverse location of the center of the core measured from the left physical edge of the paved lane.

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PFP Density Locations
Transverse Offset

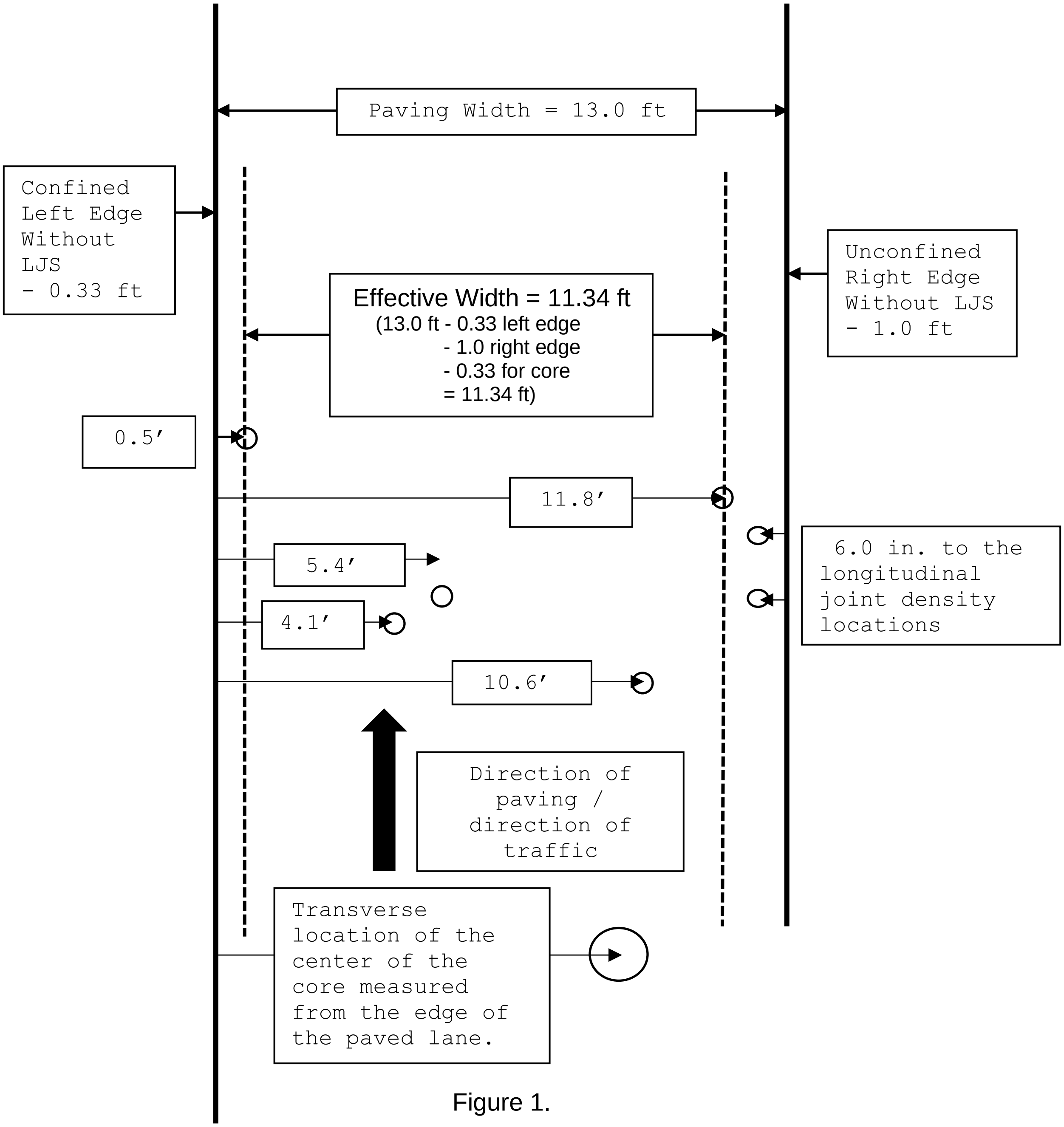

Figure 1.

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RANDOM NUMBERS

0.576	0.730	0.430	0.754	0.271	0.870	0.732	0.721	0.998	0.239
0.892	0.948	0.858	0.025	0.935	0.114	0.153	0.508	0.749	0.291
0.669	0.726	0.501	0.402	0.231	0.505	0.009	0.420	0.517	0.858
0.609	0.482	0.809	0.140	0.396	0.025	0.937	0.301	0.253	0.761
0.971	0.824	0.902	0.470	0.997	0.392	0.892	0.957	0.040	0.463
0.053	0.899	0.554	0.627	0.427	0.760	0.470	0.040	0.904	0.993
0.810	0.159	0.225	0.163	0.549	0.405	0.285	0.542	0.231	0.919
0.081	0.277	0.035	0.039	0.860	0.507	0.081	0.538	0.986	0.501
0.982	0.468	0.334	0.921	0.690	0.806	0.879	0.414	0.106	0.031
0.095	0.801	0.576	0.417	0.251	0.884	0.522	0.235	0.389	0.222
0.509	0.025	0.794	0.850	0.917	0.887	0.751	0.608	0.698	0.683
0.371	0.059	0.164	0.838	0.289	0.169	0.569	0.977	0.796	0.996
0.165	0.996	0.356	0.375	0.654	0.979	0.815	0.592	0.348	0.743
0.477	0.535	0.137	0.155	0.767	0.187	0.579	0.787	0.358	0.595
0.788	0.101	0.434	0.638	0.021	0.894	0.324	0.871	0.698	0.539
0.566	0.815	0.622	0.548	0.947	0.169	0.817	0.472	0.864	0.466
0.901	0.342	0.873	0.964	0.942	0.985	0.123	0.086	0.335	0.212
0.470	0.682	0.412	0.064	0.150	0.962	0.925	0.355	0.909	0.019
0.068	0.242	0.777	0.356	0.195	0.313	0.396	0.460	0.740	0.247
0.874	0.420	0.127	0.284	0.448	0.215	0.833	0.652	0.701	0.326
0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.876	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.777	0.491	0.523	0.665	0.919	0.146
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.281	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.454	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.659	0.463	0.994	0.307	0.631	0.422
0.116	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939
0.636	0.195	0.614	0.486	0.629	0.663	0.619	0.007	0.296	0.456
0.630	0.673	0.665	0.666	0.399	0.592	0.441	0.649	0.270	0.612
0.804	0.112	0.331	0.606	0.551	0.928	0.830	0.841	0.702	0.183
0.360	0.193	0.181	0.399	0.564	0.772	0.890	0.062	0.919	0.875
0.183	0.651	0.157	0.150	0.800	0.875	0.205	0.446	0.648	0.685

Note: Always select a new set of numbers in a systematic manner, either horizontally or vertically. Once used, the set should be crossed out.

Asphalt Content by Ignition Oven

Alternative Method needed to replace Trichloroethylene

Current methods for determining asphalt binder (AB) content include reflux extraction and nuclear AB content gauge. While reflux extraction is an effective method for determination of AB content as well as aggregate gradation, the procedure is time consuming and involves use of hazardous solvents. The nuclear AB content gauge provides fast and accurate determinations of AB content but also requires a special license and training for the gauges radioactive material. Also, the nuclear gauge does not allow for aggregate gradation analysis and can be sensitive to environmental conditions.

The ignition oven provides fast, accurate results for AB content and aggregate gradation. The ignition oven does not use solvents and does not require a special license.

How Does the Ignition Oven Work?

In simple terms, the Ignition Oven burns the AB off of the aggregate. By weighing the mix sample before, and the recovered aggregate after the AB is burned off, the uncorrected AB content can be determined.

$$\left[\begin{matrix}\text{uncorrected}\\ \text{AB content}\end{matrix}\right] = \frac{\text{weight of AB}}{\text{weight of mix}} = \frac{\text{wt. of mix before burn} - \text{wt. of agg. after burn}}{\text{wt. of mix before burn}}$$

History of the Ignition Oven

1969

In 1969 the National Cooperative Highway Research Program (NCHRP) did a study for Rapid Test Methods for Field Control of Construction. There was a section that pertained to asphalt content determinations for paving mixtures. Three test methods for rapid determination of asphalt content of asphalt paving mixtures were selected for evaluation. Two test methods, the stain method and flask method were not subjected to extensive evaluation because the third test, which has been designated the ignition method, was being developed concurrently, and appeared to be the most practical of these methods. The research was done by Clemson University. Butane gas was used as fuel which heated the specimens to 1550°F (893°C). A 1000 gram sample could be tested in approximately 30 minutes. Results indicated that asphalt determinations could be determined within an accuracy of ±0.25% when a calibration factor was used. However, the ignition test was not pursued because, butane was highly unstable and dangerous, it was determined that limestone's would typically undergo a mass loss of approximately 30% at these high temperatures, and the furnace could not be preheated.

1990-1992

The National Center of Asphalt Technology (NCAT) was optimistic about the ignition test and continued the research knowing that alternative methods to solvent extractions were being sought. NCAT developed a newer furnace and reduced the testing temperature to 1100°F (593°C) in an attempt to reduce the amount of aggregate mass loss. NCAT also used 2 flat stainless steel pans instead of a single deep dish pan to reduce testing time by increasing the samples surface area to promote a quicker and cleaner burn. The test time was increased to 1 hour and 45 minutes.

1992-1995

With the encouraging test results NCAT continued the research. A force draft ignition furnace was developed thus increasing the volume of air flow through the furnace which reduced the test time and generated a cleaner burn. In addition, newer mesh type baskets were created to further increase the samples surface area and further reduced the test time. The test temperature was again reduced to 1000°F (538°C), again to reduce the amount of aggregate mass loss during the test. An internal scale was also incorporated into the furnace. The test time was reduced to less than 1 hour. As a result of the favorable test results NCAT initiated a National Round Robin Study.

Accuracy of the Ignition Test

National Center for Asphalt Technology (NCAT) Round Robin Study

The Bureau of Materials and Physical Research (BMPR) as well as eleven other laboratory's nationwide participated in a Round Robin Study conducted by NCAT. The study was made up of 4 different mix designs totaling 32 samples. There were 8 samples per design, 4 of which were virgin aggregate made to the actual mix design gradation, and the other 4 were mixture samples both at job mix formula and optimum asphalt content. At this time the correction factors were based on the average mass loss of the 4 virgin aggregate samples after they were tested at 1067°F (575°C). The 4 mixture samples were then tested at 1000°F (538°C) and the asphalt content results were calculated using the correction factors calculated from the virgin aggregate tests. The following table lists the **corrected** ignition test results compared to the design values. The table values represent an average of the 48 mixture samples from 12 different laboratories.

	DESIGN % PASSING		**DESIGN**	**ROUND ROBIN MEASURED**		
MIX #	**#4**	**#200**	**AC**	**#4**	**#200**	**AC**
1	**71.6**	**6.0**	**6.0**	**71.5**	**5.6**	**5.98**
2	**66.8**	**7.7**	**6.0**	**66.6**	**7.7**	**5.99**
3	**61.4**	**6.7**	**5.0**	**61.4**	**7.2**	**4.97**
4	**57.0**	**5.5**	**5.5**	**56.6**	**5.1**	**5.53**

Summary of Test Methods

Procedure for the Barnstead / Thermolyne Furnace

(1) **Mixture Calibration**.

This method may be affected by the type of aggregate in the mixture. Accordingly, to optimize accuracy, an asphalt calibration factor and sieve calibration factors will be established with the testing of a set of calibration samples for each mix type and each furnace used for quality control or quality assurance. These procedures must be performed before any acceptance testing is completed.

(a) Two calibration samples, conforming to the mass outlined in Illinois-Modified AASHTO T 308, “Standard Method of Test for Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method”, shall be prepared at the design asphalt content and mix gradation. **(See Figure 5.1a & 5.1b on page 5-5)** A butter mix shall be prepared at the design asphalt content, mixed, and discarded prior to mixing any of the calibration samples to ensure accurate asphalt content. Aggregate used for the calibration samples shall be sampled from stockpiled material produced in the current construction season. The samples shall be blended, batched, and mixed as outlined in the Hot-Mix Asphalt Level III Technician Course manual.

Example: (10,000g Batch)

Material From JMF (Fig. 5.1)	Percent Blend		Batch Size (g)		Amount Aggregate (g) per Batch
032CMM16	64.8	x	10,000	=	6480
038FAM20	15.8	x	10,000	=	1580
037FAM01	16.3	x	10,000	=	1630
004MFM01	3.1	x	10,000	=	310
	100				10,000

	Batch Size		(100 - % AC Req'd From JMF) / 100 (Figure 5.1)				Batch Weight		Amount AC (g) per Batch
% Optimum AC	10,000	/	0.946	=	10,571	-	10,000	=	571

Date:

SEQ NO:

Hot Mix Aspahlt Design

	Design Number:	PAGE 10-10	
	Lab Preparing the design?(PP,PL,IL,etc.)	PP	
Producer Name & Number->	1111-01	Example Company Inc.	
Material Code Number->		High ESAL Surface Course, Mix C, N70	

Agg. No.	#1	#2	#3	#4	#5	#6	ASPHALT
Size	**032CM16**		**038FA20**	**037FA01**	**004MF01**		
Source (PROD#)							
(NAME)							
(LOC)							
Aggregate Blend	**64.8**	**0.0**	**15.8**	**16.3**	**3.1**	**0.0**	**100.0**

FIGURE 5.1a

Aggregate No.	#1	#2	#3	#4	#5	#6	Blend	Specifications		FORMULA	FORMULA RANGE	
Sieve Size								Min	Max		Min	Max
25.4 (1)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	--	--	100	100	100
19.0 (3/4)	100.0	100.0	100.0	100.0	100.0	100.0	100.0		100	100	100	100
12.5 (1/2)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	90	100	100	94	106
9.5 (3.8)	99.2	100.0	100.0	100.0	100.0	100.0	99.5		90	99	--	--
4.75 (#4)	33.9	100.0	99.0	100.0	100.0	100.0	57.0	24	65	57	52	62
2.36 (#8)	13.0	100.0	88.4	89.9	100.0	100.0	40.1	16	40	40	35	45
1.18 (#16)	4.5	100.0	74.4	55.5	100.0	100.0	26.8	10	32	27	27	27
600um (#30)	4.1	100.0	55.6	23.7	100.0	100.0	18.4	--	--	18	--	--
300um (#50)	3.7	100.0	20.0	8.3	100.0	100.0	10.0	4	16	10	6	14
150um (#100)	3.3	100.0	3.0	3.4	99.0	100.0	6.2	3	10	6	6	6
75um (#200)	2.8	100.0	1.0	1.8	88.0	100.0	5.0	4	6	5.0	3.5	6.5

Bulk Sp Gr	2.645	1	2.6	2.554	2.67	1
Apparent Sp Gr	2.783	1	2.65	2.682	2.67	1
Absorption, %	1.4	1	1.2	0.5	0	0
					SP GR AC 1.032	

SUMMARY OF TEST DATA

	AC	BULK	MAXIMUM	VOIDS		VOIDS	EFFECTIVE			ABORPTION
	% MIX	SPEC GRAV (G_{mb})	SPEC GR (G_{mm})	TOT MIX (P_a)	VMA	FILLED	AC, VOL	AC, % WT	G_{se}	AC, % WT
MIX 1	4.5	2.294	2.480	7.50	16.49	54.5	8.99	4.04	2.656	0.48
MIX 2	5.0	2.320	2.460	5.69	15.99	64.4	10.29	4.58	2.653	0.44
MIX 3	5.5	2.350	2.440	3.69	15.35	76.0	11.66	5.12	2.650	0.40
MIX 4	6.0	2.380	2.430	2.06	14.72	86.0	12.66	5.49	2.660	0.54

		d	D	% VOIDS				
	% AC	mb)	(G_{mm})	(P_a)	VMA	VFA	Gse	G_{sb}
Asphalt determined at 4.0% voids	5.42			Target				
OPTIMUM DESIGN DATA:---	5.4	344	2.444	4.0	15.5	73.7	2.651	2.623
REMARKS:								

FIGURE 5.1b

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(a) Weigh and record the weight of the tray assembly (two sample baskets, lid, and catch pan with guards in place).

(b) Preheat the ignition furnace to 482°C (900° F). To set chamber temperature, press "temp" key and input temperature of "482". Press the "enter" key. This sets the furnace chamber temperature. Press the "temp" key; "482" should be displayed for approximately 2-3 seconds and then return to actual chamber temperature. If not, repeat this step. Record the chamber temperature setting prior to the initiation of the test.

NOTE: If "enter" is not pressed while “set point" light is on, the new temperature will not be accepted.

(c) Enter a correction factor of "0.00" in the ignition furnace. To set the correction factor, press "% correction" button and input "0.00". Then press the "enter" button. Press the "% correction" button again and be sure "0.00%" appears on the display.

(d) Place one of the freshly mixed calibration samples in the sample baskets. If allowed to cool, the sample must be preheated in a 230°±9°F (110 °±5°C) oven for 25 minutes.

(e) Place the bottom sample basket in the catch pan. Evenly distribute approximately one half of the calibration sample in the lower basket taking care to keep the material away from the edges of the basket.

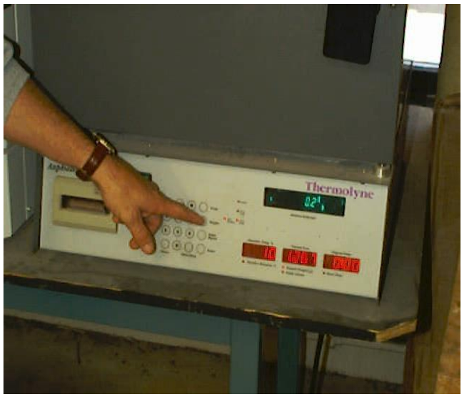
(f) Place the upper sample basket on the bottom basket assembly. Evenly distribute the remaining sample in the top basket. Use a spatula or trowel to level the sample.

(g) Weigh and record the tray assembly and sample. Calculate and record the initial weight of the sample (total weight - weight of tray assembly).

NOTE: Be sure guard strap is not resting on table top during weight measurement.

(h) Fasten the guard strap.

(i) Input the initial weight of the sample in whole grams into the ignition furnace controller. Press the "weight" button and input the initial sample weight. **Caution:** Input whole grams only--not tenths. Then press the "enter" button. Press the "weight" button and verify that the display shows the weight as entered.



NOTE: Be sure the printer switch is in the "**on**" position.

(j) Open the chamber door and place the specimen basket assembly in the furnace, carefully position the specimen basket assembly so it is not in contact with the furnace walls. Close the chamber door, and verify that the specimen mass (including the basket assembly) displayed on the furnace scale equals the total mass of the specimen and specimen basket assembly at room temperature within ± 5 g. Differences greater than 5 g or failure of the furnace scale to stabilize may indicate that the specimen basket assembly is contacting the furnace wall. Initiate the test by pressing the "start/stop" button. This will lock the sample chamber and start the combustion blower.

(k) Allow the test to continue until the "stable" light and audible stable indicator indicate the test is complete. Press the "start/stop" button. This will unlock the sample chamber and cause the printer to print out the test results.

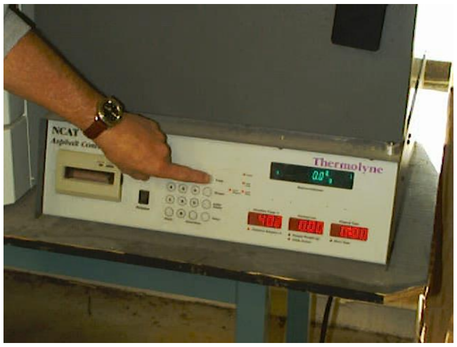
(l) Open the chamber door, remove the sample baskets, and allow cooling to room temperature (approximately 30 minutes).

(m) Perform a washed gradation analysis on the residual aggregate.

(n) Repeat the steps **(b)** through **(m)** for the second calibration sample. The reported asphalt calibration factor and the sieve calibration factors are averages of results from the first and second calibration samples. If the difference between the two calibration samples used to calculate the asphalt calibration factor exceeds 0.15%, make up two additional calibration samples, repeat steps (b) through (n) herein, discard the high and low results, and average the remaining two results. **Use the asphalt calibration factor determined from this step to determine the corrected asphalt content during the test procedure (sections 2a thru 2l).** Use the sieve calibration factors to determine the corrected washed gradation.

(2) Test Procedure

(a) Preheat the ignition furnace to 482° C (900° F). Record the furnace temperature (set point) prior to the initiation of the test.



(b) Enter the correction factor (factor that is obtained during calibration of the ignition furnace) for the specific mix to be tested.

(c) Weigh and record the weight of the tray assembly (two sample baskets, lid, and catch pan with guards in place).

(d) Prepare the sample according to Illinois-Modified AASHTO T 308, "Standard Method of Test for Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method". Place the bottom sample basket in the catch pan. Evenly distribute approximately one half of the sample in the lower basket taking care to keep the material away from the edges of the basket.

(e) The test sample must be checked for moisture content according to Illinois-Modified AASHTO T 308, "Standard Method of Test for Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method".

(f) Place the upper sample basket on the bottom basket assembly. Evenly distribute the remaining sample in the top basket. Use a spatula or trowel to level the sample.

(g) Weigh and record the tray assembly and sample. Calculate and record the initial weight of the sample (total weight - weight of tray assembly).

(h) Input the initial weight of the sample in whole grams into the ignition furnace controller. Verify that the correct weight has been entered.

(i) Open the chamber door and place the specimen basket assembly in the furnace, carefully position the specimen basket assembly so it is not in contact with the furnace walls. Close the chamber door, and verify that the specimen mass (including the basket assembly) displayed on the furnace scale equals the total mass of the specimen and specimen basket assembly at room temperature within ± 5 g. Differences greater than 5 g or failure of the furnace scale to stabilize may indicate that the specimen basket assembly is contacting the furnace wall. Initiate the test by pressing the "start/stop" button. This will lock the sample chamber and start the combustion blower.

(j) Allow the test to continue until the "stable" light and audible stable indicator indicate the test is complete. Press the "start/stop" button. This will unlock the sample chamber and cause the printer to print out the test results.

(k) Open the chamber door, remove the sample baskets, and allow cooling to room temperature (approximately 30 minutes).

(l) Calculate and record the corrected asphalt content as outlined in Section 8.10 of Illinois-Modified AASHTO T 308, "Standard Method of Test for Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method".

(3) **Gradation**

(a) Allow the sample to cool to room temperature in the sample baskets.

(b) **Empty the contents of the baskets into a pan (Ill. Modified AASHTO T 308, Section 5.6 page 5-43.** Use a small wire sieve brush to ensure that any residual fines are removed from the baskets.

(c) Perform the washed gradation analysis according to Chapter 6.0 of the Aggregate Technician Course workbook.

(d) Correct the aggregate gradation by subtracting the respective sieve calibration factors from the percent passing Procedure for the Barnstead / Thermolyne Furnace.

Safety Issues

Safety cannot be stressed enough, especially with temperatures in excess of 482°C (900°F). Eye protection must be worn at all times when loading or unloading samples into a furnace due to the possibility of aggregate fracturing at the high temperatures. Contact users may be bothered by the hot air when loading and unloading the samples. It is also important to wear clean, heat resistant gloves, because asphalt impregnated gloves conduct heat.

Example (for internal scale ovens)

The following example is using a furnace with an internal scale. An example problem using a furnace without an internal scale is computed similarly but will not be shown in the following.

First, calculating an asphalt correction factor is done by mixing 2 points at optimum asphalt content and to the Job Mix Formula during the design stage (sample sizes found on page 5-67 herein).

Example of calculating asphalt correction factor:

Sample	**#1**	**#2**
Known % Asphalt (AB)	5.0 (Mix Design Asphalt)	5.0 (Mix Design Asphalt)
Sample and Basket	8864 g	8879 g
Basket Weight	7312 g	7312 g
Sample Weight	______ g	______ g
Weight Loss	84 g	86 g
Temp. Compensation	0.10	0.12
Percent Loss	((84/_____) x 100) – 0.10 = _____	((86/_____) x 100) – 0.12 = _____
Correction Factor	(% loss) _____ - (Known % AB) _____ = _______	(% loss) _____ - (Known % AB) _____ = ______
Avg. Correction Factor	(Correction factor #1 + #2)/ 2 = ______________	

The formula for calculating the corrected asphalt content in the field on a truck sample using the correction factor computed during the design stage is as follows:

Example of calculating asphalt content during production, applying the calculated correction factor from above:

$$AB= \frac{Wb - Wa}{Wb} \text{ X } 100 - \text{Temp. Comp.} - Mc - Cf$$

Where:

AB = The corrected asphalt content percent by weight of Hot-Mix asphalt sample.
Wa = The total weight of residual aggregate remaining after ignition.
Wb = The total weight of the hot-mix asphalt sample prior to ignition.
Cf = Asphalt calibration in percent.
Mc = Moisture content in percent.

Given Information:

Wb = 1310 g
Wa = 1238 g
Cf = average correction factor from example above.
Mc = 0.10
Temp. Comp. = 0.09

Therefore the calculated corrected asphalt content is:

$$AB= \frac{1310 - 1238}{1310} \text{ X } 100 - \overset{\underline{\text{Temp. Comp.}}}{0.09} - \overset{\underline{\text{Mc}}}{0.10} - \overset{\underline{\text{Cf}}}{\underline{\qquad\quad}}$$

AB = _______%

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Barnstead/Thermolyne Tester Asphalt Content Determination Worksheet

Contract No.	Project No.	Date
Mix Plant	Name	Location
Mix Code	Name	Dist. Mix No.
Type Test	Tested By	

Sample Number					
Chamber Temperature Setting (C)					
Tray Assembly and Sample Weight (g)					
Tray Assembly Weight (g)					
Initial Sample Weight (g)					
Weight Loss (g)					
Percent Loss (% of mix)					
Temperature Compensation (%)					
Calibration Factor (%)					
Moisture Content (%)					
Corrected AB Content (%)					
Test Time (min.)					

Sieve Size	Cumulative Percent Passing				
25mm (1 in)					
19mm (3/4 in)					
12.5mm (1/2)					
9.5mm (3/8)					
4.75mm (No. 4)					
2.36mm (No. 8)					
1.18mm (No. 16)					
0.60mm (No.30)					
300 microns (No. 50)					
150 microns (No.100)					
75 microns (No.200)					

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Procedure for the Gilson Asphalt Binder Ignition Furnace

(1) **<u>Mixture Calibration For Gilson</u>**.

This method may be affected by the type of aggregate in the mixture. Accordingly, to optimize accuracy, an asphalt calibration factor and sieve calibration factors will be established with the testing of a set of calibration samples for each mix type and each furnace used for quality control or quality assurance. These procedures must be performed before any acceptance testing is completed.

(a) Two calibration samples, conforming to the mass outlined in AASHTO T 308, “Standard Method of Test for Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method” (Illinois Modified), shall be prepared at the design asphalt content and mix gradation. A butter mix shall be prepared at the design asphalt content, mixed, and discarded prior to mixing any of the calibration samples to ensure accurate asphalt content. Aggregate used for the calibration samples shall be sampled from stockpiled material produced in the current construction season. The samples shall be blended, batched, and mixed as outlined in the Hot-Mix Asphalt Level III Technician Course manual.

(b) Weigh and record the weight of the tray assembly (sample basket, lid, and catch pan).

(c) Preheat the ignition furnace to 482° C (900° F).

(d) Place one of the freshly mixed calibration samples in the sample basket. If allowed to cool, the samples must be preheated in a 230° ± 9° F (110° ± 5°C) oven for 25 minutes.

(e) Evenly distribute the calibration sample in the basket taking care to keep the material away from the edges of the basket.

(f) Weigh and record the tray assembly and sample. Calculate and record the initial weight of the sample (total weight - weight of tray assembly).

(g) Open the chamber door and place the sample basket in the furnace. Close the chamber door, and record the time.

(h) Allow the test to continue for 60 minutes or the minimum time determined to achieve 0.01% weight loss over 3 consecutive minutes.

(i) Open the chamber door, remove the sample basket, and check the sample for complete burn-off. **If it is not completely burned off, continue the test at 10-minute intervals.**

(j) Once the test is determined to be complete, remove the sample basket and allow cooling to room temperature (approximately 30 minutes).

(k) Carefully remove the aggregate particles from the basket.

(l) Dry the aggregate sample to a constant weight in a 230° ± 9° F (110° ± 5° C) oven.

(m) Record the oven-dry weight of the residual aggregate.

(n) Determine the percent weight loss: [(original sample weight - residual aggregate oven dry weight) / original sample weight] x 100.

(o) Perform a washed gradation analysis on the residual aggregate.

(p) Repeat the steps (b) through (o) herein for the second calibration sample. The reported asphalt calibration factor and the sieve calibration factors are averages of results from the first and second calibration samples. If the difference between the two calibration samples used to calculate the asphalt calibration factor exceeds 0.15%, make up two additional calibration samples, repeat steps (b) through (o) herein, discard the high and low results, and average the remaining two results. **Use the asphalt calibration factor determined from this step to determine the corrected asphalt content.** Use the sieve calibration factors to determine the corrected washed gradation.

(2) **Test Procedure For Gilson**

(a) Preheat the ignition furnace to 482° C (900° F). Record the furnace temperature prior to the initiation of the test.

(b) Weigh and record the weight of the tray assembly (sample basket, lid, and catch pan).

(c) Prepare the sample according to Illinois-Modified AASHTO T 308, “Standard Method of Test for Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method”. Place the sample basket in the catch pan. Evenly distribute the sample in the basket taking care to keep the material away from the edges of the basket.

(d) The test sample must be checked for moisture content according to Illinois-Modified AASHTO T 308, “Standard Method of Test for Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method”.

(e) Weigh and record the tray assembly and sample. Calculate and record the initial weight of the sample (total weight - weight of tray assembly).

(f) Open the chamber door and place the sample basket in the furnace. Close the chamber door and record the time.

(g) Allow the test to continue for 60 minutes or the minimum time determined to achieve 0.01% weight loss over 3 consecutive minutes.

(h) Open the chamber door, remove the sample basket, and check the sample for complete burn-off. **If it is not completely burned off, continue the test at 10-minute intervals.**

(i) Once the test is determined to be complete, remove the sample basket and allow cooling to room temperature (approximately 30 minutes).

(j) Carefully remove the aggregate particles from the basket.

(k) Dry the aggregate sample to a constant weight in a 230°±9°F (110°±5°C) oven.

(l) Record the oven-dry weight of the residual aggregate.

(m) Determine the corrected asphalt content by using the formula specified in Illinois-Modified AASHTO T 308, “Standard Method of Test for Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method”.

(3) Gradation For Gilson

(a) Allow the sample to cool to room temperature in the sample baskets.

(b) Perform the washed gradation analysis according to Chapter 6.0 of the Aggregate Technician Course workbook.

(c) Correct the aggregate gradation by subtracting the respective sieve calibration factors from the percent passing on each sieve.

Gilson Ignition Tester Asphalt Content Determination Worksheet

Contract No.	Project No.	Date
Mix Plant	Name	Location
Mix Code	Name	Dist. Mix No.
Type Test	Tested By	

Sample Number					
Chamber Temperature Setting (C)					
Tray Assembly and Sample Weight (g)					
Tray Assembly Weight (g)					
Initial Sample Weight (g)					
Residual Aggregate Weight (g)					
Weight Loss (g)					
Percent Loss (% of mix)					
Calibration Factor (%)					
Moisture Content (%)					
Corrected AB Content (%)					
Test Time (min.)					

Sieve Size	Cumulative Percent Passing				
25mm (1 in)					
19mm (3/4 in)					
12.5mm (1/2)					
9.5mm (3/8)					
4.75mm (No. 4)					
2.36mm (No. 8)					
1.18mm (No. 16)					
0.60mm (No.30)					
300 microns (No. 50)					
150 microns (No.100)					
75 microns (No.200)					

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Illinois Department of Transportation

Hot-Mix Asphalt Mix Design
Procedure for Dust Correction Factor Determination
Appendix B.12

Effective: January 1, 1998
Revised: December 1, 2017

A dust correction factor (DCF) shall be determined and applied to each new mix design using the procedure listed below. This procedure will be used to supplement the Hot-Mix Asphalt Level III Technician Course manual to account for additional minus No. 200 (minus 75-µm) material present as a result of batching with unwashed aggregates.

It is important to note the Adjusted Blend Percentages are temporary percentages used during laboratory batching only. The original Blend Percentages on the “Design Summary Sheet” remain unchanged.

> Note: When adjusting percentages to equal 100, the largest percentage should be adjusted accordingly.

A) Virgin Mix Design

1. Batch a combined aggregate sample matching the job mix formula (JMF). Test sample size shall be determined using Illinois Specification 201 and based on the nominal maximum size of the largest coarse aggregate.
2. Perform a washed test on the combined aggregate sample using Illinois Modified AASHTO T 11.
3. The DCF shall be the difference between the percent passing the No. 200 (75-µm) sieve of the washed test and the JMF.
4. Determine the mineral filler reduction (MFR) by dividing the DCF by the percent (in decimal form) mineral filler gradation passing the No. 200 (75-µm) sieve.
5. Subtract the MFR from the blend percentage of mineral filler.
6. Adjust the remaining blend percentages to sum to 100 by dividing each by the quantity (1 - MFR).

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Hot-Mix Asphalt Mix Design
Procedure for Dust Correction Factor Determination
Appendix B.12

Effective: January 1, 1998
Revised: December 1, 2017

Example

Bituminous Mixture Design

Design Number:-------->	50BITEXPL	
Lab preparing the design?(PP,PL,IL ect.)	IDOT	
Producer Name & Number-->	1111-01 Example Company Inc Somewhere 1, IL	
Material Code Number--->	17552	BITCONC BCS 1 B TONS

Agg No.	#1	#2	#3	#4	#5	#6	ASPHALT
Size	032CMM11	032CMM16	038FAM20	037FAM01	004MFM01		10124M
Source (PROD#)	51972-02	51972-02	51230-06	51790-04	51052-04		
(NAME)	MAT SER	MAT SER	MIDWEST	CONICK	LIVINGSTON		2260-01
(LOC)							EMLSCOAT
Aggregate Blend	38.0	35.0	14.5	10.0	2.5	0.0	100.0

Agg No. Sieve Size	#1	#2	#3	#4	#5	#6	Blend
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/4	88.0	100.0	100.0	100.0	100.0	100.0	95.4
1/2	45.0	100.0	100.0	100.0	100.0	100.0	79.1
3/8	19.0	97.0	100.0	100.0	100.0	100.0	68.2
#4	6.0	29.0	97.0	97.0	100.0	100.0	38.7
#8	2.0	7.0	80.0	85.0	100.0	100.0	25.8
#16	2.0	4.0	50.0	65.0	100.0	100.0	18.4
#30	1.8	3.0	35.0	43.0	100.0	100.0	13.6
#50	1.7	3.0	19.0	16.0	100.0	100.0	8.6
#100	1.5	3.0	10.0	5.0	90.0	100.0	5.8
#200	1.3	1.3	4.0	2.5	88.0	100.0	4.0

Step 1. **Batch a combined aggregate sample meeting the JMF.** Illinois Specification 201 requires a 5000-gram sample when CM11 is present.

Step 2. **Run a washed test using AASHTO T 11.**

Step 3. **Determine the Dust Correction Factor (DCF).** The DCF is the difference in the percent passing the No. 200 (75-µm) sieve between the washed test and the JMF:

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Hot-Mix Asphalt Mix Design
Procedure for Dust Correction Factor Determination
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	JMF	Washed Test	DCF
No. 200 (75	4.0%	5.6%	1.6%

Step 4. **Determine the Mineral Filler Reduction (MFR)** by dividing the DCF (%) by the percent (in decimal form) mineral filler gradation passing the No. 200 (75-µm) sieve:

MFR (%) = 1.6 / 0.88 = 1.8%

Step 5. **Determine the adjusted mineral filler blend percentage** by subtracting the MFR (%) from the blend percentage of mineral filler:

2.5% - 1.8% = 0.7%

Step 6. **Adjust the remaining blend percentages to sum to 100** by dividing each by the quantity [1 - **MFR** (in decimal form)]:

	Blend Percentage	Adjusted Blend Percentage[1]
032CMM11	38.0	38.7
032CMM16	35.0	35.6
038FAM20	14.5	14.8
037FAM01	10.0	10.2
004MFM01	2.5	0.7
	100.0	100.0

Note 1: It is important to note the Adjusted Blend Percentages are temporary percentages used during laboratory batching only. The original Blend Percentages on the “Design Summary Sheet” remain unchanged.

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Hot-Mix Asphalt Mix Design
Procedure for Dust Correction Factor Determination
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Effective: January 1, 1998
Revised: December 1, 2017

B) RAP Mix Design (Also Applicable to RAP/RAS Mix Designs)

1. Determine the Virgin Aggregate Fraction (VAF). The virgin aggregate fraction is the percentage of virgin aggregate

2. Adjust to the virgin blend percentages by dividing each virgin aggregate by the VAF.

3. Determine the RAP Adjusted JMF (RJMF)

4. Batch the virgin aggregates according to the adjusted blend percentages matching the RJMF. Test sample size shall be determined using Illinois Specification 201 and based on the nominal maximum size of the largest coarse aggregate.

5. Perform a washed test on the combined aggregate sample using Illinois Modified AASHTO T 11.

6. The DCF shall be the difference between the percent passing the No. 200 (75-µm) sieve of the washed test and the RJMF.

7. Determine the mineral filler reduction $(MFR)_{RAP}$ by dividing the DCF by the percent (in decimal form) mineral filler gradation passing the No. 200 (75-µm) sieve.

8. Subtract the MFR_{RAP} from the blend percentage of mineral filler.

9. Adjust the remaining virgin aggregate blend percentages to sum to 100 by dividing each by the quantity $(1 – MFR_{RAP})$.

10. Determine the batching blend percentages with RAP by multiplying the adjusted virgin aggregate blend percentages by the VAF.

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Hot-Mix Asphalt Mix Design
Procedure for Dust Correction Factor Determination
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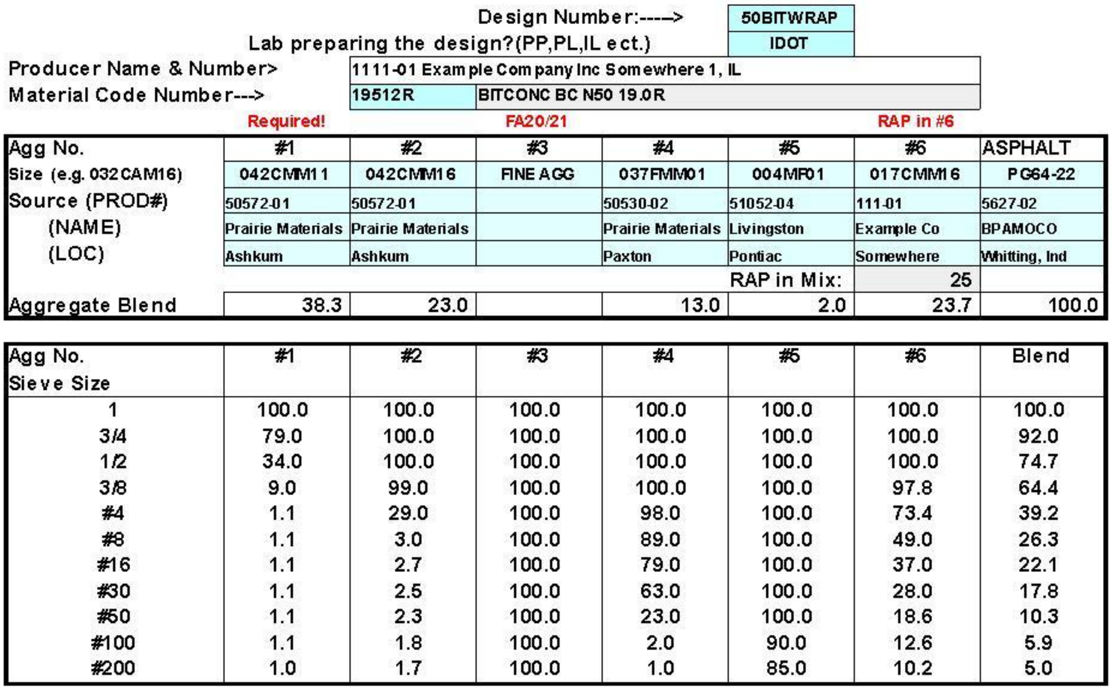
Effective: January 1, 1998
Revised: December 1, 2017

RAP Example



Design Number:----> 50BITWRAP
Lab preparing the design?(PP,PL,IL ect.) IDOT
Producer Name & Number> 1111-01 Example Company Inc Somewhere 1, IL
Material Code Number---> 19512R BITCONC BC N50 19.0R

	Required!		FA20/21			RAP in #6	
Agg No.	#1	#2	#3	#4	#5	#6	ASPHALT
Size (e.g. 032CAM16)	042CMM11	042CMM16	FINE AGG	037FMM01	004MF01	017CMM16	PG64-22
Source (PROD#)	50572-01	50572-01		50530-02	51052-04	111-01	5627-02
(NAME)	Prairie Materials	Prairie Materials		Prairie Materials	Livingston	Example Co	BPAMOCO
(LOC)	Ashkum	Ashkum		Paxton	Pontiac	Somewhere	Whitting, Ind
					RAP in Mix:	25	
Aggregate Blend	38.3	23.0		13.0	2.0	23.7	100.0

Agg No. Sieve Size	#1	#2	#3	#4	#5	#6	Blend
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/4	79.0	100.0	100.0	100.0	100.0	100.0	92.0
1/2	34.0	100.0	100.0	100.0	100.0	100.0	74.7
3/8	9.0	99.0	100.0	100.0	100.0	97.8	64.4
#4	1.1	29.0	100.0	98.0	100.0	73.4	39.2
#8	1.1	3.0	100.0	89.0	100.0	49.0	26.3
#16	1.1	2.7	100.0	79.0	100.0	37.0	22.1
#30	1.1	2.5	100.0	63.0	100.0	28.0	17.8
#50	1.1	2.3	100.0	23.0	100.0	18.6	10.3
#100	1.1	1.8	100.0	2.0	90.0	12.6	5.9
#200	1.0	1.7	100.0	1.0	85.0	10.2	5.0

Step 1. Determine the virgin aggregate fraction (VAF).

$$VAF = \frac{(100 - RAPAgg\%)}{100} \qquad VAF = \frac{(100 - 23.7)}{100}$$

VAF = 0.763

Illinois Department of Transportation

Hot-Mix Asphalt Mix Design
Procedure for Dust Correction Factor Determination
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Effective: January 1, 1998
Revised: December 1, 2017

Step 2. **Adjust to the virgin aggregate percentages** by dividing each virgin aggregate by the VAF.

	Initial		virgin agg %	
042CMM11	38.3	(÷0.763)	50.3	(added 0.1 sum = 100.0)
042CMM16	23.0	(÷0.763)	30.1	
037FMM01	13.0	(÷0.763)	17.0	
004MF01	2.0	(÷0.763)	2.6	
Sum	100.0		100.0	

Step 3. **Determine the RAP adjusted JMF (RJMF).** Combine gradation using the adjusted virgin aggregate blend percentages.

1	100.0
¾	89.4
½	66.8
3/8	53.9
#4	28.5
#8	19.2
#16	17.4
#30	14.6
#50	7.8
#100	3.8
#200	3.4

Step 4. Batch the virgin aggregates according to the adjusted blend percentages matching the RJMF. Illinois specification 201 requires a 5000-gram sample when CM11 is present.

Step 5. Run a washed test using AASHTO T11.

Step 6. Determine the dust correction factor (DCF). The DCF is the difference between the percent passing the No. 200 (75-μm) sieve of the washed test and the RJMF.

	Washed	RJMF	DCF
No. 200 (75-μm)	4.3	3.4	4.3-3.4= 0.9

DCF = 0.9

Illinois Department of Transportation

Hot-Mix Asphalt Mix Design
Procedure for Dust Correction Factor Determination
Appendix B.12

Effective: January 1, 1998
Revised: December 1, 2017

Step 7. Determine the mineral filler reduction $(MFR)_{RAP}$. The $(MFR)_{RAP}$ is determined by dividing the DCF by the percent (in decimal form) mineral filler gradation passing the No. 200 (75-μm) sieve.

$$MFR_{RAP} = \frac{0.9}{0.85} = 1.1\%$$

Step 8. Determine the mineral filler blend percentage by subtracting the MFR_{RAP} from the blend percentage of mineral filler.

$$2.6 - 1.1 = 1.5\%$$

Step 9. Adjust the remaining blend percentages to sum to 100% by dividing each by the quantity [1-MFR_{RAP} (in decimal form)]:

$$1 - MFR_{RAP} = 1 - 0.011 = 0.989$$

	Virgin %		Adj. Virgin Blend%
042CMM11	50.3	(÷0.989)	50.9
042CMM16	30.1	(÷0.989)	30.4
037FMM01	17.0	(÷0.989)	17.2
004MF01	2.6	(from step 8)	1.5
Sum	100.0		100.0

Step 10. Determine the batching blend percentages with RAP by multiplying the adjusted virgin blend % by the VAF.

VAF = 0.763

	Adjusted Virgin %		Batching Blend%	
042CMM11	50.9	(÷0.763)	38.9	(added 0.1 sum = 100.0)
042CMM16	30.4	(÷0.763)	23.2	
037FMM01	17.2	(÷0.763)	13.1	
004MF01	1.5	(÷0.763)	1.1	
		RAPAgg	23.7	
		Sum	100.0	

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Illinois Department of Transportation

Calibration of Equipment for Asphalt Binder Content Determination (Nuclear Asphalt Binder Content Gauge and Ignition Oven)

Appendix B.11

Effective Date: January 1, 2002
Revised Date: December 1, 2021

A. Scope

The Contractor may be required to use a nuclear asphalt binder content gauge (Illinois Modified AASHTO T 287) or ignition oven (Illinois Modified AASHTO T 308) to determine the asphalt binder content of a Hot-Mix Asphalt (HMA) mixture. To ensure consistency, both the Contractor and the Department shall calibrate their device(s) in the same manner using the same mixture.

B. Purpose

This procedure was developed to provide consistent calibration between the Contractor's and Department's asphalt binder content determination equipment. The procedure also applies to any third-party gauges.

C. Nuclear Asphalt Binder Content Gauge

1. Department Verification of Sample Mixture

    a. All HMA mixture designs shall be verified in accordance with the Department's "Hot-Mix Asphalt Mixture Design Verification Procedure" before submitting materials for the nuclear asphalt binder content gauge calibration.

    b. The Contractor shall provide a mix design prepared by a Hot-Mix Asphalt Level III Technician in accordance with the Department's current Hot-Mix Asphalt Level III Technician Course manual. All testing shall be performed by Hot-Mix Asphalt Level I Technicians.

2. Department Calibration Process

    a. The Department calibration shall consist of the following process:

    The Contractor shall submit the following to the District laboratory at least 2 weeks prior to production:

    - 3 empty nuclear asphalt binder content pans
    - 22 lb (10 kg) of the HMA mixture at the design optimum asphalt binder content
    - 22 lb (10 kg) of the HMA mixture at 1% below the optimum asphalt binder content

Illinois Department of Transportation

Calibration of Equipment for Asphalt Binder Content Determination (Nuclear Asphalt Binder Content Gauge and Ignition Oven)

Appendix B.11

(continued)

Effective Date: January 1, 2002
Revised Date: December 1, 2021

- 22 lb (10 kg) of the HMA mixture at 1% above the optimum asphalt binder content
- The actual blended aggregate, including the pan, used to determine the dry aggregate standard count

The Department may split out approximately 16.5 lb (7500 g) and/or 4.4 lb (2000 g) samples out of the 22 lb (10 kg) of mixture. Each of the three 16.5 lb (7500 g) samples will be placed in one of the empty calibration pans. The 4.4 lb (2000 g) samples may be used by the Department to run extractions on the samples for verification with the actual blended aggregate sample. The extraction results shall be within the following tolerances:

Sieve	Tolerance
12.5 mm (1/2 in.)	± 3.0
4.75 mm (# 4)	± 2.0
2.36 mm (# 8)	± 1.5
600 µm (# 30)	± 1.0
75 µm (# 200)	± 0.5
Asphalt Content	± 0.15

If the extraction results lie outside the above tolerances, the Contractor shall be required to resubmit all new material as outlined in C.2.

The Department will then calibrate its nuclear asphalt binder content gauges using the pans and mixtures the Contractor submitted. Once Department calibration is completed, the calibration pans will be covered with plastic bags (to prevent the introduction of moisture) and immediately sent back to the Contractor. This will be done for all 4 pans.

3. Contractor Calibration Process

   a. The Contractor shall calibrate their nuclear asphalt binder content gauges with the same calibrations pans and mixtures used by the Department within 24 hours of receiving the samples from the Department. The Contractor shall calibrate their nuclear asphalt binder content gauge only after the Department has verified the calibration samples as outlined above in Section C.1 and C.2.

Illinois Department of Transportation

Calibration of Equipment for Asphalt Binder Content Determination (Nuclear Asphalt Binder Content Gauge and Ignition Oven)

Appendix B.11

(continued)

Effective Date: January 1, 2002
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b. The Contractor shall retain the calibration pans. These pans shall be covered with plastic bags and stored in a dry, secure place.

c. Calibration shall be done after a mixture is designed, an approved Job Mix Formula (JMF) is established, and the mixture has been verified by the Department. Calibration before the mixture is designed is not allowed since this would not necessarily allow for the proper range of asphalt binder content, and the job mix gradation would not be known. The calibration temperature for both the dry aggregate count and the HMA mixture count shall be within ± 10 °F (± 6 °C) of each other and be within the range of 180 to 290 °F (± 82 to 143 °C).

D. Ignition Oven

1. Department Verification of Sample Mixture

a. All HMA mixture designs shall be verified in accordance with the Department's "Hot-Mix Asphalt Mixture Design Verification Procedure" before submitting materials for the ignition oven calibration.

b. The Contractor shall provide a mix design prepared by a Hot-Mix Asphalt Level III Technician in accordance with the Department's current Hot-Mix Asphalt Level III Technician Course Manual. All testing shall be performed by Hot-Mix Asphalt Level I Technicians.

2. Department Calibration Process

a. The Department calibration shall consist of the following process:

The Contractor shall submit the following to the District laboratory at least two weeks prior to production:

- Four individually batched, combined aggregate samples meeting the JMF. Each sample shall meet the minimum mass requirements listed in Section 6.4 of Illinois Modified AASHTO T 308.
- 1 L (1 qt.) asphalt binder

The Department will mix the asphalt binder and the four individually batched, combined aggregate samples to produce four mixed samples. Two mixed samples will be used to calibrate the District's ignition oven. If the difference between the measured asphalt binder content of the two samples exceeds 0.15%, the tests will be repeated using the two remaining mixed samples.

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Illinois Department of Transportation

Calibration of the Ignition Oven for the Purpose of Characterizing Reclaimed Asphalt Pavements (RAP)

Appendix B.13

Effective Date: January 1, 2002
Revised Date: December 1, 2021

1.0 GENERAL

1.1 This method covers the calibration of the ignition oven for characterization of reclaimed asphalt pavement (RAP). Correction factors for both gradation and asphalt content are determined by conducting parallel ignition and extraction testing.

2.0 SIGNIFICANCE AND USE

2.1 The ignition oven may be used in place of solvent extractions at the frequency stated in Section 1031 of the Standard Specifications.

2.2 This method may be used only with the approval of the Engineer.

2.3 Each RAP stockpile shall require a separate ignition oven calibration.

2.4 All RAP stockpiles and sampling frequencies shall meet the requirements stated in Section 1031 of the Standard Specifications.

3.0 REFERENCED DOCUMENTS

3.1 AASHTO Standards (as modified by Illinois):

R 76	Reducing Samples of Aggregate to Testing Size
T 2	Sampling of Aggregates
T 164	Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)
T 308	Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method

4.0 PROCEDURE

4.1 Sample the RAP according to AASHTO T 2. Obtain an adequate amount of material to perform a minimum of two solvent extractions and four ignition oven burns. The minimum sample sizes shall be governed by the nominal maximum aggregate size of the mixture defined in Illinois Modified AASHTO T 164 and T 308. Reduce the samples to testing size according to Illinois Modified AASHTO R 76.

4.2 Perform a minimum of two solvent extractions and a minimum of four ignition oven burns according to Illinois Modified AASHTO T 164 and Illinois Modified AASHTO T 308, respectively.

Illinois Department of Transportation

Calibration of the Ignition Oven for the Purpose of Characterizing Reclaimed Asphalt Pavements (RAP)
Appendix B.13

Effective Date: January 1, 2002
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4.3 AB Binder Calibration

4.3.1 Calculate the average Asphalt Binder (AB) percentage of the two extractions, P_{ext}. Calculate the average AB percentage of the four ignition oven burns, P_{ign}. Assuming the average AB content from the extraction to be correct, subtract the average extraction AB percentage from the average ignition oven AB percentage to determine the asphalt correction factor, C_f.

$$C_f = P_{ign} - P_{ext}$$

Use the asphalt correction factor to adjust the ignition oven asphalt content on all subsequent testing of that stockpile.

4.4 Gradation Calibration

4.4.1 From the two extractions, calculate the average percent passing the applicable sieve, G_{ext}. Calculate the average percent passing each applicable sieve from the four ignition oven burns, G_{ign}. Subtract the extraction average percent passing each sieve from the ignition oven average of the corresponding sieve to determine a correction factor, GC_f, for gradation for each sieve.

$$GC_f = G_{ign} - G_{ext}$$

5.0 REPORT

5.1 Report the correction factors to the nearest 0.1%

6.0 PRECISION AND BIAS

6.1 The estimates of precision and bias shall be considered those that apply to the referenced documents.

7.0 USE

7.1 Use the correction factor for percent passing the No. 200 (75-µm) sieve to adjust the minus No. 200 (75-µm) material from the ignition oven on all subsequent testing of that stockpile.

7.2 Use the asphalt correction factor to adjust the ignition oven asphalt content on all subsequent testing of that stockpile.

7.3 The ignition oven washed gradations may be used uncorrected for all sieves except for the No. 200 (75-µm) sieve.

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised Date: December 1, 2022

Standard Method of Test For

Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method

Reference AASHTO T 308-22

AASHTO Section	***Illinois Modification***
1.1	Revise the first sentence as follows: This test method covers the determination of asphalt binder content of HMA by ignition of the asphalt binder at 482 °C (900 °F) in a furnace.
2.1	Revise reference to the individual Standards as follows: T 30 (Illinois Modified)
2.1	Delete: R 66 R 76 R 97
2.1.1	Illinois Manual of Test Procedures: ▪ Appendix B4, Hot-Mix Asphalt Test Strip Procedures ▪ Appendix B6, Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples ▪ Appendix B7, Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations ▪ Appendix E3, PFP and QCP Random Density Procedure ▪ Appendix E4, PFP and QCP Hot Mix Asphalt Random Jobsite Sampling
5.1	Replace with the following: A forced-air ignition furnace that heats the specimens by either the convection or direct IR irradiation method. The convection-type furnace must be capable of maintaining a temperature of 482 ± 5°C (900 ± 9°F). The furnace chamber dimensions shall be adequate to accommodate a specimen size of 3500 g. The furnace door shall be equipped so that the door cannot be opened during the ignition test. A method for reducing furnace emissions shall be provided. The furnace shall be vented into a hood or to the outside and, when set up properly, shall have no noticeable odors escaping into the laboratory. The furnace shall have a fan capable of pulling air through the furnace to expedite the test and reduce the escape of smoke into the laboratory.
Note 1	Delete
Note 2	Renumber as Note 1.

Illinois Modified Test Procedure
Effective Date: January 1, 2002
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Standard Method of Test For

Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method

Reference AASHTO T 308-22

5.3	Replace with the following: *Oven*—An oven of sufficient size, specifically built for drying, capable of maintaining a uniform temperature of 110 ± 5 °C (230 ± 9 °F) shall be used. No other heat source for drying is permitted. The thermometer for measuring the oven temperature shall have a suitable range to determine 110 · 5 ·C (230 · 9 ·F). The thermometer may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.75 °C (± 1.35 °F) (Note 2). **Note 2** - Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; IEC 60584 thermocouple thermometer, Type T, Class 1; or E2877 digital metal stem thermometer.
Note 3	Renumber as Note 2.
5.6	Replace with the following: *Miscellaneous Equipment*—A pan with dimensions (L x W x H) 600 mm x 600 mm x 150 mm (24 in. x 24 in. x 6 in.) minimum for transferring specimens after ignition.
6.1	Replace with the following: Obtain samples of freshly produced asphalt mixture according to the appropriate Appendix in the Manual of Test Procedures.
6.2	Replace with the following: The specimen shall be the end result of reducing a larger sample according to the appropriate Appendix in the Manual of Test Procedures. A specimen of 1 kg, minimum, shall be split out to determine the moisture content.
Note 4	Renumber as Note 3.
7.1.1	Revise the first sentence as follows: For the Convection-type furnace, preheat the ignition furnace to 482 °C (900 °F).

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Effective Date: January 1, 2002
Revised Date: December 1, 2022

Standard Method of Test
For

Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method

Reference AASHTO T 308-22

AASHTO Section	***Illinois Modification***
7.2	Replace with the following: Obtain and split a HMA sample(s) according to Sections 6.2, 6.4, and A2.2 herein. Test for moisture as follows: Determine the mass of the moisture content sample immediately after splitting as outlined in Section 6.2 herein. Record this value as the original sample mass. Place this sample in a 110 ± 5 °C (230 ± 9 °F) drying oven and continue drying until it reaches a constant mass. Constant mass shall be defined as the mass at which further drying does not alter the mass more than 0.5 gram in 1 hour. Moisture content is determined as follows: $$\%\ Moisture\ Content\ (M_C) = \frac{(Original\ Sample\ Mass)\ -(Constant\ Mass)}{Constant\ Mass} \times 100$$
Note 5	Renumber as Note 4.
Note 6	Renumber as Note 5.
Note 7	Renumber as Note 6.
Note 8	Renumber as Note 7.
8.1	Replace with the following: Preheat the ignition furnace to 482 °C (900 °F).
8.2	Replace with the following: Obtain and split a HMA sample(s) according to Sections 6.2, 6.4, and A2.2 herein. Test for moisture as follows: Determine the mass of the moisture content sample immediately after splitting as outlined in Section 6.2 herein. Record this value as the original sample mass. Place this sample in a 110 ± 5 °C (230 ± 9 °F) drying oven and continue drying until it reaches a constant mass. Constant mass shall be defined as the mass at which further drying does not alter the mass more than 0.5 gram in 1 hour.

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Standard Method of Test
For
Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method

Reference AASHTO T 308-22

AASHTO Section	***Illinois Modification***
8.2 Cont'd	Moisture content is determined as follows: $\% \, Moisture \, Content \, (M_C) = \frac{(Original \, Sample \, Mass) - (Constant \, Mass)}{Constant \, Mass} \times 100$
8.7	Revise the second sentence with the following: Burn the HMA sample in the furnace for at least 60 minutes.
Note 9	Renumber as Note 8 and delete the second sentence.
8.8	Replace with the following: After ignition, open the chamber door, remove the specimen and specimen basket assembly from the furnace, and place it on a cooling plate or block. Place the protective cage over the specimen basket assembly and allow it to cool in a 110 ± 5 °C (230 ± 9 °F) drying oven until the specimen stabilizes at 110 ± 5 °C (230 ± 9 °F). Weigh and record the constant mass (M_f).
8.9 through 8.15	Delete.
Note 10	Delete
9.3 New Section	Correct the aggregate gradation by subtracting the degradation computed in Section 9.2 herein from the percent passing on the respective sieves.
Note 11	Renumber as Note 9.
Note 12	Renumber as Note 10.
Note 13	Renumber as Note 11.
A1.1	Revise the third sentence as follows: Correction factor(s) must be determined each time a change in the mix ingredients or design occurs.
A1.2	Delete the first two sentences.

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised Date: December 1, 2022

Standard Method of Test
For
Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method

Reference AASHTO T 308-22

AASHTO Section	***Illinois Modification***
A2.4	Revise the first sentence as follows: According to the requirements of the current Hot Mix Asphalt QC/QA Level III (Design) Course, prepare two calibration specimens at the design asphalt content.
A2.5	Revise the second sentence as follows: If allowed to cool, the specimens must be preheated in a 110 ± 5 °C (230 ± 9 °F) oven for 25 minutes prior to placement in the specimen basket assembly.
A2.8.1	Delete.

Standard Method of Test for

Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method

AASHTO Designation: T 308-22

AASHTO

Technically Revised: 2022 **Editorially Revised: 2022**

Technical Subcommittee: 2c, Asphalt–Aggregate Mixtures

1. SCOPE

1.1. This test method covers the determination of asphalt binder content of asphalt mixtures by ignition at temperatures that reach the flashpoint of the binder in a furnace. The means of specimen heating may be the convection method or the direct infrared (IR) irradiation method. The aggregate remaining after burning can be used for sieve analysis using T 30.

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 concerns associated with its use. It is the responsibility of the user of this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.4. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 231, Weighing Devices Used in the Testing of Materials
- M 339M/M 339, Thermometers Used in the Testing of Construction Materials
- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- R 47, Reducing Samples of Asphalt Mixtures to Testing Size
- R 66, Sampling Asphalt Materials
- R 76, Reducing Samples of Aggregate to Testing Size
- R 90, Sampling Aggregate Products
- R 97, Sampling Asphalt Mixtures
- T 30, Mechanical Analysis of Extracted Aggregate
- T 329, Moisture Content of Asphalt Mixtures by Oven Method

2.2. *ASTM Standards*:

- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E2877, Standard Guide for Digital Contact Thermometer

2.3. *International Electrotechnical Commission Standard*:

- IEC 60584-1: 2013 Thermocouples - Part 1: EMF Specifications and Tolerances

2.4. *Other Documents*:

- Manufacturer's Instruction Manual
- NCHRP Final Report, NCHRP Project No. 9-26, Phase 3

3. SUMMARY OF TEST METHOD

3.1. The asphalt binder in the asphalt mixture is ignited using the furnace equipment applicable to the particular method. This procedure covers two methods. Method A requires an ignition furnace with an internal balance. Method B requires an ignition furnace with an external balance.

3.2. The asphalt binder content is calculated as the difference between the initial mass of the asphalt mixture and the mass of the residual aggregate, with adjustments for an asphalt binder correction factor and the moisture content. The asphalt binder content is expressed as a mass percent of the moisture-free mixture. This method may be affected by the type of aggregate in the mixture. Accordingly, to optimize accuracy, correction factors for asphalt binder and aggregate will be established by testing a set of correction factor specimens for each type of asphalt mixture. Correction factors must be determined before any acceptance testing is performed.

4. SIGNIFICANCE AND USE

4.1. This method can be used for quantitative determinations of asphalt binder content and gradation in asphalt mixture and pavement specimens 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 T 30.

5. APPARATUS

5.1. *Ignition Furnace*—A forced-air ignition furnace that heats the specimens by either the convection or direct IR irradiation method. The convection-type furnace must be capable of maintaining a temperature of 538 ± 5°C (1000 ± 9°F). The furnace chamber dimensions shall be adequate to accommodate a specimen size of 3500 g. The furnace door shall be equipped so that the door cannot be opened during the ignition test. A method for reducing furnace emissions shall be provided. The furnace shall be vented into a hood or to the outside and, when set up properly, shall have no noticeable odors escaping into the laboratory. The furnace shall have a fan capable of pulling air through the furnace to expedite the test and reduce the escape of smoke into the laboratory. The ignition furnace shall be capable of operation at the temperatures required, between at least 530 and 545°C (986 and 1013°F), and have a temperature control accurate within ±5°C (±9°F) as corrected, if necessary, by standardization. More than one furnace may be used, provided each is used within its proper operating temperature range. When measuring temperature during use, the thermometer for measuring the temperature of materials shall meet the requirements of M 339M/M 339 with a temperature range of at least 530 to 545°C (986 to 1013°F) and an accuracy of ±1.25°C (±2.25°F) (Note 1).

Note 1—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class; or IEC 60584 thermocouple thermometer, Type J or K, Class 1.

5.1.1. For Method A, the furnace shall also have an internal balance thermally isolated from the furnace chamber and accurate to 0.1 g. The balance shall be capable of weighing a 3500-g specimen in addition to the specimen baskets. A data collection system will be included so that the mass 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 specimen baskets and provide for the input of a correction factor for aggregate loss. The furnace shall provide a printed ticket with the initial specimen mass, specimen mass loss, temperature compensation, correction factor, corrected asphalt binder content (percent), test time, and test temperature. The furnace shall provide an audible alarm and indicator light when the specimen mass loss does not exceed 0.01 percent of the total specimen mass for 3 consecutive min. The furnace shall also allow the operator to change the ending mass loss percentage to 0.02 percent.

5.2. *Specimen Basket Assembly*—Consisting of specimen basket(s), catch pan, and an assembly guard to secure the specimen basket(s) to the catch pan.

5.2.1. *Specimen Basket(s)*—Of appropriate size to allow the specimens to be thinly spread and allow air to flow through and around the specimen particles. Sets with two or more baskets shall be nested. The specimen shall be completely enclosed with screen mesh, perforated stainless steel plate, or other suitable material.

Note 2—Screen mesh or other suitable material with maximum and minimum openings of 2.36 mm (No. 8) and 0.600 mm (No. 30), respectively, has been found to perform well.

5.2.2. *Catch Pan*—Of sufficient size to hold the specimen basket(s) so that aggregate particles and melting asphalt binder falling through the screen are caught.

5.3. *Oven*—Capable of maintaining 110 ± 5°C (230 ± 9°F). The oven(s) for heating shall be capable of operation at the temperatures required, between 100 and 120°C (212 and 248°F), within ±5°C (±9°F) as corrected, if necessary, by standardization. More than one oven may be used, provided each is used within its proper operating temperature range. The thermometer for measuring the oven temperature shall meet the requirements of M 339M/M 339 with a temperature range of at least 90 to 130°C (194 to 266°F) and an accuracy of ±1.25°C (±2.25°F) (Note 3).

Note 3—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E2877 digital metal stem thermometer; ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class; IEC 60584 thermocouple thermometer, Type J or K, Class 1, Type T any Class; or dial gauge metal stem (bi-metal) thermometer.

5.4. *Balance*—Of sufficient capacity and conforming to the requirements of M 231, Class G 2.

5.5. *Safety Equipment*—Safety glasses or face shield, dust mask, high-temperature gloves, long-sleeved jacket, a heat-resistant surface capable of withstanding 650°C (1202°F), and a protective cage capable of surrounding the specimen baskets during the cooling period.

5.6. *Miscellaneous Equipment*—A pan larger than the specimen basket(s) for transferring the specimen after ignition, spatulas, bowls, and wire brushes.

6. SAMPLING

6.1. Obtain samples of freshly produced asphalt mixture in accordance with R 97.

6.2. The specimen shall be the end result of reducing a larger sample in accordance with R 47.

6.3. If the mixture is not sufficiently soft to separate with a spatula or trowel, place it in a large, flat pan in an oven at 110 ± 5°C (230 ± 9°F) until it is workable. Do not leave the specimen in the oven for an extended period of time. Excessive heating may cause detrimental effects such as asphalt draindown or oxidation.

6.4. The size of the test specimen shall be governed by the nominal-maximum aggregate size of the asphalt mixture and shall conform to the mass requirement shown in Table 1. When the mass of the specimen exceeds the capacity of the equipment used, the specimen may be divided into suitable increments, tested, and the results appropriately combined for calculation of the asphalt binder content (using a weighted average). Specimen sizes shall not be more than 500 g greater than the minimum recommended specimen mass.

Note 4—Large specimens of fine mixes tend to result in incomplete ignition of asphalt binder.

Table 1—Mass Requirements

Nominal-Maximum Aggregate Size,[a] mm	Sieve Size	Minimum Mass of Specimen, g
4.75	No. 4	1200
9.5	$^3/_8$ in.	1200
12.5	$^1/_2$ in.	1500
19.0	$^3/_4$ in.	2000
25.0	1 in.	3000
37.5	1$^1/_2$ in.	4000

[a] Nominal-maximum aggregate size—one size larger than the first sieve to retain more than 10 percent.

TEST METHOD A—INTERNAL BALANCE

7. TEST PROCEDURES

7.1. *Test Initiation*:

7.1.1. For the convection-type furnace, preheat the ignition furnace to 538 ± 5°C (1000 ± 9°F) or to the temperature determined by the correction factor process in the Annex. Manually record the furnace temperature (set point) prior to the initiation of the test if the furnace does not record automatically.

7.1.2. For the direct IR irradiation-type furnace, use the same burn profile as used during the correction factor determination.

7.2. Use T 329 to oven dry the asphalt mixture specimen to a constant mass or determine the moisture content of a companion specimen.

7.3. Enter into the ignition furnace, or manually record, the asphalt binder correction factor for the specific mix to be tested, as determined in the Annex.

7.4. Determine and record the mass of the specimen basket assembly to the nearest 0.1 g.

7.5. Prepare the specimen as described in Section 6. Place the specimen basket(s) in the catch pan. Evenly distribute the specimen in the basket(s), taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the specimen.

7.6. Determine and record the total mass of the specimen and specimen basket assembly at room temperature to the nearest 0.1 g. Calculate and record the initial mass of the specimen, M_i (total mass minus the mass of the specimen basket assembly).

7.7. Input the initial mass of the specimen, M_i, in whole grams into the ignition furnace controller. Verify that the correct mass has been entered.

7.8. Reset the internal balance to zero.

7.9. Open the chamber door and place the specimen basket assembly in the furnace, carefully positioning the specimen basket assembly so it is not in contact with the furnace walls. Close the chamber door and verify that the specimen mass (including the basket assembly) displayed on the furnace scale equals the total mass recorded in Section 7.6 within ±5 g. Differences greater than

5 g or failure of the furnace scale to stabilize may indicate that the specimen basket assembly is contacting the furnace wall.

Note 5—Due to the extreme heat of the furnace, the operator should wear safety equipment—high-temperature gloves, face shield, and fire-retardant shop coat—when opening the door to load or unload the specimen.

7.10. Initiate the test by pressing the start/stop button. This operation will lock the specimen chamber and start the combustion blower.

Note 6—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. Specimen ignition typically increases the temperature well above the set point, depending on the specimen size and asphalt binder content.

7.11. 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 3 consecutive min). Press the start/stop button. This operation will unlock the specimen chamber and cause the printer to print out the test results.

Note 7—An ending mass loss percentage of 0.02 may be substituted when the aggregate exhibits an excessive amount of loss during ignition testing. The precision and bias statement was developed using 0.01 percent. Both precision and accuracy may be adversely affected by using 0.02 percent.

7.12. Open the chamber door, remove the specimen basket assembly, and place it on a cooling plate or block. Place the protective cage over the specimen basket assembly, and allow it to cool to room temperature (approximately 30 min).

7.13. Determine and record the total mass of the specimen and specimen basket assembly after ignition to the nearest 0.1 g. Calculate and record the final mass of the specimen, M_f (total mass minus the mass of the specimen basket assembly).

7.14. Use the corrected asphalt binder content (percent) from the printed ticket. If this value is not corrected, subtract the asphalt binder correction factor. If a moisture content has been determined per T 329, subtract the percent moisture from the asphalt binder content on the printed ticket, and report the resultant value as the corrected asphalt binder content (P_b).

Note 8—Asphalt binder content can also be calculated using Equation 1 from Method B (Section 8.16).

TEST METHOD B—EXTERNAL BALANCE

8. TEST PROCEDURES

8.1. Preheat the ignition furnace to 538 ± 5°C (1000 ± 9°F) or the temperature determined by the correction factor process in the Annex.

8.2. Use T 329 to oven dry the asphalt mixture specimen to a constant mass or determine the moisture content of a companion specimen.

8.3. Record the asphalt binder correction factor for the specific mix to be tested, as determined by the correction factor process in the Annex.

8.4. Determine and record the mass of the specimen basket assembly to the nearest 0.1 g.

8.5. Prepare the specimen as described in Section 6. Place the specimen baskets in the catch pan. Evenly distribute the specimen in the basket(s), taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the specimen.

8.6. Determine and record the total mass of the specimen basket assembly at room temperature to the nearest 0.1 g. Calculate and record the initial mass of the specimen, M_i (total mass minus the mass of the specimen basket assembly).

8.7. Open the chamber door and place the specimen basket assembly in the furnace. Burn the asphalt mixture specimen in the furnace for at least 45 min.

Note 9—The appropriate time for the initial burn of an asphalt mixture specimen is dependent on the specimen size. For large specimens, the time could be significantly longer than 45 min. See the Manufacturer's Instruction Manual for guidelines.

8.8. Open the chamber door, remove the specimen basket assembly, and place it on a cooling plate or block. Place the protective cage over the specimen basket assembly, and allow it to cool to room temperature (approximately 30 min).

8.9. Determine and record the total mass of the specimen and specimen basket assembly after cooling to the nearest 0.1 g.

8.10. Place the specimen and specimen basket assembly back into the furnace.

8.11. Burn the specimen for at least 15 min after the furnace reaches the set point temperature.

8.12. Open the chamber door, remove the specimen and specimen basket assembly, and place it on a cooling plate or block. Place the protective cage over the specimen basket assembly, and allow it to cool to approximately room temperature (approximately 30 min).

8.13. Weigh and record the total mass of the specimen and specimen basket assembly after cooling to the nearest 0.1 g.

8.14. Repeat Sections 8.10 through 8.13 until the change in measured mass of the specimen after ignition does not exceed 0.01 percent of the initial specimen mass, M_i.

Note 10—An ending mass loss percentage of 0.02 may be substituted when the aggregate exhibits an excessive amount of loss during ignition testing. The precision and bias statement was developed using 0.01 percent. Both precision and accuracy may be adversely affected by using 0.02 percent. After the time required to obtain the specified mass loss has been established for each mixture, repeated mass determinations may not be necessary.

8.15. Calculate and record the final mass of the specimen, M (total mass minus the mass of the specimen basket assembly).

8.16. Calculate the asphalt binder content of the specimen as follows:

$$P_b, \% = \left[\frac{(M_i - M_f)}{M_i} \times 100 \right] - C_F - MC \qquad (1)$$

where:

P_b = the measured (corrected) asphalt binder content, percent;

M_i = the total mass of the asphalt mixture specimen prior to ignition, g;

M_f = the total mass of aggregate remaining after the ignition, g;

C_F = the correction factor, percent by mass of asphalt mixture specimen; and

MC = the moisture content of the companion asphalt mixture specimen, percent, as determined by T 329. (If the specimen was oven dried prior to initiating the procedure, $MC = 0$.)

9. GRADATION

9.1. Allow the contents of the specimen baskets to cool to room temperature prior to performing the gradation analysis. Empty the contents of the baskets into a container, being careful to capture all material. Use a small wire sieve brush to ensure that any residual fines are removed from the baskets and catch pan.

9.2. Perform the gradation analysis according to T 30.

10. REPORT

10.1. *The report shall include the following*:

10.1.1. Test method (A or B);

10.1.2. Corrected asphalt binder content;

10.1.3. Correction factor;

10.1.4. Temperature compensation factor (if applicable);

10.1.5. Specimen mass;

10.1.6. Moisture content (if determined, per T 329); and

10.1.7. Test temperature.

Note 11—If Method A is performed, attach the original printed ticket to the report.

11. PRECISION AND BIAS

11.1. *Precision*—Criteria for judging the acceptability of ignition burn results for asphalt binder content obtained by Method A or Method B are given in Table 2.

11.1.1. *Single-Operator Precision*—The figures in Column 2 of Table 2 are the standard deviations that have been found to be appropriate for the conditions of test described in Column 1. Two results obtained in the same laboratory, by the same operator using the same equipment, in the shortest practical period of time, should not be considered suspect unless the difference in the two results exceeds the values given in Table 2, Column 3.

11.1.2. *Multilaboratory Precision*—The figures in Column 2 of Table 2 are the standard deviations that have been found to be appropriate for the conditions of test described in Column 1. Two results submitted by two different operators testing the same material in different laboratories shall not be considered suspect unless the difference in the two results exceeds the values given in Table 2, Column 3.

Table 2—Precision Estimates

Condition	Standard Deviation $(1s)^a$	Acceptable Range of Two Test Results $(d2s)^a$
Single-operator precision		
Asphalt binder content (%)	0.069	0.196
Multilaboratory precision		
Asphalt binder content (%)	0.117	0.330

[a] These values represent the 1s and d2s limits described in ASTM C670.

Note 12—The precision estimates given in Table 2 are based on the analysis of test results from three pairs of AMRL proficiency samples. The data analyzed consisted of results from 353 to 461 laboratories for each of the three pairs of samples. The analysis included two binder grades: PG 52-34 and PG 64-22. Average results for asphalt binder content ranged from 4.049 to 5.098 percent. The details of this analysis are in NCHRP Final Report, NCHRP Project No. 9-26, Phase 3.

Note 13—The precision estimates are based on four aggregate types, four replicates, and twelve laboratories participating with no laboratory results deleted as outlying observations. All four aggregates were tested in surface mixes and had relatively low absorption values.

11.2. *Bias*—Any biases inherent to the ignition oven process used for Test Methods A and B, when testing for asphalt binder content and aggregate gradation, are accounted for by the determination and application of appropriate correction factors.

12. KEYWORDS

12.1. Aggregate; asphalt binder; asphalt binder content; asphalt mixture; convection; correction factor; direct infrared irradiation; external balance; gradation; ignition; ignition furnace; internal balance.

ANNEX A—CORRECTION FACTORS

(Mandatory Information)

A1. ASPHALT BINDER AND AGGREGATE

A1.1. Asphalt binder content results may be affected by the type of aggregate in the mixture and the ignition furnace. Therefore, asphalt binder and aggregate correction factors must be established by testing a set of correction specimens for each job mix formula (JMF) mix design. Correction factor(s) must be determined before any acceptance testing is completed and repeated each time a change in the mix ingredients or design occurs. Any changes greater than 5 percent in stockpiled aggregate proportions should require a new correction factor. Historical data or scientific studies may be used to determine the correction factor(s) in lieu of using this testing procedure if the testing agency provides reference to the studies/data.

A1.2. *Asphalt Binder Correction Factor*—Certain aggregate types may result in unusually high correction factors (greater than 1.0 percent). Such mixes should be corrected and tested at a lower temperature, as described below. Each ignition furnace will have its own unique asphalt binder correction factor determined in the location where testing will be performed.

A1.3. *Aggregate Correction Factor*—Due to potential aggregate breakdown during the ignition process, an aggregate correction factor will be determined for each ignition furnace in the location where testing will be performed when the following conditions occur: aggregates that have a proven history of excessive breakdown or aggregates from an unknown source.

A2. CORRECTION FACTOR PROCEDURE

A2.1. Obtain samples of aggregate in accordance with R 90. Reduce the samples to testing size as needed according to R 76.

A2.2. Obtain samples of asphalt binder in accordance with R 66.

Note A1—Include other additives that may be required by the JMF.

A2.3. Prepare an initial, or "butter" mix at the design asphalt binder content. Mix and discard the butter mix prior to preparing any of the correction specimens to ensure an accurate asphalt binder content.

A2.4. Prepare two correction specimens at the JMF design asphalt binder content and gradation. Aggregate used for correction specimens shall be sampled from the material designated for use in production. An additional "blank" (aggregate only) specimen shall be batched at the JMF gradation. Determine an aggregate gradation in accordance with T 30 on the "blank" specimen.

A2.5. Place the freshly mixed specimens directly into the specimen basket assembly. If specimens are allowed to cool prior to placement in the specimen basket assembly, the specimens must be dried to constant mass at a temperature of 110 ± 5°C (230 ± 9°F). Do not preheat the specimen basket assembly.

A2.6. Test the specimens in accordance with Method A or Method B of the procedure.

A2.7. Once both of the correction specimens have been burned, determine the asphalt binder content for each specimen by calculation or from the printed oven tickets, if available.

A2.8. If the difference between the asphalt binder contents of the two specimens exceeds 0.15 percent, repeat Section A2.3 through A2.7 with two more specimens and, from the four results, discard the high and low result. Determine the correction factor from the two original or remaining results as appropriate. Calculate the difference between the actual and measured asphalt binder contents for each specimen. The asphalt binder correction factor, C_F, is the average of the differences expressed as a percentage by mass of the asphalt mixture.

A2.8.1. If the asphalt binder correction factor exceeds 1.0 percent, the test temperature should be lowered to 482 ± 5°C (900 ± 9°F) for a convection-type furnace. If there is no improvement in the correction factor, it is permissible to use the higher temperature.

Note A2—The temperature for determining the asphalt binder content of asphalt mixture specimens by this procedure shall be the same temperature determined for the correction specimens.

A2.8.2. For the direct IR irradiation-type furnaces, the Default burn profile should be used for most materials. The operator may select burn-profile Option 1 or Option 2 to optimize the burn cycle. Option 1 is designed for aggregate that requires a large asphalt binder correction factor (greater than 1 percent)—typically very soft aggregate (such as dolomite). Option 2 is designed for samples that may not burn completely using the Default burn profile. The burn profile for testing asphalt mixture samples shall be the same burn profile selected for correction samples.

A2.9. Perform a gradation analysis on the residual aggregate in accordance with T 30, if required. The results will be utilized in developing an aggregate correction factor and should be calculated and reported to the nearest 0.1 percent.

A2.9.1. From the gradation results, subtract the percent passing each sieve for each specimen from the percent passing each sieve of the "blank" specimen gradation results from Section A2.4.

A2.9.2. Determine the average difference for the two values. If the difference for any single sieve exceeds the allowable difference for that sieve as listed in Table A2.1, then aggregate gradation correction factors (equal to the resultant average differences) for all sieves shall be applied to all acceptance gradation test results determined by T 30, prior to final rounding and reporting. If the 0.075-mm (No. 200) sieve is the only sieve outside the limits in Table A2.1, apply the aggregate correction factor to only the 0.075-mm (No. 200) sieve.

Table A2.1—Permitted Sieving Difference

Sieve	Allowable Difference
Sizes larger than or equal to 2.36 mm (No. 8)	±5.0 percent
Sizes larger than 0.075 mm (No. 200) and smaller than 2.36 mm (No. 8)	±3.0 percent
Sizes 0.075 mm (No. 200) and smaller	±0.5 percent

Determining the Asphalt Binder Content of Asphalt Mixtures Using Automated Extraction

INTRODUCTION

The objective of this section is to introduce the Automated Extractor. Upon completion of this section, students shall be able to process material, prepare test specimens, operate testing equipment and analyze and report test data.

All content presented in this section is based upon Illinois Modified ASTM D8159-18 and this test method should be referenced for all details.

SUMMARY OF TEST METHOD

The asphalt paving mixture is extracted using the automated extraction equipment, using the following solvent types: tetrachloroethylene, trichloroethylene, or methylene chloride. The asphalt binder content is calculated by taking difference between the mass of the moisture-free mixture and the mass of the extracted aggregate and mineral matter. This test method is used for quantitative determination of asphalt binder in asphalt mixtures. The asphalt binder content is expressed as mass percent of moisture-free mixture (Pb).

EQUIPMENT

Automated Extraction Unit - The Automated Extraction Unit shall be a fully automated system similar to the one shown in Figure 1 and be composed of the following components:

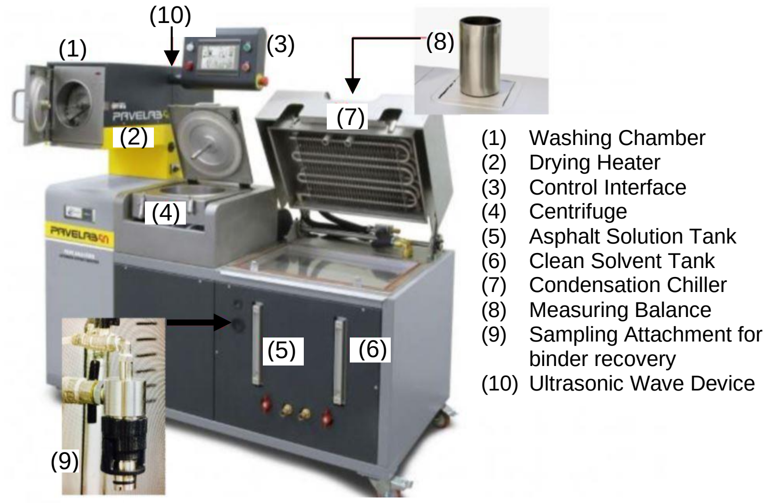


FIG. 1 Automated Extraction Unit

Washing Chamber (Fig. 1, #1) - Stainless steel washing chamber fitted with an ultrasonic device, a heating system, a rotating washing drum, and a closing door with a safety lock.

Centrifuge (Fig. 1, #4) - Stainless steel centrifuge casing with cover and safety lock. Internal centrifuge spindle capable of accommodating a cup with appropriate geometry and rotating at a speed suitable to ensure the separation between mineral filler passing the designated drum mesh sieve and solvent. To remove mineral filler from the cup after the centrifugation process, a special inlay paper is required inside the cup prior to start of extraction.

Solvent Pump - Capable of transferring the solvent from the clean solvent tank to the washing chamber.

Condenser (Fig. 1, #7) - Stainless steel tank with built-in cooling coil for water cooling to condense solvent.

Pump, Air or Vacuum - Solvent-resistant pump, able to circulate air and solvent vapors during the drying cycle. The circulation of the air ensures that the solvent vapors are extracted from the specimen and released in the condenser.

Recovery Module - Composed of two chambers and integrated cooling system, capable of adequately recovering solvent from an asphalt mixture. One chamber shall serve as a binder and solvent solution storage chamber, and the other serving as a clean solvent storage and recovery chamber. All chambers shall have the capability to allow transfer of solvent through the extraction process.

Solvent Recovery and Binder Storage Chamber – Will be fitted with heating system to distill solvent, fill level indicators to prevent heating when chamber is empty, and an outlet tap.

Clean Solvent Storage and Recovery Chamber – Will be fitted with integrated cooling system, fill level indicator, outlet tap, and mechanism to allow solvent distillate to flow or be transferred back to washing chamber.

Washing Drum (Fig. 2) - A stainless steel washing drum able to contain the specimen. The cylindrical wall is made of mesh having an aperture of 0.075 mm. The mesh shall be interchangeable and resistant to wear and impacts from the aggregates during the test. The mesh should be maintained and verified according Appendix X1. The drum shall have a closing system (lid). The connection between the parts of the drum and the closing lid will ensure the sealing with regards to fine particles. (Any aperture should be smaller than the mesh filtering grade.)

FIG. 2 – Washing Drum with Lid

Centrifuge Cup (Fig. 3) - A stainless steel cup to collect mineral filler. Centrifuge cup capacity minimum capacity is 200 g. The total estimated mineral filler content passing through the washing drum mesh should not exceed the capacity of the centrifuge cup in order to avoid overflowing into recovery plant. The Centrifuge cup geometry varies; refer to manufacturer for appropriate centrifuge cup specifications.

FIG. 3 – Centrifuge Cup

Inlay paper – Used for centrifuge cup shall meet the following specifications: weight: 40 g/m2; pH neutral. Inlay paper size specifications are per manufacturer recommendation.

Oven - Capable of maintaining the temperature at 110 ± 5°C (230 ± 9°F).

Pan - Capable of containing the specimen for the heating procedure.

Balance - Readable to 0.1 g and capable of measuring the mass of specimen and container.

Solvent – One of the following solvents shall be used: Tetrachloroethylene, Trichloroethylene or Methylene Chloride. No other solvents are approved for use in this procedure. The pH of the solvent shall meet the requirements of the manufacturer and shall be verified according to manufacturer recommendations.

SAMPLING

When sampling material for specimen preparation, it is critical to ensure proper procedure is employed. Samples should be representative of the larger source and precaution should be taken to avoid segregation. Obtain specimens in accordance with Illinois Modified AASHTO T168.

SPECIMEN PREPARATION

Separate specimen by hand spatula or trowel, then split and reduce specimen to required testing size listed in Table 1 in accordance with Illinois Modified AASHTO R 76 If specimen is not able to be separated or split, place specimen in a large, flat pan and warm it in a 110 ± 5°C (230 ± 9°F) oven only until splitting can be performed.

Table 1 Test Specimen Size and Cycles

Material	Minimum Mass of Sample, g	Wash Cycles	Dry Cycles
RAS	750	12	5
IL4.75, IL9.5, IL9.5FG, RAP, FRAP, 9.5SMA	1250	10	5
12.5 SMA, IL19.0, IL19.0FG	1750	10	5

NOTE: When the mass of the test specimen exceeds the capacity of the equipment used (specifically, the capacity of the centrifuge cup is the limiting factor for sampling in this particular method), the test specimen may be divided into suitable increments, tested, and the masses of each increment combined before calculating the asphalt binder content (Section 9).

If the specimen was obtained from the field and contains moisture, oven dry the HMA specimen to a constant mass at a temperature of 110 ± 5°C (230 ± 9°F) Constant mass shall be defined as the mass at which further drying does not alter the mass by more than 0.5 g when weighed at 1 hour intervals.

PROCEDURE

All necessary unit connections must be made in accordance with manufacturer's instructions. The operating instructions of the machine supplier must be followed for calibrating, checking, and operating the unit.

Sample Preparations

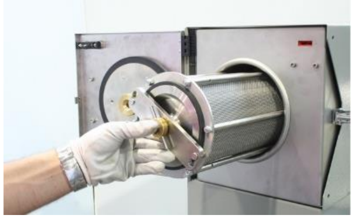
Carefully clean the centrifuge cup (Fig. 3) to be sure there is no residue on the bottom and under the rim. Line the inside lateral surface of the centrifuge cup with inlay paper as per manufacturer recommendations. Determine the mass of the centrifuge cup with inlay paper inside and record as (M4) to the nearest 0.1 g. Place the centrifuge cup into the centrifuge (Fig. 1, #4), close the centrifuge door, and engage the lock.

NOTE: Apply manufacturer-recommended lubricant to the bottom rim of the centrifuge cup to ease insertion into and removal from the centrifuge chamber.

Carefully clean the washing drum and the lid (Fig. 2) to be sure there is no residue at the bottom, under the rim, and inside the meshes. Determine the mass of the empty, dry washing drum with its lid on and record as (M1) to the nearest 0.1 g.

Put the loose, moisture-free asphalt mixture specimen into the washing drum. Close the drum lid and determine the mass of the drum with lid and specimen and record as (M2) to the nearest 0.1 g.

NOTE: Compressed air or a soft cloth and a brush are suitable for cleaning the vessels before extraction. It is not recommended to use water to clean the centrifuge cup or washing drum.



Place the closed and filled washing drum into the washing chamber (Fig. 1, #1) after recording the mass. Close the door and engage the lock.

Via the built-in HMI system, set the number of washing and drying cycles in accordance with Table 1.

Extraction Process

Start the extraction process in accordance with manufacturer instructions. If the solvent is not running at least light straw or running clear as seen through the inspection window. Continue increasing the number of washing cycles until removal of the binder from the mixture is complete. If the number of wash cycles is greater than Table 1, report the actual number of wash cycles completed. Once the set number of washing cycles is achieved, the drying phase begins automatically.

NOTE: The color of the solvent is an indicator of the residual asphalt binder in the specimen. The clearer the solvent color is, the less residual asphalt binder remains in the specimen.)

The extraction process consists of several different sequenced and timed user-controlled stages (phases) to allow the customization of the extraction process depending on the specimen characteristics, including weight and material type.

Washing Phase

The solvent is pumped from the clean solvent tank into the washing chamber (Fig. 1, #1). The asphalt specimen is soaked in the solvent inside the rotating washing drum inside the washing chamber for a user designated amount of time, depending on specimen size and material type. The total washing time, also known as washing cycles, is preselected by the user before beginning the extraction process via an HMI (See Table 1). During each washing cycle, the extracted binder, solvent, and mineral filler flow out into the centrifuge that separates liquid from the mineral filler. The mineral filler remains in the centrifuge cup, and the liquid extract (mix of solvent and asphalt binder) flows to the extracted binder and solvent tank.

Drying Phase

The user preselects the number of drying cycles, depending on specimen size and type, via an HMI before the start of the extraction process (See Table 1). Once the washing cycles and system flushing are complete, the drying phase will automatically begin. The user may select the appropriate amount of drying cycles depending on the size and type of specimen. A suitable system of valves ensures that the circuit connecting the washing chamber, centrifuge, and condenser is closed to the atmosphere and sealed, creating a vacuum. The vacuum or air pump creates an air flow on the circuit, ensuring extraction of solvent vapors from the specimen (drying) and vapor releasing (condensation) on the condenser. At the end of the drying phase, the condensed vapors are conveyed to the clean solvent tank by means of an appropriate valve.

The recovery cycle is continuous and runs in parallel to washing and drying cycles. The minimum and maximum filling requirements are set per the manufacturer’s recommendation.

After Extraction

At the end of the extraction process, remove the washing drum, open the lid, and visually inspect that the aggregates are clean and dry. Determine the mass of the drum with extracted specimen with the lid on after extraction and record as (M3) to the nearest 0.1 g.

Remove the filler cup from the centrifuge and visually inspect that the filler is dry. Brush any remaining aggregate from the washing chamber into the filler cup. Determine the mass of the centrifuge cup with the extracted mineral filler after extraction and record as (M5) to the nearest 0.1 g.

CALCULATIONS

Calculate the amount of aggregates and mineral filler collected from the washing drum and the centrifuge cup after the extraction process, where:

M1 = Empty washing drum with lid before the extraction, g
M2 = Washing drum with lid on, filled with asphalt mixture before extraction, g
M3 = Washing drum filled with asphalt mixture after the extraction, g
M4 = Empty centrifuge cup with liner paper before the extraction, g
M5 = Centrifuge cup with liner paper with P200 mineral filler after extraction, g
M6 = M2 – M1 Total asphalt mixture weight, g
M7 = M3 – M1 Dry aggregate weight minus weight of the mineral filler, g
M8 = M5 – M4 Total weight of the dry mineral filler, P200, g
M9 = M7 + M8 Total dry aggregate specimen weight, g
PB = Binder content on specimen, %

Calculate the amount of binder extracted from the specimen during the process using the following formula and record %PB to the nearest 0.1%.

Total asphalt binder, % PB = ((M6 - M9) / M6)*100

Classroom Calculation Example

Use the given information below to calculate the final %PB for a 9.5 mm FRAP sample utilizing the auto extractor.

Mix Type			
Sample Number	CTL 191514	**Basket #/Cup**	1/B
Before Extraction			
Empty Drum (M1)	3981.0	**Cup with new filter (M4)**	663.60
Filled Drum (M2)	5325.4	**New Filter**	6.30
Original Sample Weight (M6) = M2-M1			
After Extraction			
Filled Drum (M3)	5190.6	**Cup with used filter (M5)**	738.30
Empty Drum (M1)	3981.0	**Cup with new filter (M4)**	663.60
Aggregate Only (M7) = M3 – M1			
Dust in cup (M8) = M5 – M4			
Extracted Agg. + Dust (M9) = M7 + M8			
Final Values			
Original Sample (M6) = M2 – M1			
Extracted Aggregate (M9) = M7 + M8			
Bitumen = M6-M9			
Final PB% = ((M6-M9)/M6)*100			

NOTE: Record and calculate M1-M9 values to the nearest 0.1g and calculate the PB to the nearest 0.1%

Illinois Modified Test Procedure
Effective Date: February 28, 2019
Revised Date: December 1, 2022

Standard Method of Test
for
Automated Extraction of Asphalt Binder from Asphalt Mixtures

Reference ASTM D8159-19

AASHTO Section	***Illinois Modification***
2.1	Replace ASTM D979/979M with AASHTO T168 Replace ASTM D1461 with AASHTO T110 Replace ASTM D1856 with AASHTO R59 Replace ASTM D2042 with AASHTO T44 Replace ASTM D2172/2172M with IL Modified AASHTO T164 Replace ASTM D2872 with AASHTO T240 Replace ASTM D3666 with AASHTO R89 Replace ASTM D4753 with AASHTO M231 Replace ASTM D5444 with AASHTO T30 Replace AASHTO R47 with IL Modified AASHTO R76
5.2	Replace the first paragraph with the following: Washing Drum (Fig. 2)—A stainless steel washing drum able to contain the specimen. The cylindrical wall is made of mesh having an aperture of 0.075 mm. The mesh shall be interchangeable and resistant to wear and impacts from the aggregates during the test. The mesh should be maintained and verified according Appendix X1. The drum shall have a closing system (lid). The connection between the parts of the drum and the closing lid will ensure the sealing with regards to fine particles. (Any aperture should be smaller than the mesh filtering grade.)
5.3	Replace with the following: Centrifuge Cup (Fig. 3)—A stainless steel cup to collect mineral filler. Centrifuge cup capacity minimum capacity is 200 g. The total estimated mineral filler content passing through the washing drum mesh should not exceed the capacity of the centrifuge cup in order to avoid overflowing into recovery plant. NOTE 3—Centrifuge cup geometry varies; refer to manufacturer for appropriate centrifuge cup specifications.
6.2	Replace with the following: Solvent – One of the following solvents shall be used. No other solvents are approved for use in this procedure. The pH of the solvent shall meet the requirements of the manufacturer and shall be verified according to manufacturer recommendations.
6.2.1	Delete the last two sentences.
6.2.2	Delete the last two sentences.

Illinois Modified Test Procedure
Effective Date: February 28, 2019
Revised Date: December 1, 2022

Standard Method of Test
for
Automated Extraction of Asphalt Binder from Asphalt Mixtures
(continued)
Reference ASTM D8159-19

AASHTO Section	***Illinois Modification***
7.2.1	Replace with the following: Separate specimen by hand spatula or trowel, then split and reduce specimen to required testing size listed in Table 1 in accordance with Illinois Modified AASHTO R76. If specimen is not able to be separated or split, place specimen in a large, flat pan and warm it in a 110 ± 5°C (230 ± 9°F) oven only until splitting can be performed. Table 1 Test Specimen Size and Cycles

Material	Minimum Mass of Sample, g	Wash Cycles	Dry Cycles
RAS	750	12	5
IL4.75, IL9.5, IL9.5FG, RAP, FRAP, 9.5SMA	1250	10	5
12.5 SMA, IL19.0, IL19.0FG	1750	10	5

	NOTE 8—When the mass of the test specimen exceeds the capacity of the equipment used (specifically, the capacity of the centrifuge cup is the limiting factor for sampling in this particular method), the test specimen may be divided into suitable increments, tested, and the masses of each increment combined before calculating the asphalt binder content (Section 9).
7.2.2	Replace the last sentence with the following: Constant mass shall be defined as the mass at which further drying does not alter the mass by more than 0.5 g when weighed at 1 hour intervals.
8.7	Replace with the following: Via the built-in HMI system, set the number of washing and drying cycles in accordance with Table 1.

Illinois Modified Test Procedure
Effective Date: February 28, 2019
Revised Date: December 1, 2022

Standard Method of Test
for
Automated Extraction of Asphalt Binder from Asphalt Mixtures
(continued
Reference ASTM D8159-19

AASHTO Section	***Illinois Modification***
8.8.1	Replace with the following: Start the extraction process in accordance with manufacturer instructions. If the solvent is not running at least light straw or running clear as seen through the inspection window (Fig. 1, #3), continue increasing the number of washing cycles until removal of the binder from the mixture is complete. If the number of wash cycles if greater than Table 1, report the actual number of wash cycles completed. Once the set number of washing cycles is achieved, the drying phase begins automatically.
8.9.2	Add the following sentence after the first sentence: Brush any remaining aggregate from the washing chamber into the filler cup.
9.3	Add the following: Record and calculate M1 – M9 values to the nearest 0.1 g. Calculate the PB to the nearest 0.1%

This Page Is Reserved

Designation: D8159 – 19

Standard Test Method for Automated Extraction of Asphalt Binder from Asphalt Mixtures[1]

This standard is issued under the fixed designation D8159; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the quantitative determination of asphalt binder content in asphalt mixtures and pavement specimens, using the automated computer controller or human-machine interface system (HMI), to perform a solvent extraction for specification acceptance, service evaluation, quality control, and research.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.4 An ILS is being conducted according to Practice E691 and will be available on or before December 2018. Therefore, this standard should not be used for acceptance or rejection of a material for purchasing purposes.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D979/D979M Practice for Sampling Bituminous Paving Mixtures

D1461 Test Method for Moisture or Volatile Distillates in Asphalt Mixtures

D1856 Test Method for Recovery of Asphalt From Solution by Abson Method

D2042 Test Method for Solubility of Asphalt Materials in Trichloroethylene

D2872 Test Method for Effect of Heat and Air on a Moving Film of Asphalt (Rolling Thin-Film Oven Test)

D3666 Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials

D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing

D5404/D5404M Practice for Recovery of Asphalt from Solution Using the Rotary Evaporator

D5444 Test Method for Mechanical Size Analysis of Extracted Aggregate

D5546 Test Method for Solubility of Asphalt Binders in Toluene by Centrifuge (Withdrawn 2017)[3]

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

2.2 *AASHTO Standard:*[4]

R 47 Standard Practice for Reducing Samples of Hot Mix Asphalt (HMA) to Testing Size

3. Summary of Test Method

3.1 The asphalt paving mixture is extracted using the automated extraction equipment, using only the following

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[1] This test method is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.25 on Analysis of Asphalt Mixtures.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

solvent types: tetrachloroethylene, trichloroethylene, or methylene chloride. The asphalt binder content is calculated by the arithmetic difference between the mass of the moisture-free mixture and the mass of the extracted aggregate and mineral matter. This test method is used for quantitative determination of asphalt binder in asphalt mixtures. The asphalt binder content is expressed as mass percent of moisture-free mixture (Pb).

4. Significance and Use

4.1 This test method is used for quantitative determination of asphalt binder in asphalt mixtures and asphalt pavement samples for specification acceptance, service evaluation, control, and research.

4.2 Aggregates obtained by this method may be used for sieve analysis using Test Method D5444. Extracted asphalt binder from this test method may be recovered using Test Method D1856 or Practice D5404/D5404M.

Note 1—The quality of results produced by this standard is dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of Specification D3666 are generally considered capable of competent and objective testing, sampling, inspection, etc. Users of this standard are cautioned that compliance with Specification D3666 alone does not completely ensure reliable results. Reliable results depend on many factors; following the suggestions of Specification D3666 or some similar acceptable guidance provides a means of evaluating and controlling some of those factors.

5. Apparatus

5.1 *Automated Extraction Unit,* consisting of a fully automated system with a process flow chart equivalent to the one reported in Fig. 1.

5.1.1 The automated extraction system shall be composed of the following components:

5.1.2 *Washing Chamber (*Fig. 1*, #1)*—Stainless steel washing chamber fitted with an ultrasonic device, a heating system, a rotating washing drum, and a closing door with a safety lock.

5.1.3 *Inspection Window (*Fig. 1*, #3)*—Transparent window, allowing monitoring of the color of the solvent flowing from the washing chamber to the centrifuge.

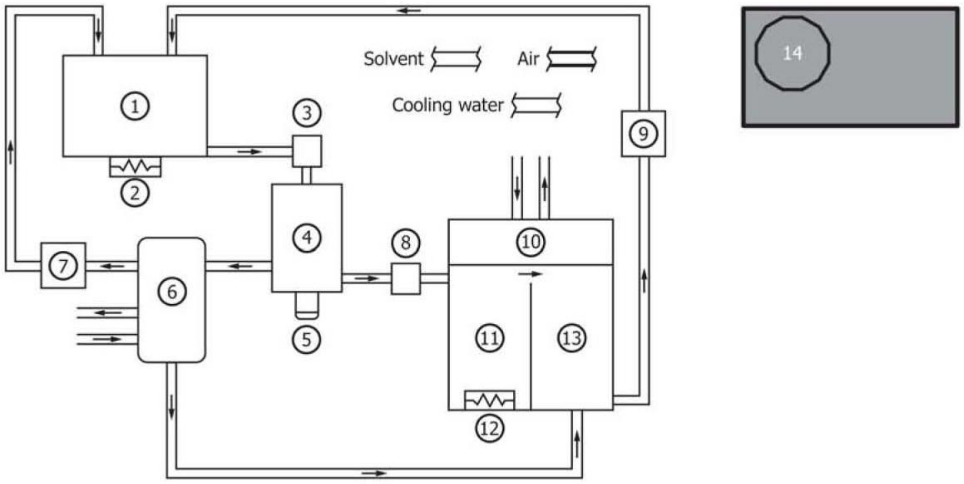
5.1.4 *Centrifuge (*Fig. 1*, #4)*—Stainless steel centrifuge casing with cover and safety lock. Internal centrifuge spindle capable of accommodating a cup with appropriate geometry and rotating at a speed suitable to ensure the separation between mineral filler passing the designated drum mesh sieve and solvent consistent with Section 6. To remove mineral filler from the cup after the centrifugation process, a special inlay paper is required inside the cup prior to start of extraction.

5.1.5 *Solvent Pump (*Fig. 1*, #9)*—Capable of transferring the solvent from the clean solvent tank to the washing chamber.

5.1.6 *Condenser (*Fig. 1*, #6)*—Stainless steel tank with built-in cooling coil for water cooling to condense solvent.

5.1.7 *Pump, Air or Vacuum (*Fig. 1*, #7)*—Solvent-resistant pump, able to circulate air and solvent vapors during the drying cycle. The circulation of the air ensures that the solvent vapors are extracted from the specimen and released in the condenser.

5.1.8 *Recovery Module*—Composed of two chambers and integrated cooling system, capable of adequately recovering solvent from an asphalt mixture. One chamber shall serve as a binder and solvent solution storage chamber, and the other serving as a clean solvent storage and recovery chamber. All chambers shall have the capability to allow transfer of solvent through the extraction process.



1. Washing chamber
2. Washing chamber heating system
3. Inspection window
4. Centrifuge
5. Centrifuge motor
6. Condenser
7. Vacuum or air pump
8. Outlet valve
9. Solvent pump
10. Integrated cooling system
11. Extracted binder and solvent solution tank
12. Distillation unit heating system for collection and partial solvent recovery
13. Clean solvent tank
14. Human-machine interface (HMI)

FIG. 1 Schematic Drawing of Automated Extraction Unit

5.1.8.1 *Solvent Recovery and Binder Storage Chamber,* fitted with heating system to distill solvent, fill level indicators to prevent heating when chamber is empty, and an outlet tap.

5.1.8.2 *Clean Solvent Storage and Recovery Chamber,* fitted with integrated cooling system, fill level indicator, outlet tap, and mechanism to allow solvent distillate to flow or be transferred back to washing chamber.

5.2 *Washing Drum (*Fig. 2*)*—A stainless steel washing drum able to contain the specimen. The cylindrical wall is made of mesh having an aperture of one of the following mesh sizes: 0.063 mm, 0.075 mm, or 0.090 mm. The mesh shall be interchangeable and resistant to wear and impacts from the aggregates during the test. The drum shall have a closing system (lid). The connection between the parts of the drum and the closing lid will ensure the sealing with regards to fine particles. (Any aperture should be smaller than the mesh filtering grade.) The washing drum with lid closed fits into washing chamber in Fig. 1, #1 after being filled with asphalt mixture prior to extraction.

NOTE 2—Washing drum mesh aperture can be selected according to individual user requirements for sieve size at which the mineral filler is separated from the recovered aggregate.

5.3 *Centrifuge Cup (*Fig. 3*)*—A stainless steel cup to collect mineral filler during extraction. The cup is placed empty with inlay paper prior to extraction into the centrifuge chamber in Fig. 1, #4.

NOTE 3—Centrifuge cup geometry varies; refer to manufacturer for appropriate centrifuge cup specifications.

5.4 Inlay paper for centrifuge cup shall meet the following specifications: weight: 40 g/m^2; pH neutral. Inlay paper size specifications are per manufacturer recommendation. See Note 4.

NOTE 4—Inlay paper suggested size: 383 by 205 mm. Other inlay paper types and sizes may be applicable; check with manufacturer before use.

5.5 *Oven,* capable of maintaining the temperature at 110 ± 5 °C.

5.6 *Pan,* capable of containing the specimen for the heating procedure.

5.7 *Balance,* readable to 0.1 g and capable of measuring the mass of specimen and container. The balance shall conform to the requirement of Guide D4753, Class GP2.

FIG. 3 Centrifuge Cup with Inlay Paper

6. Reagents and Materials

6.1 *Purity of Reagents*—Unless otherwise indicated, all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.[5] Other grades may be used if the reagent is of sufficiently high purity to permit its use without reducing the efficiency of extraction or damaging the equipment. For certain solvents, stabilization agents may be added to maintain required solvent quality based on manufacturer recommendations.

6.2 *Solvent*—One of the following solvents shall be used. No other solvents are approved for use in this procedure.

6.2.1 *Tetrachloroethylene,* reagent grade at initial filling. This solvent type must maintain solvent alkalinity above 7 ppm NaOH equivalent and pH value above 7.2. The solvent alkalinity and pH shall be verified once per week or at an interval selected at the discretion of the user based on machine usage and material type, or per manufacturer recommendations.

FIG. 2 Washing Drum with Lid

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[5] Reagent Chemicals, American Chemical Society Specifications, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

6.2.2 *Trichloroethylene,* reagent grade at initial filling. This solvent type must maintain solvent alkalinity above 7 ppm NaOH equivalent and pH value above 7.2. The solvent alkalinity and pH shall be verified once per week or at an interval selected at the discretion of the user based on machine usage and material type, or per manufacturer recommendations.

NOTE 5—Tetrachloroethylene and trichloroethylene, 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 should be taken not to allow these solvents to fall below manufacturer-recommended alkalinity and pH levels. Follow manufacturer recommendations regarding solvent quality management.

6.2.3 *Methylene Chloride,* reagent grade at initial filling.

NOTE 6—This solvent type does not require regular alkalinity and pH verification.

NOTE 7—All local, state, and federal regulations must be followed when hauling, using, storing, and discarding extracted material and solvent. These requirements include fire ordinances and wastewater treatment regulations. The Safety Data Sheets (SDS) or Materials Safety Data Sheets (MSDS) for each solvent must be followed closely to avoid misuse.

7. Sampling, Test Specimens, and Test Units

7.1 Obtain specimens in accordance with Practice D979/D979M.

7.2 *Preparation of Test Specimens:*

7.2.1 Separate specimen by hand spatula or trowel, then split and reduce specimen to required testing size in accordance with AASHTO R 47. If specimen is not able to be separated or split, place specimen in a large, flat pan and warm to 110 ± 5 °C [230 ± 9 °F]. Split or quarter the material until the mass of material required for test is obtained, and determine the mass of the specimen. The size of the test specimen shall be governed by the nominal maximum aggregate size of the mixture and shall conform to the mass requirement shown in Table 1.

TABLE 1 Size of Test Specimen

Nominal Maximum Aggregate Size Standard, mm	Sieve Size	Minimum Mass of Sample, kg
4.75	No. 4	0.5
9.5	⅜ in.	1
12.5	½ in.	1.5
19.0	¾ in.	2
25.0	1 in.	3
37.5	1½ in.	4

NOTE 8—When the mass of the test specimen exceeds the capacity of the equipment used (specifically, the capacity of the centrifuge cup is the limiting factor for sampling in this particular method), the test specimen may be divided into suitable increments, tested, and the masses of each increment combined before calculating the asphalt binder content (Section 9). The total estimated mineral filler content passing through the washing drum mesh should not exceed capacity of the centrifuge cup used, in order to avoid overflowing into recovery plant.

7.2.2 If the specimen was obtained from the field and contains moisture, oven dry the HMA specimen to a constant mass at a temperature of 110 ± 5 °C or determine the moisture content of the specimen according to Test Method D1461, so that the measured mass loss can be corrected for moisture. Constant mass is defined as less than 0.05 % loss in mass between consecutive 15-min intervals.

8. Procedure

8.1 All necessary unit connections must be made in accordance with manufacturer's instructions. The operating instructions of the machine supplier must be followed for calibrating, checking, and operating the unit.

8.2 *Preliminary Operations:*

8.3 Carefully clean the centrifuge cup (Fig. 3) to be sure there is no residue on the bottom and under the rim. Line the inside lateral surface of the centrifuge cup with inlay paper as per manufacturer recommendations. Determine the mass of the centrifuge cup with inlay paper (M4) inside to the nearest 0.1 g. Place the centrifuge cup into the centrifuge (Fig. 1, #4), close the centrifuge door, and engage the lock.

NOTE 9—Apply manufacturer-recommended lubricant to the bottom rim of the centrifuge cup to ease insertion into and removal from the centrifuge chamber.

8.4 Carefully clean the washing drum and the lid (Fig. 2) to be sure there is no residue at the bottom, under the rim, and inside the meshes. Determine the mass of the empty, dry washing drum with its lid on (M1) to the nearest 0.1 g.

8.5 Put the loose, moisture-free asphalt mixture specimen into the washing drum. Close the drum lid and determine the mass of the drum with lid and specimen (M2) to the nearest 0.1 g.

NOTE 10—Compressed air or a soft cloth and a brush are suitable for cleaning the vessels before extraction. It is not recommended to use water to clean the centrifuge cup or washing drum.

8.6 Place the closed and filled washing drum into the washing chamber (Fig. 1, #1) after recording the mass. Close the door and engage the lock.

8.7 Via the built-in HMI system, set the number of washing and drying cycles in accordance with the material weight and characteristics and based on manufacturer recommendations.

8.8 *Extraction Process:*

8.8.1 Start the extraction process in accordance with manufacturer instructions. Continue increasing the number of washing cycles until removal of the binder from the mixture is complete. The asphalt binder will be fully extracted from the specimen when the solvent is running at least light straw or running clear as seen through the inspection window (Fig. 1, #3). Once the set number of washing cycles is achieved, the drying phase begins automatically.

NOTE 11—The color of the solvent is an indicator of the residual asphalt binder in the specimen. (The clearer the solvent color is, the less residual asphalt binder remains in the specimen.) Washing and drying cycles may be added to the preselected number during the extraction process per manufacturer specifications.

8.8.2 The extraction process consists of several different sequenced and timed user-controlled stages (phases) to allow the customization of the extraction process depending on the specimen characteristics, including weight and material type.

8.8.2.1 *Washing Phase*—The solvent is pumped from the clean solvent tank into the washing chamber (Fig. 1, #1). The asphalt specimen is soaked in the solvent inside the rotating washing drum inside the washing chamber for a user-designated amount of time, depending on specimen size and material type. The total washing time, also known as washing cycles, is preselected by the user before beginning the extraction process via an HMI. During each washing cycle, the extracted binder, solvent, and mineral filler flow out into the centrifuge that separates liquid from the mineral filler. The mineral filler remains in the centrifuge cup, and the liquid extract (mix of solvent and asphalt binder) flows to the extracted binder and solvent tank.

NOTE 12—The duration of each washing cycle varies between manufacturers; refer to manufacturer guidelines for recommendation on total washing cycle selection for various mix types.

8.8.2.2 *Drying Phase*—The user preselects the number of drying cycles, depending on specimen size and type, via an HMI before the start of the extraction process. Once the washing cycles and system flushing are complete, the drying phase will automatically begin. The user may select the appropriate amount of drying cycles depending on the size and type of specimen. A suitable system of valves ensures that the circuit connecting the washing chamber, centrifuge, and condenser is closed to the atmosphere and sealed, creating a vacuum. The vacuum or air pump creates an air flow on the circuit, ensuring extraction of solvent vapors from the specimen (drying) and vapor releasing (condensation) on the condenser. At the end of the drying phase, the condensed vapors are conveyed to the clean solvent tank by means of an appropriate valve.

NOTE 13—The duration of each drying cycle varies between manufacturers; refer to manufacturer guidelines for recommendation on total drying cycle selection for various mix types.

8.8.2.3 The recovery cycle is continuous and runs in parallel to washing and drying cycles. The minimum and maximum filling requirements are set per the manufacturer's recommendation.

8.9 *After Extraction:*

8.9.1 At the end of the extraction process, remove the washing drum, open the lid, and visually inspect that the aggregates are clean and dry. Determine the mass of the drum with extracted specimen with the lid on after extraction (M3) to the nearest 0.1 g.

NOTE 14—If necessary, put the drum under a fume hood to vent solvent vapors and then put into the oven at 110 ± 5 °C until dried to constant mass.

8.9.2 Remove the filler cup from the centrifuge and visually inspect that the filler is dry. Determine the mass of the centrifuge cup with extracted mineral filler after extraction (M5) to the nearest 0.1 g.

8.9.3 If the total weight of the dry mineral filler (M8) exceeds the capacity of the centrifuge cup, either 200 g or 300 g respective of the centrifuge cup model used, then the test should be considered invalid. The original sample size should be decreased and the test re-run. See Note 8.

NOTE 15—If necessary, put the centrifuge cup under a fume hood to vent solvent vapors and then put into the oven at 110 ± 5 °C until dried to constant mass.

9. Calculation and Interpretation of Results

9.1 Calculate the amount of aggregates and mineral filler collected from the washing drum and the centrifuge cup after the extraction process as follows:

M1 = Empty washing drum with lid before the extraction, g
M2 = Washing drum with lid on filled with asphalt mixture before extraction, g
M3 = Washing drum filled with asphalt mixture after the extraction, g
M4 = Empty centrifuge cup with liner paper before the extraction, g
M5 = Centrifuge cup with liner paper with P200 mineral filler after extraction, g
M6 = M2 – M1 Total asphalt mixture weight, g
M7 = M3 – M1 Dry aggregate weight minus weight of the mineral filler, g
M8 = M5 – M4 Total weight of the dry mineral filler, P200, g
M9 = M7 + M8 Total dry aggregate specimen weight, g
PB = Binder content on specimen, %

9.2 Calculate the amount of binder extracted from the specimen during the process as follows:

$$\text{total asphalt binder, \% PB} = \left(\left(M6 - M9\right)/M6\right)*100 \qquad (1)$$

10. Precision and Bias

10.1 The precision of this test method is based on an interlaboratory study of WK58842, Standard Test Method for Automated Extraction of Asphalt Binder from Asphalt Mixtures, conducted in 2018. Six laboratories tested a single asphalt mixture. Every "test result" represents an individual determination. Each laboratory submitted a single test result, from a single operator. Except for the lack of replicates, the design and analysis of the data were based on Practice E691; the details are given in ASTM Research Report No. RR:D04-1041.[6]

10.1.1 *Repeatability Limit* (r)—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the "*r*" value for that material; "*r*" is the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory.

10.1.1.1 Repeatability limits cannot be determined without replicate test results from the participating laboratories.

10.1.2 *Reproducibility Limit* (R)—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

10.1.2.1 Reproducibility can be interpreted as the maximum difference between two results, obtained under reproducibility conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

10.1.2.2 Reproducibility limits are listed in Table 2.

10.1.3 The terms "repeatability limit" and "reproducibility limit" are used as specified in Practice E177.

10.1.4 Any judgment in accordance with 10.1.1 and 10.1.2 would have an approximate 95 % probability of being correct.

10.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method; therefore, no statement on bias is being made.

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[6] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D04-1041. Contact ASTM Customer Service at service@astm.org.

TABLE 2 Total Asphalt Binder %

Asphalt Mixture	Average $\bar{x}$	Reproducibility Standard Deviation s_R	Reproducibility Limit R
	4.98	0.08	0.23

10.3 The precision statement was determined through statistical examination of six test results, from six laboratories, on a single asphalt mixture.

APPENDIXES

(Nonmandatory Information)

X1. MAINTENANCE

X1.1 Per manufacturer's instructions.

X2. CALIBRATION/EQUIPMENT VERIFICATION

X2.1 Verify annually that the aggregate and mineral filler after extraction are constant mass per manufacturer instructions. If this is not done, then constant mass must be achieved using an oven.

X2.2 Verify annually that the percentage of the recovered binder that is soluble in the solvent is at least 99.0 %, in accordance with Test Method D5546. Recover binder using Test Method D1856 or Practice D5404/D5404M, then use Test Method D2872 to remove residual solvent prior to running Test Method D2042.

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Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: December 1, 2023

Standard Method of Test
for
Mechanical Analysis of Extracted Aggregate

Reference AASHTO T 30-21

AASHTO Section	***Illinois Modification***
2.1	Replace AASHTO Standard T 164 with the following: • Illinois Modified AASHTO T 164 Replace AASHTO Standard T 255 with the following: • Illinois Modified AASHTO T 255 Replace AASHTO Standard T 308 with the following: • Illinois Modified AASHTO T 308
2.2	Add the following reference: Illinois Modified ASTM D 8159 Automated Extraction of Asphalt Binder from Asphalt Mixtures
7.1	Replace the first sentence with the following: The sample shall be dried until further drying at 110 ± 5 °C (230 ± 9 °F) does not alter the mass more than 0.5 gram in 1 hour.
New Note 7	Add at the end of Section 7.4: When the extraction has been conducted according to Illinois Modified ASTM D8159, the wash-in-water cycle in Sections 7.2 through 7.4 may be omitted.
A2.2	Replace the second sentence with: This mass is shown in Table A2.1 for three sieve-frame dimensions in common use.

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Standard Method of Test for

Mechanical Analysis of Extracted Aggregate

AASHTO Designation: T 30-21

Technically Revised: 2021 **Editorially Revised: 2023**

Technical Subcommittee: 2c, Asphalt–Aggregate Mixtures

1. SCOPE

1.1. This method covers a procedure for the determination of the particle-size distribution of fine and coarse aggregates extracted from asphalt mixtures using sieves with square openings.

1.2. The values stated in SI units are to be regarded as the standard.

1.3. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:
- M 231, Weighing Devices Used in the Testing of Materials
- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- R 35, Superpave Volumetric Design for Asphalt Mixtures
- R 61, Establishing Requirements for Equipment Calibrations, Standardizations, and Checks
- T 164, Quantitative Extraction of Asphalt Binder from Asphalt Mixtures
- T 255, Total Evaporable Moisture Content of Aggregate by Drying
- T 308, Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method

2.2. *ASTM Standards*:
- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- E11, Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

3. SIGNIFICANCE AND USE

3.1. This method is used to determine the grading of aggregates extracted from asphalt mixtures. The results are used to determine compliance of the particle-size distribution with applicable requirements and to provide necessary data for control of the production of various aggregates to be used in asphalt mixtures.

4. APPARATUS

4.1. *Balance*—A Class G2 balance meeting the accuracy requirements of M 231.

4.2. *Sieves*—Conforming to the requirements of ASTM E11.

4.3. *Mechanical Sieve Shaker*—A mechanical sieving device, if used, shall continually reorient the particles on the sieving surface. The sieving action shall meet the requirements for sieving adequacy described in Section 7 in a reasonable time period (Note 1).

Note 1—Use of a mechanical sieve shaker is recommended when the size of the sample is 20 kg (44 lb) or greater, and may be used for smaller samples, including fine aggregate. Excessive time (more than 10 min) to achieve adequate sieving may result in degradation of the sample. The same mechanical sieve shaker may not be practical for all sizes of samples, because a large sieving area is needed for practical sieving of a large nominal size coarse aggregate. Use of the same device for a smaller size of coarse aggregate or fine aggregate will likely result in loss of a portion of the sample.

4.4. *Oven*—An oven of sufficient size, capable of maintaining a uniform temperature of 110 ± 5°C (230 ± 9°F).

4.5. *Wetting Agent*—Any dispersing agent, such as dishwashing detergent, that will promote separation of the fine materials.

4.6. *Container*—A pan or vessel of a size sufficient to contain the sample covered with water and to permit vigorous agitation without loss of any part of the sample or water.

4.7. *Spoon or Mixing Utensil*—Or similar device for agitating the sample during the washing procedure.

4.8. *Mechanical Washing Apparatus (Optional)*—See Note 2.

Note 2—The use of some mechanical washing equipment with certain material types may cause degradation of the sample, impacting the results of the particle size analysis. To determine if a particular mechanical washing apparatus causes significant degradation, prepare a known aggregate blend gradation in the laboratory using washed and graded aggregate from individual aggregate stockpiles similarly to preparing an aggregate trial blend gradation as specified in R 35. Mechanically wash and then grade the prepared aggregate blend sample. Compare the mechanically washed grading results to the known gradation of the laboratory-prepared aggregate blend for each sieve size. If the determined percentage passing each sieve for mechanical washing differs by more than the acceptable range of two results between laboratories given in Table 1, the mechanical washing apparatus should not be used.

5. CALIBRATIONS, STANDARDIZATIONS, AND CHECKS

5.1. Unless otherwise specified, follow the requirements and intervals for equipment calibrations, standardizations, and checks found in R 18.

5.2. Follow the procedures for performing equipment calibration, standardizations, and checks found in R 61.

6. SAMPLE

6.1. The sample shall consist of the entire lot or representative sample of aggregate obtained according to T 164 or T 308 from which the binder material has been extracted.

7. PROCEDURE

7.1. Dry the sample, if necessary, until further drying at 110 ± 5°C (230 ± 9°F) does not alter the mass by more than 0.1 percent (Note 3). Determine and record the mass of the sample to the nearest 0.1 g.

Note 3—Samples obtained from T 164 or T 308 should be dried to constant mass as part of the procedures within those standards. If the procedures described herein are completed immediately following the procedures in either of those methods, it will not be necessary to dry the sample again. If more than 24 h pass between the completion of T 164 or T 308 and the beginning of this test procedure, or if the sample is stored in a high-humidity environment, or has otherwise been subjected to moisture, the sample should be dried again to constant mass.

7.1.1. If the sample consists of aggregate obtained from T 164, add the mass of mineral matter contained in the extracted asphalt binder to the mass of the dry sample and record this value as the initial specimen mass (Note 4). The procedure for determination of the mineral matter content of the extracted asphalt is described in T 164.

Note 4—If the asphalt mixture was extracted in accordance with T 164, Method E, for plant control purposes, a mineral matter determination may not have been completed. In this case, record the mass determined in Section 7.1 as the initial specimen mass.

7.1.2. If the sample consists of aggregate obtained from T 308, the mass determined in Section 7.1 shall agree with the mass of aggregate remaining after ignition (M_f from T 308) within 0.1 percent. If the variation exceeds 0.1 percent, the results of this test should not be used for acceptance purposes. Record the mass determined in Section 7.1 as the initial specimen mass.

7.2. Place the test sample in a container and cover it with water. Add a sufficient amount of wetting agent to assure a thorough separation of the material finer than the 75-µm (No. 200) sieve from the coarser particles. Add the wetting agent (Note 5). Agitate the contents of the container vigorously and immediately decant the wash water over a nest of two sieves consisting of a 2.00-mm (No. 10) or 1.18-mm (No. 16) sieve superimposed on a 75-µm (No. 200) sieve (Note 6). The use of a large spoon or similar device is recommended to aid the process of agitating the contents of the container. Limit agitation by mechanical washing equipment to a maximum of 10 min.

Note 5—There should be enough wetting agent to produce a small amount of suds when the sample is agitated. The quantity will depend on the hardness of the water, the quality of the detergent, and the agitation process. Excessive suds may overflow the sieves and carry some material with them.

Note 6—When mechanical washing equipment is used, the introduction of water, agitating, and decanting may be a continuous operation.

7.3. Vigorously agitate the sample, bringing the particles finer than the 75-µm (No. 200) sieve into suspension. Decant the suspension over the sieve nest in order to completely separate the fine particles from the coarse particles. Use care to avoid, as much as possible, the decantation of the coarse particles of the sample onto the sieve nest. Repeat the operation until the wash water is clear. Do not overflow or overload the 75-µm (No. 200) sieve.

7.4. Return all material retained on the nested sieves to the container. Dry the washed aggregate in the container to constant mass in accordance with T 255 and determine its mass to the nearest 0.1 percent.

7.5. Sieve the aggregate over various sieve sizes, including the 75-µm (No. 200) sieve as required by the specification covering the asphalt mixtures. Additional sieve sizes may be used to regulate the amount of material on a sieve to meet the requirements of Annex A2. Nest the sieves in order of decreasing size of opening from top to bottom and place the sample on the top sieve. Agitate the sieves by a mechanical apparatus for a sufficient period, established by trial or checked by measurement on the actual test sample, to meet the criterion for adequacy of sieving described in Annex A1.

7.6. Limit the quantity of material on a given sieve so that all particles have the opportunity to reach sieve openings a number of times during the sieving operation. Do not overload sieves; see Annex A2.

7.7. Record the mass of material passing each sieve, the mass retained on the next sieve, and the amount passing the 75-µm (No. 200) sieve. The sum of these masses must be within 0.2 percent of the mass after washing.

8. CALCULATIONS

8.1. Add the mass of dry material passing the 75-µm (No. 200) sieve by dry sieving to the mass removed by washing, and if applicable, the mass of mineral matter in the asphalt binder, to obtain the total passing the 75-µm (No. 200) sieve. Calculate percentages passing, total percentages retained, or percentages in various size fractions to the nearest 0.1 percent by dividing each by the initial specimen mass determined in Section 7.1.1 or 7.1.2, as applicable.

8.2. For aggregate samples obtained from T 308, apply the aggregate correction factor, as required in T 308, to obtain the final total passing percentages.

9. REPORT

9.1. Report the results of the sieve analysis as follows: (a) total percentages passing each sieve; or (b) total percentages retained on each sieve; or (c) percentages retained between consecutive sieves, depending on the form of the specifications of the material being tested. Report percentages to the nearest whole number, except for the percentage passing the 75-µm (No. 200) sieve, which shall be reported to the nearest 0.1 percent.

10. PRECISION AND BIAS

10.1. *Precision*—The estimates of precision for this test method are listed in Table 1. The estimates are based on the results from the AASHTO re:source Proficiency Sample Program, with testing conducted according to T 30. The data are based on the analyses of the test results from 47 to 190 laboratories that tested 17 pairs of proficiency test samples (Samples No. 1 through 34). The values in the table are given for different ranges of total percentage of aggregate passing a sieve.

Table 1—Precision

	Total Percentage of Material Passing a Sieve	Standard Deviation (1s) Percent[a]	Acceptable Range of Two Results—(d2s) Percent[a]
Extracted aggregate:[b]			
Single-operator precision	95 to 100	0.49	1.4
	40 to 94	1.06	3.0
	25 to 39	0.65	1.8
	10 to 24	0.46	1.3
	5 to 9	0.29	0.8
	2 to 4	0.21	0.6
	0 to 1	0.17	0.5
Multilaboratory precision	95 to 100	0.57	1.6
	40 to 94	1.24	3.5
	25 to 39	0.84	2.4
	10 to 24	0.81	2.3
	5 to 9	0.56	1.6
	2 to 4	0.43	1.2
	0 to 1	0.32	0.9

[a] These numbers represent, respectively, the (1s) and (d2s) limits described in ASTM C670.

[b] The precision estimates are based on aggregates with nominal maximum sizes of 19.0 mm ($^3/_4$ in.) to 9.5 mm ($^3/_8$ in.).

10.2. *Bias*—This test method has no bias because the values determined can only be defined in terms of this test method.

11. KEYWORDS

11.1. Coarse aggregate; fine aggregate; particle size; sieves.

ANNEX A

(Mandatory Information)

A1. TIME EVALUATION

A1.1. The minimum time requirement should be evaluated for each shaker at least annually by the following method:

A1.1.1. Shake the sample over nested sieves for approximately 10 min.

A1.1.2. Provide a snug-fitting pan and cover for each sieve, and hold the items in a slightly inclined position in one hand.

A1.1.3. Hand-shake each sieve continuously for 60 s by striking the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times per min, turning the sieve about one sixth of a revolution at intervals of about 25 strokes.

A1.2. If more than 0.5 percent by mass of the total sample before sieving passes any sieve after one minute of continuous hand-sieving, adjust the shaker time and re-check procedure.

A1.3. In determining sieving time for sieve sizes larger than 4.75 mm (No. 4), limit the material on the sieve to a single layer of particles.

A1.4. If the size of the mounted testing sieves makes the described sieving motion impractical, use 203-mm (8-in.) diameter sieves to verify the adequacy of sieving.

A2. OVERLOAD DETERMINATION

A2.1. Do not exceed a mass of 7 kg/m^2 (4 g/in^2) of sieving surface for sieves with openings smaller than 4.75 mm (No. 4) at the completion of the sieving operation.

A2.2. Do not exceed a mass in kg of the product of 2.5 × (sieve opening in millimeters) × (effective sieving area in square millimeters) for sieves with openings 4.75 mm (No. 4) and larger. This mass is shown in Table A2.1 for three sieve-frame dimensions in common use. Do not cause permanent deformation of the sieve cloth due to overloading.

Note A1—The 7 kg/m^2 (4 g/in.^{2}) amounts to 200 g for the usual 203-mm (8-in.) diameter sieve [with effective or clear sieving surface diameter of 190.5 mm ($7^{1}/_{2}$ in.)] or 450 g for a 305-mm (12-in.) diameter sieve [with effective or clear sieving surface diameter of 292.1 mm ($11^{1}/_{2}$ in.)].

A2.3. As provided below, the amount of material retained on a sieve may be regulated by: (1) the introduction of a sieve with larger openings immediately above the given sieve, (2) testing the sample in a number of increments, or (3) testing the sample over a nest of sieves with a larger sieve-frame dimension.

A2.3.1. Insert an additional sieve with opening size intermediate between the sieve that may be overloaded and the sieve immediately above that sieve in the original set of sieves.

A2.3.2. Split the sample into two or more portions, sieving each portion individually. Combine the masses of the several portions retained on a specific sieve before calculating the percentage of the sample on the sieve.

A2.3.3. Use sieves having a larger frame size and providing greater sieving area.

Table A2.1—Maximum Allowable Mass of Material Retained on a Sieve, kg

Sieve Opening Size	Nominal Dimensions of Sieve[a]		
	203.2 mm (8 in.) dia[a]	254 mm (10 in.) dia[a]	304.8 mm (12 in.) dia[a]
	Sieving Area, m^2 (in.^{2})		
	0.0285 (44.2)	0.0457 (70.8)	0.0670 (103.5)
50 mm (2 in.)	3.6	5.7	8.4
37.5 mm ($1^{1}/_{2}$ in.)	2.7	4.3	6.3
25.0 mm (1 in.)	1.8	2.9	4.2
19.0 mm ($^{3}/_{4}$ in.)	1.4	2.2	3.2
12.5 mm ($^{1}/_{2}$ in.)	0.89	1.4	2.1
9.5 mm ($^{3}/_{8}$ in.)	0.67	1.1	1.6
4.75 mm (No. 4)	0.33	0.54	0.80

[a] The sieve area for round sieves is based on an effective diameter of 12.7 mm ($^{1}/_{2}$ in.) less than the nominal frame diameter because ASTM E11 permits the sealer between the sieve cloth and the frame to extend 6.35 mm ($^{1}/_{4}$ in.) over the sieve cloth. Thus, the effective or clear sieving diameter for a 203.2-mm (8.0-in.) diameter sieve frame is 190.5 mm ($7^{1}/_{2}$ in.). Sieves produced by some manufacturers do not infringe on the sieve cloth by the full 6.35 mm ($^{1}/_{4}$ in.).

EXTRACTION TEST

The extraction test is a method used to determine a variety of information about an existing bituminous concrete pavement or hot-mix asphalt mixture sample. The extraction test dissolves and removes the asphalt binder (AB) from the aggregate. This enables the Level I Technician to determine the AB content of the original mixture. Once the AB is removed, a washed gradation analysis can be performed on the remaining aggregate to determine the gradation of the mixture. This is a useful tool for investigations and process control.

This section describes the method for running extraction tests. Also included is a copy of the AASHTO T 164 procedure along with a list of deviations from this procedure used by Illinois.

PURPOSE OF TEST

A. Asphalt by weight of total mix

B. Analysis of particle size expressed as a percentage of the total aggregate passing a particular sieve:

  (1) Evaluate compliance with mix formula.

  (2) Make adjustments in weight of ingredient materials.

    (a) Changes due to degradation that occurs during aggregate drying and the mixing process.

    (b) Changes in ingredient gradations.

EQUIPMENT

A. Reflux Process - liquid-vapor-liquid:

  (1) Jar.

  (2) Baskets.

  (3) Hotplate.

  (4) Condenser.

  (5) Ahlstrom's (Eaton-Dikeman) Filter paper or equivalent, Grade #613.

  (6) Trichloroethane (TCE) or methyl chloride.

B. Safety Equipment:

   (1) Ventilation hoods.

   (2) Solvent resistant gloves.

   (3) Eye protection.

   (4) Rubber apron.

C. General Equipment:

   (1) Power vented oven capable of maintaining 230 ± 9° F (110° ± 5° C).

   (2) Electronic balance with a minimum capacity of 2500 grams with a sensitivity of 0.1 grams.

   (3) Graduated beaker of more than 1000 ml capacity with minimum graduations of 50 ml.

SPLIT SAMPLE

A. Sample for Reflux extraction.

B. Sample for moisture content by oven drying, not distillation.

WEIGHTS NECESSARY TO BEGIN EXTRACTION

A. Pan weight.

B. Pan and sample weight.

C. Pan, sample, and dried filters weight.

ACCURACY

A. Asphalt content:

   (1) Measured in 0.1% by weight of the total sample.

   (2) One gram per thousand

B. Aggregate:

  (1) Measured in 1% by weight of the total aggregate.

  (2) Ten grams per thousand

C. Dust, or - 75µm (- #200) material:

  (1) Measured in 0.1% by weight of the total aggregate.

  (2) One gram per thousand

PREPARE SAMPLE FOR EXTRACTION

A. Put on safety equipment.

B. Fill jar with fluid:

  (1) 1,000 ml. TCE

  (2) 150 ml. alcohol

C. Get necessary weights.

D. Fold filters and place in baskets.

E. Place samples in filters.

F. Wash the pan into the rest of the sample.

G. Place baskets carefully in jar.

H. Make sure the water is on.

I. Start heating gently.

WHEN FLUID DRIPPING FROM THE SAMPLE IS CLEAR

A. Turn off hot plate.

B. Do not turn off ventilation or water.

C. Wait until sample is drained (fluid has stopped dripping from bottom basket).

UNLOAD SAMPLE FROM BASKETS

A. Put on safety equipment.

B. Use hooks to reach into jar.

C. Place baskets in vented area for five or more minutes.

D. Empty filters into original pre-weighed pan.

E. Fold empty filters and place in pan, do not invert cone.

DRYING THE EXTRACTED AGGREGATE

A. Place the pan, extracted aggregate and filters in a 110° ± 5° C (230° ± 9° F) vented oven for three hours.

B. After three hours, begin successive weighing. The sample is dry when one hour weighing differ by less than 0.5 grams.

WASHED GRADATION

A. Perform gradation analysis according to Illinois Test Procedure 11 and Illinois Test Procedure 27.

CALCULATIONS:

A. Adjust total sample weight for moisture content:

(1) Moisture content = [Original moisture sample weight minus dry moisture sample weight] divided by original moisture sample weight.

(2) Corrected extraction sample weight = original extraction sample weight - [moisture content x original extraction sample weight].

B. Calculate asphalt content to nearest 0.1%.

C. Calculate aggregate on passing basis to nearest 1%.

D. Calculate dust content to nearest 0.1%

DIFFERENCES BETWEEN IDOT AND AASHTO PROCEDURES

A. Quantitative Extraction:

(1) Moisture content.

(a) IDOT - (original - dry)/original weight

(b) AASHTO - measures water from distillation.

(2) Filters per frame.

(a) IDOT - two per frame.

(b) AASHTO - one per frame.

(3) Sample weights.

(a) IDOT - weights are made in pan.

(b) AASHTO - weights are made in the frame.

(c) IDOT - weights are made to the nearest 0.1g.

(d) AASHTO - weights are made to the nearest 0.5g.

(4) Mineral matter.

(a) IDOT - disregard mineral matter.

(b) AASHTO – determine mineral matter in abson and add back to aggregate weight.

(5) Increase in filter weight.

(a) IDOT - original filter weight is made by subtraction and is not reweighed.

(b) AASHTO - filter is weighed separately before & after the extraction.

B. Mechanical analysis of extracted aggregate:

(1) Sample weights.

(a) IDOT - weights are made to the nearest 0.1g.

(b) AASHTO - weights are made to the nearest 0.1%.

(2) Sample Drying.

(a) IDOT - defines dry as less than 0.5 grams loss in weight in two successive one hour weighing at 230° ± 9° F (110° ± 5° C).

(b) AASHTO - defines dry as "further drying at 230° ± 9° F (110° ± 5° C) does not alter the (aggregate) weight 0.1%."

(3) Total aggregate weight.

(a) IDOT – Hot-Mix asphalt mixture minus asphalt.

(b) AASHTO – Hot-Mix asphalt mixture minus asphalt, plus the mineral matter in the extract solution.

(4) Sieving procedure.

(a) IDOT - required sieve sizes, shaking procedure, shaking time, and the calculations are described in Section 6 of the Illinois Aggregate Certified Technician Course.

(b) AASHTO - does not specify.

EXTRACTION WORKSHEET

Preparation before Extraction

1) Pan Tare Weight ______________________________

2) Sample & Pan Weight ______________________________

3) Sample, Pan & Clean Filter Weight ______________________________

Run Extraction

7) Aggregate, Pan & Used Filter Weight ______________________________

11) Used Filter & Pan Weight ______________________________

Calculations

______________ **(Sample & Pan Weight)** - ______________ **(Pan Tare Weight)** = ______________ **(Weight of Sample)**

______________ **(Sample, Pan & Filter Weight)** - ______________ **(Sample & Pan Weight)** = ______________ **(Clean Filter Weight)**

______________ **(Used Filter & Pan Weight)** - ______________ **(Pan Tare Weight)** = ______________ **(Used Filter Weight)**

______________ **(Sample, Pan & Clean Filter Wt.)** - ______________ **(Aggregate, Pan & Used Filter Wt.)** = ______________ **(Asphalt Binder Lost)**

______________ **(Asphalt Binder Lost)** / ______________ **(Weight of Sample)** X 100 = ______________ **(% Asphalt Binder)**

______________ **(Used Filter Weight)** - ______________ **(Clean Filter Weight)** = ______________ **(Dust retained in filter)***

***{This weight is added to the dust weight in your aggregate gradation.}**

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Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: December 1, 2022

Standard Method of Test
for
Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)

Reference AASHTO T 164-22[1] (ASTM D 2172 / D 2172M-11)

AASHTO Section	***Illinois Modification***
2.1	Delete Reference to AASHTO Standard T 168
2.2	Add the following: • Illinois Modified ASTM D8159, Standard Test Method for Automated Extraction of Asphalt Binder from Asphalt Mixtures
New Section 2.4	Replace all references to AASHTO T 168 with the following Manual of Test Procedures Appendices: • Appendix B6 – HMA QC/QA Initial Daily Plant and Random Samples • Appendix B7 – Determination of Random Density Procedures • Appendix E3 – PFP & QCP Random Density Procedure • Appendix E4 – PFP & QCP HMA Random Jobsite Sampling
3.2	Replace with the following: *Constant mass* – shall be defined as the mass at which further drying does not alter the mass by more than 0.5 g when weighed at 1 hour intervals.
4.1	Replace with the following: The HMA mixture is extracted with trichloroethylene; *normal*-propyl bromide; or methylene chloride, using the extraction equipment applicable to Test Method A, B, E or F. The asphalt binder content is calculated by differences from the mass of the extracted aggregate and moisture content, and mineral matter in the extract (when using centrifuge extraction from Test Method A and when using the automated extraction in Method F . The asphalt binder content is expressed as a mass percent of moisture-free mixtures.
5.1	Replace the first sentence with the following: Method A, B, or F shall be used for quantitative determinations of asphalt binder in HMA mixtures and pavement samples for specification acceptance, service evaluation, quality control, and research.
6.1	Replace with the following: *Oven*—Shall meet the temperature requirements listed in the document "Hot-Mix Asphalt Laboratory Equipment". The oven shall be capable of maintaining the temperature at 110 ± 5°C (230 ± 9°F), for warming the sample. Thermometers for measuring temperature of materials shall have a suitable range to determine 50 – 450 °F (10 – 232 °C). The thermometers may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.75 °C (± 1.35 °F) (see Note 3).

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Effective Date: June 1, 2012
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Standard Method of Test
for
Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)

Reference AASHTO T 164-22[1] (ASTM D 2172 / D 2172M-11)

AASHTO Section	***Illinois Modification***
Note 3	Replace with the following: Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; IEC 60584 thermocouple thermometer, Type T, Class 1; or E2877 digital metal stem thermometer.
6.2	Replace with the following: *Oven*—Shall meet the temperature requirements listed in the document "Hot-Mix Asphalt Laboratory Equipment". The oven shall be capable of maintaining the temperature at 149 to 163 ± 5 °C (300 to 325 ± 9 °F), for drying the sample if the moisture content is not determined. Thermometers for measuring temperature of materials shall have a suitable range to determine 50 – 450 °F (10 – 232 °C). The thermometers may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.75 °C (± 1.35 °F) (see Note 4).
Note 4	Replace with the following: Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; IEC 60584 thermocouple thermometer, Type T, Class 1; or E2877 digital metal stem thermometer.
7.4	Delete
Note 4	Delete
9.2.1	Add at the end: Illinois requires the material to be split to the sample size by use of the splitter specified in Illinois Test Procedure 248 and further as specified in IL Modified AASHTO T 312.
9.2.2	Add at the end: Refer to IL Modified ASTM D8159 for the sample size requirements when using Method F.
10.1	Replace with the following: When required, calculate the moisture content of the mixture. Moisture content in the sample is defined as follows: $\frac{Original\ Mass - Oven\ Dry\ Mass}{Oven\ Dry\ Mass} \times 100$

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Standard Method of Test
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Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)

Reference AASHTO T 164-22[1] (ASTM D 2172 / D 2172M-11)

AASHTO Section	***Illinois Modification***
Note 9	Delete
12.3	Replace the first sentence with the following: Cover the test portion in the bowl with trichloroethylene, methylene chloride, or *normal*-propyl bromide extractant, and allow sufficient time for the solvent to disintegrate the test portion (not more than 1 h).
12.4	Allow the machine to stop; add 200 mL (or more as appropriate for the mass of the sample) of trichloroethylene, methylene chloride, or *normal*-propyl bromide extractant, and repeat the procedure.
12.6	Replace with the following: When centrifuge extraction from Test Method A is used, the amount of mineral matter in the extract shall be determined. Any of the test procedures specified in Annex A1 may be used to determine the amount of mineral matter.
13.	Replace with the following: If centrifuge extraction from Test Method A is used, or when any other method of extraction is used and the amount of mineral matter in the extract is determined, then the asphalt binder content in the test portion shall be calculated as follows: Asphalt Binder Content, % = $\frac{(W_1 - W_2) - (W_3 + W_4)}{W_1 - W_2} x100$ Where: W_1 = mass of test portion, W_2 = mass of water in test portion, W_3 = mass of extracted mineral aggregate, and W_4 = mass of mineral matter in the extract. When method B, E, or F is used and the amount of mineral matter in the extract is not determined, then the percent asphalt binder content in the test portion shall be calculated as follows: Asphalt Binder Content, % = $\frac{\text{Sample Mass, Dry} - \text{Aggregate Mass, Dry}}{\text{Sample Mass, Dry}} \text{ x } 100$

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Standard Method of Test
for
Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)

Reference AASHTO T 164-22[1] (ASTM D 2172 / D 2172M-11)

AASHTO Section	***Illinois Modification***
14.1.1.2	Revise the first sentence as follows: *Cylindrical Metal Frames*, two.
16.2.1	Replace with the following: Dry two sheets of filter paper for each metal frame to a constant mass in an oven at 110 ± 5 °C (230 ± 9 °F). Fold each filter paper into quarters. Place the first filter paper into the metal frame in the shape of a cone with three layers on one side and one layer of filter paper on the other side. Place the second filter paper in the cone in the opposite direction, creating four layers of filter paper around the basket.
16.2.2	Replace with the following: Determine the mass of each sample, weighing the pan, sample, and filter paper to the nearest 0.1 gram.
16.2.3	Delete the last two sentences.
16.2.6	Replace the second sentence as follows: Dry the frames in the vented hood; transfer the sample and filters into the original tared pan; and place the pan, sample, and filters in a vented oven at 110 ± 5 °C (230 ± 9 °F) for 3 hours before determining the constant mass. Record the mass.
Test Method D	Delete: Test Method D
18	Delete
19	Delete
20	Delete
Note 18	Delete
25.2.6	Delete the third, fourth, and the final sentence.

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Standard Method of Test
for
Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)

Reference AASHTO T 164-22[1] (ASTM D 2172 / D 2172M-11)

AASHTO Section	***Illinois Modification***
25.2.6	Replace the final sentence with the following: A thermometer for measuring water temperature may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.5 °C (± 0.9 °F) (see Note 23).
New Section	After Section 26.1, add the heading: TEST METHOD F
New Section 27	Add the following: Extraction to determine asphalt content and gradation may be done according to Illinois Modified ASTM Designation D8159.
27	Re-number old Section 27 to be Section 28.
27.1	Re-number old Section 27.1 to be Section 28.1. Delete the last sentence.
27.2	Re-number old Section 27.2 to be Section 28.2. Delete the last sentence.
28	Re-number old Section 28 to be Section 29.
28.1	Re-number old Section 28.1 to be Section 29.1.
A1.1.1.2	Ignition Furnace or Bunsen Burner. The ignition furnace shall meet the temperature requirements listed for ignition oven in the document “Hot-Mix Asphalt Laboratory Equipment”.
Note A1	Delete
A1.2.2.1	Replace the third sentence with: Transfer all of the extract (from Method A, B, E, or F as appropriate) to an appropriate (feed) container suitably equipped with a feed control (valve or clamp, etc.).
A1.3.1.2	Replace with the following: *Water Bath* – Shall meet the temperature requirements listed in the document “Hot-Mix Asphalt Laboratory Equipment”.

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Standard Method of Test
for
Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)

Reference AASHTO T 164-22[1] (ASTM D 2172 / D 2172M-11)

AASHTO Section	***Illinois Modification***
A1.3.2.1	Replace the second sentence with the following: Place the flask in a constant-temperature bath controlled to ± 1 °C (± 1.8 °F), and allow it to reach the temperature at which the flask was calibrated. Replace the last sentence and Note A2 with the following: The thermometer for measuring temperature of the water bath shall have a suitable range to determine 25 ± 1 °C (77 ± 1.8 °F). The thermometers may optionally meet the requirements of M 339M/M 339 and optionally an accuracy of ± 0.25 °C (± 0.45 °F) (see Note A1). **Note A1** - Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E879 thermistor thermometer; ASTM E1137/E1137M Pt-100 RTD platinum resistance thermometer, Class A; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, Class AA.

Standard Method of Test for

Quantitative Extraction of Asphalt Binder from Asphalt Mixtures

AASHTO Designation: T 164-22[1]

AASHTO

Technically Revised: 2022

Editorially Revised: 2022

Technical Subcommittee: 2c, Asphalt–Aggregate Mixtures

ASTM Designation: D2172/D2172M-11

1. SCOPE

1.1. These methods cover the quantitative determination of asphalt binder in hot mix asphalt (HMA) and HMA pavement samples. Aggregate obtained by these methods may be used for sieve analysis using T 30.

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 concerns associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific hazards are given in Section 8.

Note 1—The results obtained by these methods may be affected by the age of the material tested, with older samples tending to yield slightly lower asphalt binder contents. Best quantitative results are obtained when the test is made on HMA mixtures and pavements shortly after their preparation. It is difficult to remove all the asphalt binder when some aggregates are used; some solvent may remain within the mineral matter affecting the measured asphalt binder content.

1.4. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 231, Weighing Devices Used in the Testing of Materials
- M 339M/M 339, Thermometers Used in the Testing of Construction Materials
- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- R 59, Recovery of Asphalt Binder from Solution by Abson Method
- R 97, Sampling Asphalt Mixtures

5. SIGNIFICANCE AND USE

5.1. All of the methods can be used for quantitative determinations of asphalt binder in HMA mixtures and pavement samples for specification acceptance, service evaluation, quality control, and research. Each method prescribes the solvents and any other reagents that can be used in the method. R 59 requires that Method A or E (Note 2) and reagent-grade trichloroethylene be used when asphalt binder is recovered from solution.

Note 2—The vacuum extractor, Section 22.1.1, can be modified by a vacuum trap attached to the top of the "end point" sight tube to collect the extract to allow its use for recoveries (Figure 4b).

6. APPARATUS

6.1. *Oven*—Capable of maintaining the temperature at 110 ± 5°C (230 ± 9°F), for warming the sample. Oven(s) for heating shall be capable of operation at the temperatures required, between 100 to 120°C (212 to 248°F), within ±5°C (±9°F), as corrected, if necessary, by standardization. More than one oven may be used, provided each is used within its proper operating temperature range. The thermometer for measuring the temperature of materials shall meet the requirements of M 339M/M 339 with a temperature range of at least 90 to 130°C (194 to 266°F), and an accuracy of ±1.25°C (±2.25°F) (see Note 3).

Note 3—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E2877 digital metal stem thermometer; ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class; IEC 60584 thermocouple thermometer, Type J or K, Class 1, Type T any Class; or dial gauge metal stem (bi-metal) thermometer.

6.2. *Oven*—Capable of maintaining the temperature at 149 to 163 ± 5°C (300 to 325 ± 9°F), for drying the sample if the moisture content is not determined. Oven(s) for drying shall be capable of operation at the temperatures required, between 145 to 170°C (293 to 338°F), within ±5°C (±9°F), as corrected, if necessary, by standardization. More than one oven may be used, provided each is used within its proper operating temperature range. The thermometer for measuring the temperature of materials shall meet the requirements of M 339M/M 339 with a temperature range of at least 140 to 175°C (284 to 347°F), and an accuracy of ±1.25°C (±2.25°F) (see Note 4).

Note 4—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class; or IEC 60584 thermocouple thermometer, Type J or K, Class 1, Type T any Class.

6.3. *Pan*—Flat, of appropriate size.

6.4. *Balance*—The balance shall have sufficient capacity, be readable to 0.1 percent of the sample mass or better, and conform to the requirements of M 231.

6.5. *Cylinders*—Graduated, 1000- or 2000-mL capacity.

7. REAGENTS

7.1. *Methylene Chloride*—Technical grade. *Caution*—see Section 8.

7.2. *n-Propyl Bromide*—Conforming to ASTM D6368—see Section 8.

7.3. *Trichloroethylene*—Reagent grade (Note 5) or conforming to ASTM D4080—see Section 8.

7.4. *Terpene*—Extractant, shall be nonhalogenated, nontoxic, and shall readily dissolve asphalt binder from HMA and place it into solution. This extractant shall be easily rinsed from the remaining

- T 30, Mechanical Analysis of Extracted Aggregate
- T 84, Specific Gravity and Absorption of Fine Aggregate
- T 110, Moisture or Volatile Distillates in Hot Mix Asphalt (HMA)
- T 228, Specific Gravity of Semi-Solid Asphalt Materials
- T 329, Moisture Content of Asphalt Mixtures by Oven Method

2.2. *ASTM Standards*:

- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- D604, Standard Specification for Diatomaceous Silica Pigment (withdrawn 2003; no replacement)
- D2111, Standard Test Methods for Specific Gravity and Density of Halogenated Organic Solvents and Their Admixtures
- D4080, Standard Specification for Trichloroethylene, Technical and Vapor-Degreasing Grade
- D6368, Standard Specification for Vapor-Degreasing Solvents Based on *normal*-Propyl Bromide and Technical Grade *normal*-Propyl Bromide
- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E879, Standard Specification for Thermistor Sensors for General Purpose and Laboratory Temperature Measurements
- E1137/E1137M, Standard Specification for Industrial Platinum Resistance Thermometers
- E2877, Standard Guide for Digital Contact Thermometers

2.3. *International Electrotechnical Commission Standards*:

- IEC 60584-1: 2013 Thermocouples - Part 1: EMF Specifications and Tolerances
- IEC 60751: 2008 Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors

2.4. *Federal Standard*:

- Fed. Std. No. 29, CFR 1910.1200 OSHA Hazard Communication Standard; see also Permissible Exposure Limits—Annotated Tables, available at https://www.osha.gov/dsg/annotated-pels/

3. TERMINOLOGY

3.1. *nominal maximum size (of aggregate)*—one size larger than the first sieve that retains more than 10 percent aggregate.

3.2. *constant mass*—shall be defined as the mass at which further drying does not alter the mass by more than 0.05 percent when weighed at 2-h intervals.

4. SUMMARY OF TEST METHODS

4.1. The HMA is extracted with trichloroethylene, *n*-propyl bromide, or methylene chloride, using the extraction equipment applicable to the particular method. Terpene extractant may be used in Method A or E. The asphalt binder content is calculated by differences from the mass of the extracted aggregate, moisture content, and mineral matter in the extract. The asphalt binder content is expressed as a mass percent of moisture-free mixtures.

aggregate without forming a gel, and the extractant rinsed from the aggregate shall pass readily through the diatomaceous earth and the filter.

7.5. When asphalt binder is intended to be extracted and then tested for additional properties, a reagent-grade solvent must be used (Note 5).

Note 5—Non-reagent-grade solvents may contain epoxy resins that may affect the properties of the recovered binder. In particular, certain acid modified binders may be affected by non-reagent-grade solvents.

Note 6—Only vented ovens should be used when terpene extractants are used.

8. PRECAUTIONS

8.1. The solvents listed in Section 7 should be used only under a hood or with an effective surface exhaust system in a well-ventilated area, because they are all toxic to some degree, as described in 29 CFR 1910.1200. Trichloroethylene, methylene chloride, and *n*-propyl bromide in the presence of heat and moisture may form acids that are extremely corrosive to certain metals, particularly when subject to contact over lengthy periods of time. Proper precautions should be taken to not allow these solvents to remain in small quantities in the effluent tanks of aluminum vacuum extractors.

8.2. Trichloroethylene stored in a steel container and in continuous contact with moisture may decompose by dehydrohalogenation to form unsaturated hydrocarbon liquids and hydrogen chloride. Steel drums containing trichloroethylene should be stored in a cool, dry location, kept tightly sealed, and opened as infrequently as possible. Trichloroethylene should be transferred from the drums to clean, dry, brown glass bottles for laboratory use. The hydrogen chloride in decomposed trichloroethylene may harden an asphalt during the extraction and Abson recovery test (R 59).

8.3. All local, state, and federal regulations must be followed when hauling, using, storing, and discarding extractants and rinse water. These requirements include fire ordinances as well as wastewater treatment regulations. The Material Safety Data Sheet should be followed closely to avoid fires and explosions. Storage of extractant-soaked rags should be prohibited.

9. SAMPLING

9.1. Obtain samples in accordance with R 97.

9.2. *Preparation of Test Specimens*:

9.2.1. If the HMA is not sufficiently soft to separate with a spatula or trowel, place it in a large, flat pan, and warm it in a 110 ± 5°C (230 ± 9°F) oven only until it can be handled or separated. Split or quarter the material until the mass of material required for the test is obtained.

9.2.2. The size of the test sample shall be governed by the nominal maximum aggregate size of the HMA and conform to the mass requirement shown in Table 1 (Note 7).

Table 1—Size of Sample

Nominal Maximum Aggregate Size		Minimum Mass of Sample, kg
mm	in.	
4.75	No. 4	0.5
9.5	$^{3}/_{8}$ in.	1
12.5	$^{1}/_{2}$ in.	1.5
19.0	$^{3}/_{4}$ in.	2
25.0	1 in.	3
37.5	$1^{1}/_{2}$ in.	4

Note 7—When the mass of the test specimen exceeds the capacity of the equipment used (for a particular method), the test specimen may be divided into suitable increments, tested, and the results appropriately combined for calculation of asphalt binder content (Section 13).

9.2.3. Unless the HMA sample is free of moisture (Note 9), a test specimen is required for the determination of moisture (Section 10) in the HMA. Take this test specimen from the remaining sample in the HMA immediately after obtaining the extraction test specimen.

Note 8—If the extraction test is being performed only to recover asphalt binder from the HMA and the percent asphalt binder is not being determined, it is unnecessary to determine the moisture content of the HMA.

Table 2—Dimensional Equivalents

mm	in.	mm	in.	mm	in.
0.8	$^{1}/_{32}$	44.5	$1^{3}/_{4}$	157.2	$6^{3}/_{16}$
1.6	$^{1}/_{16}$	47.6	$1^{7}/_{8}$	158.8	$6^{1}/_{4}$
2.0	$^{5}/_{64}$	50.8	2	163.5	$6^{7}/_{16}$
3.2	$^{1}/_{8}$	55.6	$2^{3}/_{16}$	165.1	$6^{1}/_{2}$
4.0	$^{5}/_{32}$	56.4	$2^{7}/_{32}$	187.3	$7^{3}/_{8}$
4.8	$^{3}/_{16}$	57.2	$2^{1}/_{4}$	203.2	8
5.6	$^{7}/_{32}$	58.7	$2^{5}/_{16}$	247.7	$9^{3}/_{4}$
6.4	$^{1}/_{4}$	63.5	$2^{1}/_{2}$	254.0	10
7.9	$^{5}/_{16}$	66.7	$2^{5}/_{8}$	257.2	$10^{1}/_{8}$
9.5	$^{3}/_{8}$	71.4	$2^{13}/_{16}$	260.4	$10^{1}/_{4}$
12.7	$^{1}/_{2}$	76.2	3	279.4	11
15.9	$^{5}/_{8}$	88.9	$3^{1}/_{2}$	304.8	12
19.1	$^{3}/_{4}$	95.3	$3^{3}/_{4}$	320.7	$12^{5}/_{8}$
25.4	1	101.6	4	330.2	13
28.6	$1^{1}/_{8}$	108.0	$4^{1}/_{4}$	342.9	$13^{1}/_{2}$
30.2	$1^{3}/_{16}$	127.0	5	355.6	14
35.7	$1^{13}/_{32}$	138.1	$5^{7}/_{16}$	368.3	$14^{1}/_{2}$
38.1	$1^{1}/_{2}$	149.2	$5^{7}/_{8}$	384.2	$15^{1}/_{8}$
40.5	$1^{19}/_{32}$	152.4	6	393.7	$15^{1}/_{2}$
41.3	$1^{5}/_{8}$	154.8	$6^{3}/_{32}$	406.4	16
42.9	$1^{11}/_{16}$	155.6	$6^{1}/_{8}$	—	—

10. MOISTURE CONTENT

10.1. When required, determine the moisture content of the mixture (Section 9.2.3) in accordance with the procedure described in T 110 or T 329.

Note 9—If recovery of asphalt binder from the solution obtained from the extraction test is not required, the entire test specimen may be dried in an oven at a temperature of 105 to 165°C (221 to 329°F) to constant mass prior to extraction, instead of determining the moisture content.

10.2. Calculate the mass of water (W_2, Section 13) in the extraction test portion by multiplying mass percent water (Section 10.1) by the mass of the extraction test portion (W_1, Section 13).

TEST METHOD A

11. APPARATUS

11.1. *In addition to the apparatus listed in Section 6, the following apparatus is required for Method A*:

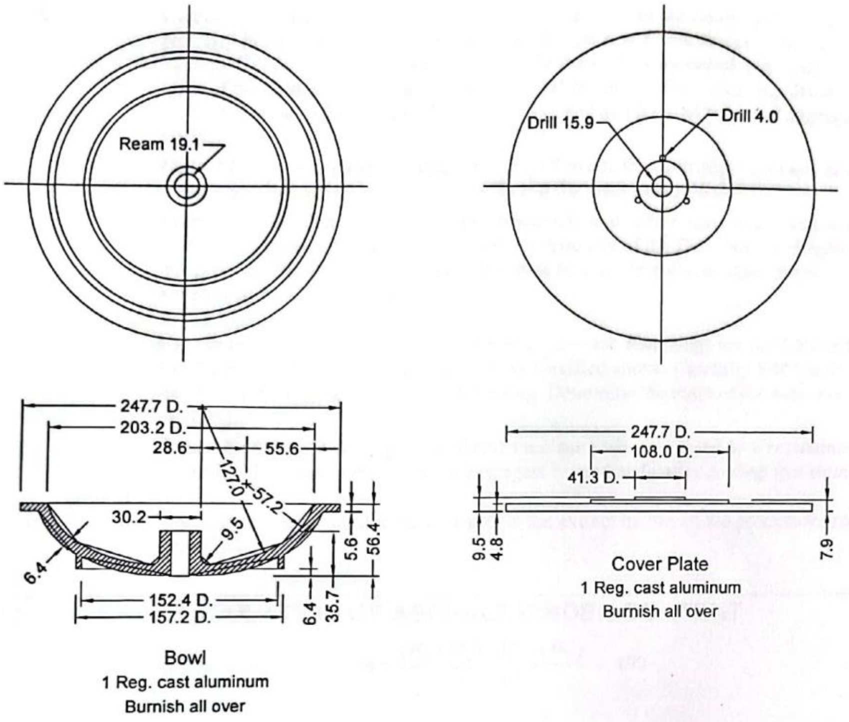
11.1.1. *Extraction Apparatus*—Consisting of a bowl approximating that shown in Figure 1 and an apparatus in which the bowl may be revolved at controlled variable speeds up to 3600 r/min. The speed may be controlled manually or with a preset speed control. The apparatus should be provided with a container for catching the solvent discharged from the bowl and a drain for removing the solvent. The apparatus preferably shall be provided with explosion-proof features and installed in a hood or an effective surface exhaust system to provide ventilation.

Note 10—Similar apparatus of larger size may be used.

11.1.2. *Filter Rings*—Felt or paper, to fit the rim of the bowl.

11.1.3. *Low-Ash Paper Filter Rings*—May be used in place of the felt filter ring (Section 11.1.2). Such filter rings shall consist of low-ash filter paper stock, 1.27 ± 0.13 mm (0.05 ± 0.005 in.) thick. The nominal base weight of the paper shall be 150 ± 14 kg (330 ± 30 lb) for a ream [500 sheets, 635 by 965 mm (25 by 38 in.)]. The ash content of the paper should not exceed 0.2 percent (approximately 0.034 g per ring).

Note 11—Where terpene extractants are used, the gears and shaft should be lubricated frequently.



Note: See Table 2 for dimensional equivalents. All dimensions shown in millimeters unless otherwise noted.

Figure 1—Extraction Unit Bowl (Method A)

12. PROCEDURE

12.1. Determine the moisture content of the material in accordance with Section 10.

12.2. Place the test portion into a bowl.

12.3. Cover the test portion in the bowl with trichloroethylene, methylene chloride, *n*-propyl bromide, or terpene extractant, and allow sufficient time for the solvent to disintegrate the test portion (not more than 1 h). Place the bowl containing the test portion and the solvent in the extraction apparatus. Dry the filter ring to a constant mass in an oven at 110 ± 5°C (230 ± 9°F), and fit it around the edge of the bowl. Clamp the cover on the bowl tightly, and place an appropriate container under the drain to collect the extract.

12.4. Start the centrifuge revolving slowly, and gradually increase the speed to a maximum of 3600 r/min until the solvent ceases to flow from the drain. Allow the machine to stop; add 200 mL (or more as appropriate for the mass of the sample) of trichloroethylene, methylene chloride, *n*-propyl bromide, or terpene extractant, and repeat the procedure. Use sufficient solvent additions (not less than three) until the extract is not darker than a light straw color (when viewed against a white background). Collect the extract and the washings in an appropriate container for mineral matter determination.

12.5. Carefully transfer the filter ring and all of the aggregate in the centrifuge bowl into a tared metal pan. Dry in air under a hood until the fumes dissipate, and then to a constant mass in an oven at 110 ± 5°C (230 ± 9°F) (Notes 12 and 13). The mass of the extracted aggregate (W_3) is equal to the mass of the contents in the pan minus the initial dry mass of the filter ring. Brush off mineral matter adhering to the surface of the filter ring, and add it to the extracted aggregate for further testing.

Note 12—The filter and aggregate may be left inside the centrifuge bowl and dried to constant mass in an oven at 110 ± 5°C (230 ± 9°F) and the mass determined.

Note 13—The filter ring may be dried separately to constant mass in an oven at 110 ± 5°C (230 ± 9°F) provided that care is taken not to lose any of the fine material clinging to the filter. If this procedure is used, the aggregate may then be dried to constant mass either in an oven or on a hot plate at 110 ± 5°C (230 ± 9°F).

12.5.1. Use the following alternative procedure when low-ash filter rings are used. Place the aggregate and filter rings in a clean metal pan. Dry as specified above. Carefully fold the dried filter ring and stand it on the aggregate. Burn the filter ring. Determine the mass of the extracted aggregate in the pan (W_3).

Note 14—Because dry aggregate absorbs moisture when exposed to air containing moisture, determine the mass of the extracted aggregate immediately after cooling to a suitable temperature.

12.6. Determine the amount of mineral matter in the extract by one of the procedures specified in Annex A1.

13. CALCULATION OF ASPHALT BINDER CONTENT

$$\text{asphalt binder content, \%} = \frac{(W_1 - W_2) - (W_3 + W_4)}{W_1 - W_2} \times 100 \qquad (1)$$

where:

W_1 = mass of test portion;

W_2 = mass of water in test portion;

W_3 = mass of extracted mineral aggregate; and

W_4 = mass of mineral matter in the extract.

Note 15—When ashless filter rings are not used, add the increase in mass of the felt ring to W_4.

Note 16—When it is desired to express the asphalt binder content as a mass percent of the moisture-free aggregate, substitute the mass $W_3 + W_4$ for the mass $W_1 - W_2$ in the divisor of Equation 1.

TEST METHOD B

14. APPARATUS

14.1. *In addition to the apparatus listed in Section 6, the following apparatus is required for Test Method B:*

14.1.1. *Extraction Apparatus*—Similar to that shown in Figure 2.

Figure 2—Extraction Apparatus (Method B)

14.1.1.1. *Glass Jar*—Cylindrical, plain, made of heat-resistant glass. The jar shall be free of cracks, scratches, or other evidence of flaws that might cause breakage during heating.

14.1.1.2. *Cylindrical Metal Frames*—One or two. The lower frame shall have legs of sufficient length to support the frame, including the apex of the metal cone and paper cone liner above the solvent level. When two frames are used, the upper frame shall have legs of sufficient length to support the metal cone and paper cone liner at or above the top rim of the lower frame. The legs of the upper frame shall fit securely in the top rim of the lower frame. A bail handle may be provided on the inside of the top rim of each frame for convenient handling. The metal used in fabricating the frames shall be essentially unreactive to the solvents used in the test.

14.1.1.3. *Condenser*—Fabricated with a truncated hemispherical condensing surface and a truncated conical top. Other suitable geometric shapes may also be used, provided they accomplish the condensing and flow functions intended. The material used in fabricating the condenser shall be essentially unreactive to water and to the solvent used and shall be provided with a suitable water inlet and outlet.

14.1.1.4. *Filter Paper*—Medium-grade, fast-filtering. The diameter of the paper shall be such that when folded in accordance with the directions given below, it shall completely line the metal cones in the frames.

14.1.1.5. *Thermal Distributing Protective Pad*—Approximately 3 mm (0.1 in.) thick for use as insulation between the glass jar and hot plates.

14.1.1.6. *Electric Hot Plate*—Thermostatically controlled, of sufficient dimensions and heat capacity to permit refluxing of the solvent as described in Section 16.2.5.

15. PREPARATION OF TEST PORTION

15.1. Prepare a test portion for moisture determination and extraction in accordance with the procedure described in Section 9.

16. PROCEDURE

16.1. *Moisture*:

16.1.1. Determine the moisture content of the HMA (Section 9.2.3) in accordance with the method described in Section 10.

16.2. *Extraction*:

16.2.1. Dry one sheet of filter paper for each frame used to a constant mass in an oven at 110 ± 5°C (230 ± 9°F). Fold each paper on its diameter; fold the ends over, and spread it open to form a proper size to fit inside the metal cones.

16.2.2. Determine the mass of each frame with its filter paper liner to the nearest 0.5 g. Record the mass of each frame.

16.2.3. Place the test portion in the frame(s). If two frames are used, distribute the test portion approximately equally between the two. The top of the test portion must be below the upper edge of the paper liner. Determine the mass of each loaded frame separately to the nearest 0.5 g. Again, record the mass.

16.2.4. Use one of the solvents (Note 17) specified in Section 7.1, 7.2, or 7.3. Pour the solvent into the glass cylinder, and place the bottom frame into it. The solvent level should be below the apex of the one in the lower frame. If two frames are used, place the upper frame in the lower frame, fitting its legs into the holes in the upper rim of the lower frame.

Note 17—Sufficient denatured ethyl alcohol may be poured over the test portion(s) to wet the filter paper. A mixture of 20 percent denatured alcohol and 80 percent trichloroethylene has proven to be a better solvent for some aggregates.

16.2.5. If required, place the thermal insulating pad on the hot plate and then the cylinder on the pad. Cover the condenser. Circulate a gentle, steady stream of cool water through the condenser. Adjust the temperature of the hot plate so that the solvent will boil gently and a steady stream of condensed solvent flows into the cone. If necessary, adjust the temperature of the hot plate to maintain the solvent stream at a rate necessary to keep the test portions in the cone(s) completely covered with condensed solvent. Take care not to allow condensed solvent to overflow the filter cone(s). Continue the refluxing until the solvent flowing from the lower cone is a light straw color (when viewed against a white background). At this point, turn off the hot plate and allow the apparatus to cool enough to handle; turn off the condenser and remove it from the cylinder.

16.2.6. Remove the frame assembly from the cylinder. Allow it to dry in air (hood), and then dry it to a constant mass in an oven at 110 ± 5°C (230 ± 9°F) (Note 11).

16.2.7. Determine the mineral matter in the extraction solution by one of the procedures specified in Annex A1.

17. CALCULATION OF ASPHALT BINDER CONTENT

17.1. Calculate the percentage of asphalt binder in the test portion in accordance with the procedure described in Section 13.

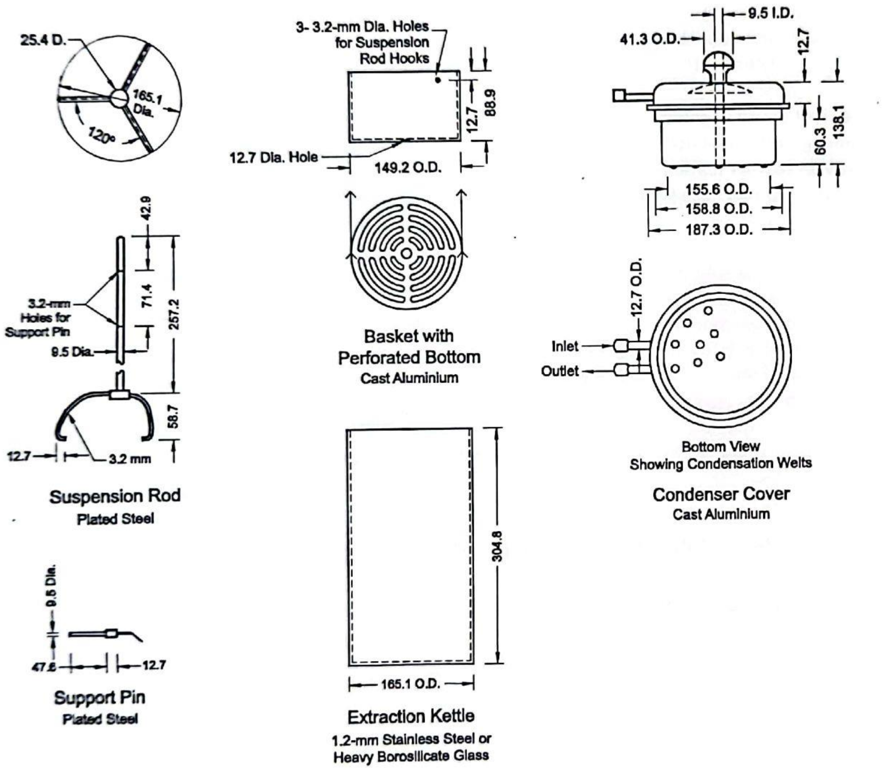
TEST METHOD D

18. APPARATUS

18.1. *In addition to the apparatus listed in Section 6, the following apparatus is required for Test Method D:*

18.1.1. *Extraction Apparatus*—As shown in Figure 3, consisting of an extraction kettle of metal or borosilicate glass, fitted with a perforated basket and a condenser top. The underside of the condenser shall be covered with numerous rounded knobs to distribute the condenser solvent uniformly over the surface of the sample. The suspension of the basket shall be arranged to support the basket 13 mm ($^{1}/_{2}$ in.) above the bottom of the kettle, for immersion of the test portion in the solvent, and at least 75 mm (3 in.) above the bottom of the kettle for refluxing (Note 10).

18.1.2. *Cloth Filter Sacks*—With an elastic hem for lining the basket.



Note: All dimensions shown in millimeters unless otherwise noted.

Figure 3—Extractor Unit (Method D)

19. PREPARATION OF TEST PORTIONS

19.1. Prepare test portions for moisture determination and extraction in accordance with the procedure described in Section 9.

20. PROCEDURE

20.1. *Moisture*:

20.1.1. Determine the moisture content of the HMA (Section 9.2.3) in accordance with the method described in Section 10.

20.2. *Extraction*:

20.2.1. Insert a filter sack in the extraction basket, and determine the mass with the tare pan to determine the total tare mass. Place the test portion in the filter sack, and determine the total mass. Calculate the mass of the test portion.

20.2.2. Attach the suspension rod to the loaded basket, and set the assembly into the extraction kettle. Pour approximately 600 mL of solvent (Section 7.1, 7.2, or 7.3) over the test portion. Set the condenser cover in place on the kettle. Provide a flow of cold water through the condenser lid. Raise the basket to immersion level—for example 13 mm ($^1/_2$ in.) 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 heating rate so that the solvent is maintained at a gentle boil, avoiding vigorous boiling, which might wash fines over the sides of the basket.

20.2.3. Continue heating with the test portion in the immersion position for 15 to 30 min, and then raise the basket to refluxing level. Increase the heat, and maintain active boiling until the solvent dripping from the basket appears to be a light straw color when viewed against a white background. If a stainless steel kettle is used, lift out the basket and the condenser cover assembly for examination of the solvent.

20.2.4. Remove the extractor from the hot plate, and allow it to cool for several minutes. Lift out the basket and condenser assembly. Cover the kettle; remove the filter sack, and distribute its contents into the tared pan in which the mass of the test portion was originally determined. Place the filter sack on top of the recovered aggregate. Dry on a steam bath and then in an oven at 110 ± 5°C (230 ± 9°F) to constant mass. Transfer the extract solution to a 1000-mL graduate. Wash the extractor clean with solvent, and add the washings to the extract solution.

20.2.5. Determine the mineral matter in the extract solution by one of the procedures specified in Annex A1.

21. CALCULATION OF ASPHALT BINDER CONTENT

21.1. Calculate the percentage of asphalt binder in the test portion in accordance with the procedure described in Section 13.

TEST METHOD E

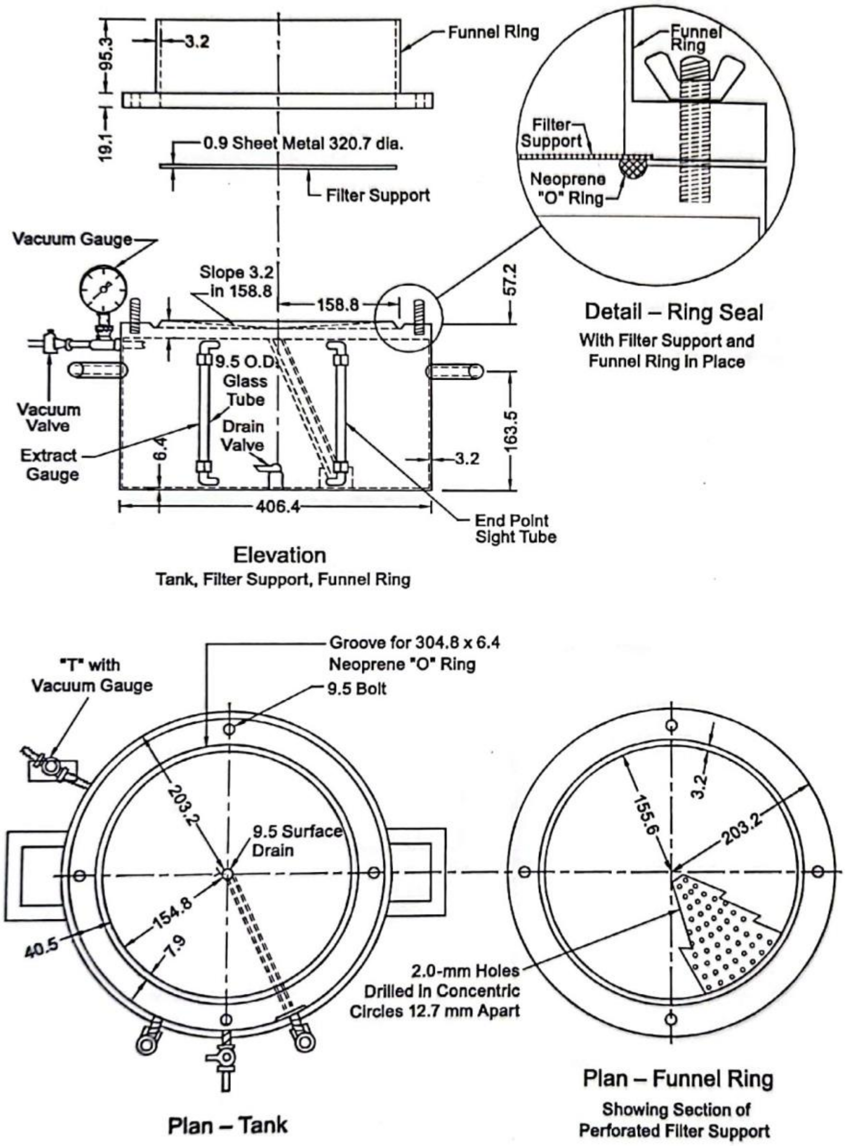
22. APPARATUS

22.1. *In addition to the apparatus listed in Section 6, the following apparatus is required for Test Method E*:

22.1.1. *Vacuum Extractor*—Complete with the vacuum pump, gasket, rubber tubing, filter paper, support plate, and funnel ring. The dimensional equivalents and apparatus shown in Table 3, and Figures 4a, 4b, and 4c and similar designs, are suitable.

Table 3—Dimensional Equivalents

in.	mm	in.	mm
16	406	$2^{1}/_{4}$	57
$12^{5}/_{8}$	321	$1^{19}/_{32}$	40
12	305	$^{3}/_{4}$	19
8	203	$^{1}/_{2}$	12.7
$6^{7}/_{16}$	164	$^{3}/_{8}$	9.5
$6^{1}/_{4}$	159	$^{1}/_{4}$	6.4
$6^{1}/_{8}$	156	$^{3}/_{64}$	1.19
$6^{3}/_{32}$	155	0.060	1.52
$3^{3}/_{4}$	95		



Detail – Ring Seal

With Filter Support and Funnel Ring In Place

Elevation

Tank, Filter Support, Funnel Ring

Plan – Tank

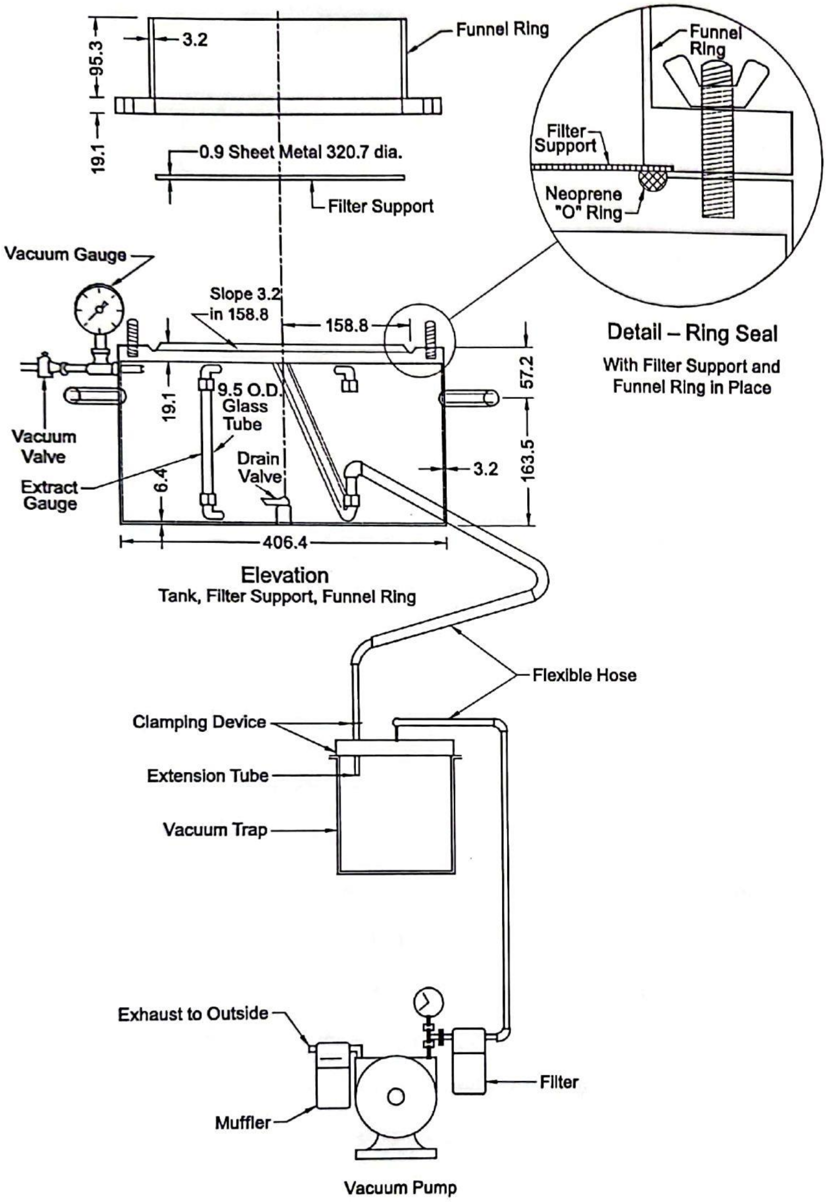
Plan – Funnel Ring

Showing Section of Perforated Filter Support

Tank and funnel ring are fabricated from sheet aluminum or stainless steel.

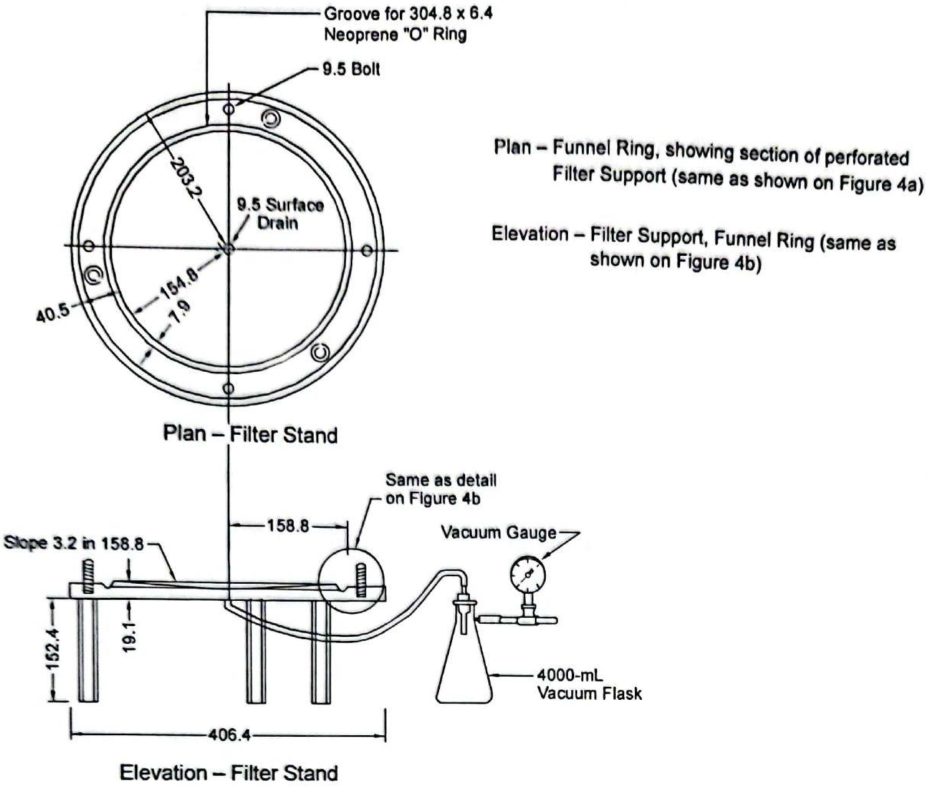
Note: See Table 3 for dimensional equivalents. All dimensions shown in millimeters unless otherwise noted.

Figure 4a—Vacuum Extractor



Note: All dimensions are shown in millimeters unless otherwise noted.

Figure 4b—Vacuum Extractor



Note: All dimensions are shown in millimeters unless otherwise noted.

Figure 4c—Vacuum Extractor

22.1.2. *Filter Paper*—Medium-grade, fast-filtering, 330 mm (13 in.) in diameter.

22.1.3. *Sample Container*—3.8-L (4-qt) capacity or greater.

22.1.4. *Erlenmeyer Flasks*—Glass, two, having a capacity of 4000 mL each.

22.1.5. *Graduated Cylinder*—Glass, having a capacity of 500 mL.

22.1.6. *Wash Bottle*—Plastic, having a capacity of 500 mL.

22.1.7. *Dial Thermometer*—Having a range from 10 to 82°C (50 to 180°F).

22.1.8. *Mixing Spoon.*

22.1.9. *Spatula.*

22.1.10. *Stiff Bristled Brush.*

22.1.11. *Erlenmeyer Flask*—Glass, having a capacity of 1000 mL.

22.1.12. *Watch Glass*—Having a diameter of approximately 100 mm (4 in.).

22.1.13. *Metal Tongs*—150 to 200 mm (6 to 8 in.) long.

22.1.14. *Sieves*—1.18-mm (No. 16) and 75-µm (No. 200), 305 mm (12 in.) in diameter (optional).

Note 18—Use apparatus and materials listed under Sections 22.1.11, 22.1.12, 22.1.13, 23.1, and 23.2 only with HMA that is hard to filter, as in Method E-II.

22.1.15. *Stainless Steel Beaker*.

23. REAGENTS AND MATERIALS

23.1. *Diatomaceous Silica Filtering Aid*—Conforming to Type B of ASTM D604.[2]

23.2. *Ethyl Alcohol*—Denatured (optional).

23.3. *Methylene Chloride* (Note 19).

Note 19—Any of the other solvents listed in Section 7 may be substituted for methylene chloride.

24. PREPARATION OF TEST PORTIONS

24.1. Prepare test portions for moisture determination and extraction in accordance with the procedure described in Section 9.

25. PROCEDURE

25.1. Determine the moisture content of the HMA (Section 9.2.3) in accordance with the method described in Section 10.

25.2. *Extraction*:

25.2.1. Place the extraction test portion into the tared stainless steel beaker, and determine the mass (Note 20).

25.2.2. If the test portion is above 54°C (130°F), allow it to cool to a temperature less than 54°C (130°F). When sufficiently cool, pour 200 mL of denatured alcohol, if needed, over the specimen (Note 20). Add approximately 700 mL of extractant, and stir until the asphalt binder is visually in solution (Note 21).

Note 20—Alcohol should not be needed with terpene extractants.

Note 21—If equipment is available, an ultrasonic cleaning tank may be used instead of the beaker (Section 25.2.1) in which to bring the asphalt binder into solution (Section 25.2.2).

METHOD E-I

25.2.3. Dry the filter paper (more than one filter paper may be used) to constant mass in an oven at 110 ± 5°C (230 ± 9°F), and place the filter paper on the extractor, taking care to center the filter paper and tighten the wing nuts "finger tight" (Note 22).

Note 22—Experience has shown that clogging of the filter may be reduced by decanting the extract solution through nested 1.18-mm (No. 16) and 75-µm (No. 200) sieves onto the filter.

When sieves are used, the solution will be decanted onto the 1.18-mm (No. 16) sieve instead of the filter.

25.2.4. Start the vacuum pump and slowly decant extract solution from the sample container onto the filter. When all solution has been removed from the filter paper, the vacuum pump may be stopped or left running.

25.2.5. Cover the sample remaining in the container with extractant, up to 700 mL. Stir gently until the asphalt binder and aggregate fines appear to be in suspension (or start the ultrasonic cleaner if used). Repeat the step in Section 25.2.4.

25.2.6. Repeat Section 25.2.5 until the solution is a light straw color (when viewed against a white background) and the aggregate is visually clean. The flow of solvent may be slowed for color observation by partially opening the vacuum valve and reducing the vacuum. If terpene extractant is used, pour all of the extractant onto the filter, and allow the vacuum to continue until the fluid has passed through the filter. Repeat Sections 25.2.5 and 25.2.4, using water preferably above 43°C (110°F), as many times as necessary to remove the terpene residue from the aggregate and render the rinse water clear. Operate the vacuum pump for a few minutes after the last wash to aid in drying the test portion. Scrape the aggregate away from the side of the funnel ring toward the center of the filter to avoid loss when the ring is removed. Also wash the sides of the funnel ring to remove any fines. Stop the vacuum pump and remove the ring, then brush the clinging aggregate into the tared drying pan. Carefully pick up the filter paper and aggregate by holding the paper on opposite sides and raising it straight up. Transfer the aggregate on the filter paper to the tared drying pan, and brush the clinging aggregate from the filter into the pan. Alternatively, the filter paper and aggregate may be contained separately in tared pans or the aggregate may be contained in a tared pan and the filter paper placed on top of it. In either case, use care to assure that all traces of aggregate in the test sample are transferred to the drying pan(s). A thermometer for measuring water temperature shall meet the requirements of M 339M/M 339 with a temperature range of at least 30 to 60°C (86 to 140°F), and an accuracy of ±0.5°C (±0.9°F) (see Note 23).

Note 23—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E2877 digital metal stem thermometer; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; or IEC 60584 thermocouple thermometer, Type T, Class 1.

25.2.7. Dry the extracted aggregate and filter to a constant mass in an oven at 110 ± 5°C (230 ± 9°F) (Note 24).

Note 24—See the alternate procedure in Section 12.5.1 when low-ash filter paper is used.

25.2.8. Determine the mass of the filter and aggregate in the pan(s), and record it. Subtract the mass of the filter and pan to determine the mass of the extracted aggregate.

25.2.9. Determine the mineral matter in the extract solution by one of the procedures specified in Annex A1 (Note 25).

Note 25—Sections 25.2.9 and 25.2.15 may be omitted when this method is used only for control of asphalt binder content during HMA production (plant control).

METHOD E-II

25.2.10. To extract a slow-filtering HMA mixture efficiently, prepare the test portion as described in Sections 25.2.1 and 25.2.2.

25.2.11. Dry the filter paper to constant mass in an oven at 110 ± 5°C (230 ± 9°F), and place the filter paper on the extractor, taking care to center the filter paper and tighten the wing nuts “finger tight” (Note 22).

25.2.12. Weigh between 50 and 200 g of oven-dried diatomaceous silica filtering aid into a 1000-mL Erlenmeyer flask; record the mass, and then add 500 mL of extractant. Swirl until the diatomaceous silica is completely in suspension.

25.2.13. Immediately pour the diatomaceous silica and extractant over the filter. Two predried filters separated by an additional 50 to 100 g of diatomaceous earth may be used to retain the minus 75-µm (No. 200) material, if desired, to facilitate improved flow of the liquid. Start the vacuum pump, and let it run until the pad formed by the diatomaceous silica is surface dry and begins to crack slightly (Note 26).

Note 26—Some diatomaceous silica may be washed through the filter and included in the mineral matter determination of Section 25.2.15. Blank tests are recommended to determine the amount of diatomaceous silica, if any, lost through the filter. An appropriate correction will be required in the mineral matter mass.

25.2.14. Place the watch glass in the extractor, and slowly decant the extractant from the container over the watch glass (Note 27). Stop the vacuum pump when all the solution has been removed from the filter. Repeat as in Section 25.2.5, except decant the solution onto the watch glass. Complete the procedure as in Section 25.2.6. Also wash the watch glass with extractant to remove any fines onto the filter.

Note 27—When nested sieves are used, the watch glass may be omitted.

25.2.15. Determine the amount of mineral matter in the extract solution by one of the procedures specified in Annex A1 (Note 25).

26. CALCULATION OF ASPHALT BINDER CONTENT (APPLICABLE TO BOTH METHOD E-I AND METHOD E-II)

26.1. Calculate the percentage of asphalt binder in the test portion in accordance with the procedure described in Section 13.

27. PRECISION AND BIAS

27.1. The single-laboratory standard deviation has been found to be 0.18 percent. Therefore, results of two properly conducted tests by the same operator on the same batch should not differ by more than 0.52 percent. These values become 0.21 and 0.58, respectively, when extractant containing 85 percent terpene is used (Notes 28 and 29).

27.2. The multilaboratory standard deviation has been found to be 0.29 percent. Therefore, the results of two properly conducted tests from two different laboratories on samples from the same batch should not differ by more than 0.81 percent. These values become 0.29 and 0.83, respectively, when extractant containing 85 percent terpene is used (Notes 28 and 29).

Note 28—These numbers represent, respectively, the (1s) and (d2s) limits as described in ASTM C670.

Note 29—These precision statements are based on one pair of reference samples with 59 laboratories participating and three laboratory results deleted as outlying observations. The reference samples contained aggregate with 98 percent passing the 9.5-mm ($^3/_8$-in.) screen. All test methods were used in the interlaboratory test program.

28. KEYWORDS

28.1. Asphalt binder; asphalt mixture; asphalt mixture extraction; centrifuge; hot mix asphalt; mineral matter; reflux; solvent; vacuum extraction.

ANNEX A

(Mandatory Information)

A1. DETERMINING THE AMOUNT OF MINERAL MATTER IN THE EXTRACT

A1.1. *Ashing Method*:

A1.1.1. *Apparatus*:

A1.1.1.1. *Ignition Dish*—At least 125 mL in capacity.

A1.1.1.2. Ignition Furnace or Bunsen Burner. The ignition furnace shall be capable of operation at the temperatures required, between 500 to 600°C (932 to 1112°F) and have temperature control accurate within ±25°C (±45°F), as corrected, if necessary, by standardization. More than one furnace may be used, provided each is used within its proper operating temperature range. When measuring temperatures during use, the thermometer for measuring the temperature of materials shall meet the requirements of M 339M/M 339 with a temperature range of at least 475 to 625°C (890 to 1160°F) and an accuracy of ±12.5°C (±22.5°F) (see Note A1).

Note A1—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type J or K, any Class; or IEC 60584 thermocouple thermometer Type J or K, any Class.

A1.1.1.3. Steam Bath or Hot Plate.

A1.1.1.4. Desiccator.

A1.1.1.5. *Analytical Balance*—Conforming to the requirements of M 231, Class B.

A1.1.1.6. *Cylinder*—100 mL in capacity.

A1.1.2. *Reagents*:

A1.1.2.1. *Ammonium Carbonate Solution*—Saturated solution of reagent-grade ammonium carbonate $[(NH_4)_2CO_2]$.

A1.1.3. *Procedure*:

A1.1.3.1. Determine either the volume or mass of the total extract (W_1). Condition the ignition dish in an ignition furnace or over a Bunsen burner at a dull red heat for a minimum of 10 min; cool it in a desiccator, and determine the mass of the ignition dish to the nearest 0.001 g. Agitate the extract thoroughly, and immediately measure 100 mL or 100 g into the ignition dish. Evaporate to dryness on a steam bath or hot plate. Ash the residue at a dull red heat (500 to 600°C [932 to 1112°F]) and cool it. Determine the mass of the ash, and add 5 mL of saturated ammonium carbonate solution per gram of ash. Digest at room temperature for 1 h. Dry in an oven at 110 ± 5°C (230 ± 9°F) to constant mass; cool in a desiccator, and determine the mass to the nearest 0.001 g (G). Calculate the mass of mineral matter in the total volume of extract (W_4) as follows:

$$W_4 = G\,(W_1/100) \tag{A1.1}$$

where:

G = ash remaining in the ignition dish to nearest 0.001 g; and

W_1 = total volume, mL (or total mass, g) of extract.

A1.2. *Centrifuge Method*:

A1.2.1. *Apparatus*:

A1.2.1.1. Any suitable high-speed (3000-r/min or higher) centrifuge of the continuous-flow type.[3]

A1.2.1.2. Balance—Conforming to the requirements of M 231, Class G 1.

A1.2.1.3. Funnel or Steam Hood.

A1.2.2. *Procedure*:

A1.2.2.1. Determine the mass of a clean, empty centrifuge cup (or bowl) to the nearest 0.01 g, and place it in the centrifuge. Position a container at the appropriate spout to catch the effluent from the centrifuging operation. Transfer all of the extract (from Method A, B, D, or E as appropriate) to an appropriate (feed) container suitably equipped with a feed control (valve or clamp, etc.). To ensure quantitative transfer of the extract to the feed container, the receptacle containing the extract should be washed several times with small amounts of clean solvent and the washings added to the feed container. Start the centrifuge, and allow it to reach a constant operational speed (e.g., 9000 r/min for the SMM type and 20,000 + r/min for the Sharples type). Open the feed line, and feed the extract into the centrifuge at a rate of 100 to 150 mL/min. After all the extract has passed through the centrifuge, wash the feed mechanism (with the centrifuge still running) with several increments of clean solvent, allowing each increment to run through the centrifuge until the effluent is essentially colorless.

A1.2.2.2. Allow the centrifuge to stop, and remove the cup (or bowl). Clean the outside with fresh solvent. Allow the residual solvent to evaporate in a funnel or steam hood, and then dry the container in an oven controlled at 110 ± 5°C (230 ± 9°F). Cool the container and redetermine the mass to the nearest 0.01 g immediately. The increase in mass is the mass of mineral matter, W_4 (Section 13), in the extract.

A1.3. *Volumetric Method*:

A1.3.1. *Apparatus*:

A1.3.1.1. Flask.

A1.3.1.2. *Water Bath*—Capable of controlling temperature to ±0.1°C (±0.2°F).

A1.3.1.3. *Balance*—Conforming to the requirements of M 231, Class G 2.

A1.3.2. *Procedure*:

A1.3.2.1. Place the extract in a previously tared and calibrated flask. Place the flask in a constant-temperature bath controlled to ±0.1°C (±0.2°F), and allow it to reach the temperature at which the flask was calibrated. When the desired temperature has been reached, fill the flask with solvent at the same temperature. Bring the level of the liquid in the flask up to the neck; insert the stopper, making sure the liquid overflows the capillary, and remove the flask from the bath. Wipe the flask dry; determine the mass to the nearest 0.1 g, and record the result as the mass of the contents of the flask, M_1. A thermometer for measuring water bath temperature shall meet the requirements of M 339M/M 339 with a temperature range of at least 15 to 100°C (59 to 212°F), and an accuracy of ±0.03°C (±0.05°F) (see Note A2).

Note A2—Instead of using a controlled temperature bath, the temperature of the extract may be measured and the necessary corrections to the volume of the flask and the density of the asphalt binder and solvent made. Thermometer types suitable for use include ASTM E1 mercury thermometer; ASTM E879 thermistor thermometer, Special order; ASTM E1137/E1137M Pt-100 RTD platinum resistance thermometer, Special order; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, Special order.

A1.3.2.2. After the extracted aggregate has dried to a constant mass and cooled, determine the mass to the nearest 0.1 g. Record the mass of the initial sample minus the mass of the extracted aggregate as the mass of the asphalt binder and fines in the extract, M_2.

A1.3.2.3. Calculate the volume of asphalt and fines in the extract as follows:

$$V_1 = V_2 - \frac{(M_1 - M_2)}{G_1} \qquad (A1.2)$$

where:

V_1 = volume of asphalt and fines in the extract, mL;

V_2 = volume of the flask, mL;

M_1 = mass of the contents of the flask, g;

M_2 = mass of the asphalt binder and fines in the extract (or mass of the initial sample minus the mass of the extracted aggregate), g; and

G_1 = specific gravity of the solvent determined to the nearest 0.001 in accordance with ASTM D2111.

A1.3.2.4. Calculate the mass of fines in the extract as follows:

$$W_4 = K(M_2 - G_3V_1) \qquad (A1.3)$$

where:

W_4 = mass of mineral matter in the extract;

$K = \frac{G_2}{G_2 - G_3}$;

G_2 = specific gravity of fines as determined in accordance with T 84;

G_3 = specific gravity of asphalt binder as determined in accordance with T 228;

M_2 = as given in Section A1.3.2.3; and

V_1 = as given in Section A1.3.2.3.

---

[1] This method is similar to ASTM D2172/D2172M-11.

[2] Celite 110, manufactured by Johns-Manville, has been found satisfactory for this purpose; however, all filtering aids should be presieved through a 75-µm (No. 200) sieve when the gradation test on the aggregate is to be performed.

[3] The Sharples Supercentrifuge and the SMM continuous-flow centrifuge have been found suitable for this method.

NUCLEAR ASPHALT CONTENT GAUGE

PURPOSE OF TEST

A. Asphalt content.

B. Does not give any other test result.

EQUIPMENT

A. Gauge:

  (1) Americium/Beryllium or other neutron emitting source.

  (2) Electronic detectors.

  (3) Microprocessor capable of a 3-point calibration.

  (4) Readout instrument calibrated in % asphalt.

  (5) 6 Gauge pans.

B. Electronic Balance capable of weighing to 12 kg (26.5 lbs.) readable to 1.0 g (0.002 lb.).

C. Power vented oven capable of heating to 350° ± 5° F (177° ± 3° C) or 500° ± 5° F (260° ± 3° C) for mixtures containing RAP.

D. Straight edge, steel, approximately 0.5 m (18 in.) in length.

E. Plywood 19 mm (3/4 in.) minimum thickness, or metal plate 10 mm (3/8 in.) minimum thickness.

F. Assorted spoons, scoops, and mixing bowls.

G. Metal stemmed thermometers with a temperature range of 50° - 500° F (10° - 260° C), readable to 5° F (3° C).

H. Mixing apparatus.

I. Mixing tool, either a steel trowel or spatula, for spading and hand mixing.

TROUBLESHOOTING

A. Material:

(1) Compare count of the original blended aggregate to the count on the blended aggregate currently used in production.

(2) If the two counts on the blended aggregate differ by more than 1% a new calibration should be performed.

B. Gauge:

(1) Let the gauge warm up for ten minutes.

(2) Obtain background count:

(a) Measured count on an empty drawer (16 minutes):

- Daily when in use
- If the gauge is moved
- When results appear wrong

(b) Keep a diary of background (empty drawer) counts:

- Date
- Exact location
- Count.

(c) Must be within 0.5% of the average of the last four counts in that specific location (one retest allowed).

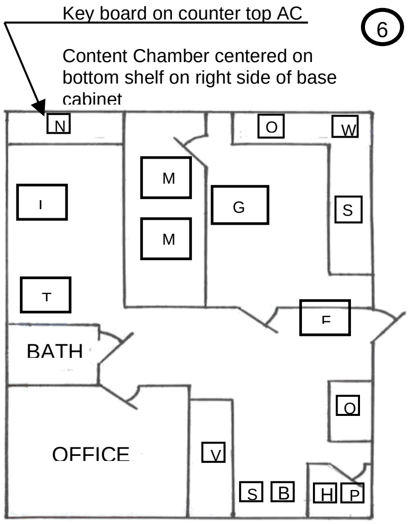
AB Content Gauge Lab Diary

Nuclear AC Content Gauge and Lab Equipment

Equipment Symbols

B	Water Bath
N	Nuclear Asphalt Content Gauge
P	Hot Plate
S	Electronic Scales
I	Ignition Oven
G	Gyratory Compactor
H	Marshall Hammer
V	Vaccum Pycnometer
F	Fridge/Freezer
M	MaryAnn Shaker
T	Parts Washer
W	Washing Sink

Note: The nuclear density gauge is stored in the shaker room at night.



Key board on counter top AC

Content Chamber centered on bottom shelf on right side of base cabinet

Diary Example of Background Counts of AB Content Gauge:

BACKGROUND COUNTS					
Date	**Count**	**Ave.**	**Toler.**	**Time**	**Initials**
6/08/21	2422			5:00 a	JMH
“	2413			5:16 a	JMH
“	2398			5:32 a	JMH
“	2385			5:48 a	JMH
6/09/21	2412			6:15 a	JMH
6/10/21	2392			5:19 a	JMH
6/11/21	2386			6:04 a	JMH

⑦

Background Counts

1) Daily when in use.
2) If the gauge is moved.
3) When results appear wrong.

JMH – Joseph M. Helms

* See Page 6 for exact location of gauge

(3) Statistical analysis:

(a) One per week (when the gauge is in use).

(b) When the gauge has been transported by vehicle.

(c) When results appear wrong.

Diary Example of Statistical Analysis for AB Content Gauge:

Statistical Analysis				
Date	**Ave. Count**	**Count Ratio**	**Time**	**Initials**
6/01/21	2489	0.51	1 min.	JMH
6/14/21	2472	0.47	1 min.	JMH
6/15/21	2479	0.54	1 min.	JMH
6/22/21	2470	0.56	1 min.	JMH

Statistical Analysis ⑩

1) One per week, when gauge is in use
2) When gauge has been transported by vehicle
3) When results appear wrong

*** See Page 6 of diary for exact location of gauge**

Ratio Table

Time	Limits
1 min.	0.35 to 0.71
4 min.	0.17 to 0.35
8 min.	0.12 to 0.25
16 min.	0.09 to 0.18

JMH = Joseph M Helms

C. Environment:

(1) Reads the presence of plastic.

(2) Can be affected by humidity.

(3) Can be affected by solvents commonly used in the lab for cleaning.

DETERMINATION OF WEIGHT FOR CALIBRATION AND TESTING - W_o**

A. Obtain materials as specified in the JOB MIX FORMULA. (SEE FIGURE 5.2, on page 5-119)

B. Dry the aggregate to a constant weight.

C. Blend approximately 8 - 9 kg of the aggregate to the proportions in the JOB MIX FORMULA.

Example: (8000g Batch)

Material From JMF (Fig. 5.2)	Percent Blend		Batch Size (g)		Amount Aggregate (g) per Batch
032CMM16	64.8	x	8000	=	5184
038FAM20	15.8	x	8000	=	1264
037FAM01	16.3	x	8000	=	1304
004MFM01	3.1	x	8000	=	248
	100				8000

D. Determine W_o, the total weight of sample:

(1) Place dry blended aggregate in a gauge pan in two layers.

(2) Raise and drop the pan 25 mm (1”), four times, striking the bottom evenly, after each layer.

(3) Do not compact.

(4) Strike off the blended aggregate sample even with the top of the pan.

(5) Record the weight.

(6) Place a thermometer in the blended aggregate.

(7) Place the blended aggregate in an oven at 180° - 290° F (82° - 143° C).

(a) Blended aggregate sample must be 180° - 290° F (82° - 143° C) immediately prior to testing.

(b) Further calibration and testing shall be within 10° F (6° C) of this sample (select a convenient temperature for production testing).

(8) Obtain count on dry aggregate (W_o):

(a) The purpose is to detect changes in the aggregate from calibration to production testing.

(b) If the count varies by more than 1.0% from the original count a new calibration is needed.

(9) Record the count and temperature.

****Definition of W_o - The weight of dry blended aggregate in a sample pan.**

Date:

FIGURE 5.2

SEQ NO:

Hot Mix Aspahlt Design

Design Number:		PAGE 10-10
Lab Preparing the design?(PP,PL,IL,etc.)		PP
Producer Name & Number->	1111-01	Example Company Inc.
Material Code Number->		High ESAL Surface Course, Mix C, N70

Agg. No.	#1	#2	#3	#4	#5	#6	ASPHALT
Size	**032CM16**		**038FA20**	**037FA01**	**004MF01**		
Source (PROD#)							
(NAME)							
(LOC)							
Aggregate Blend	**64.8**	**0.0**	**15.8**	**16.3**	**3.1**	**0.0**	**100.0**

Aggregate No.	#1	#2	#3	#4	#5	#6	Blend	Specifications		FORMULA	FORMULA RANGE	
Sieve Size								Min	Max		Min	Max
25.4 (1)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	--	--	100	100	100
19.0 (3/4)	100.0	100.0	100.0	100.0	100.0	100.0	100.0		100	100	100	100
12.5 (1/2)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	90	100	100	94	106
9.5 (3.8)	99.2	100.0	100.0	100.0	100.0	100.0	99.5		90	99	--	--
4.75 (#4)	33.9	100.0	99.0	100.0	100.0	100.0	57.0	24	65	57	52	62
2.36 (#8)	13.0	100.0	88.4	89.9	100.0	100.0	40.1	16	40	40	35	45
1.18 (#16)	4.5	100.0	74.4	55.5	100.0	100.0	26.8	10	32	27	27	27
600um (#30)	4.1	100.0	55.6	23.7	100.0	100.0	18.4	--	--	18	--	--
300um (#50)	3.7	100.0	20.0	8.3	100.0	100.0	10.0	4	16	10	6	14
150um (#100)	3.3	100.0	3.0	3.4	99.0	100.0	6.2	3	10	6	6	6
75um (#200)	2.8	100.0	1.0	1.8	88.0	100.0	5.0	4	6	5.0	3.5	6.5

Bulk Sp Gr	2.645	1	2.6	2.554	2.67	1
Apparent Sp Gr	2.783	1	2.65	2.682	2.67	1
Absorption, %	1.4	1	1.2	0.5	0	0
					SP GR AC 1.032	

SUMMARY OF TEST DATA

	AC % MIX	BULK SPEC GRAV (Gmb)	MAXIMUM SPEC GR (Gmm)	VOIDS TOT MIX (Pa)	VMA	VOIDS FILLED	EFFECTIVE AC, VOL	 AC, % WT	Gse	ABORPTION AC, % WT
MIX 1	4.5	2.294	2.480	7.50	16.49	54.5	8.99	4.04	2.656	0.48
MIX 2	5.0	2.320	2.460	5.69	15.99	64.4	10.29	4.58	2.653	0.44
MIX 3	5.5	2.350	2.440	3.69	15.35	76.0	11.66	5.12	2.650	0.40
MIX 4	6.0	2.380	2.430	2.06	14.72	86.0	12.66	5.49	2.660	0.54

	% AC	d (Gmb)	D (Gmm)	% VOIDS (Pa)	VMA	VFA	Gse	Gsb
Asphalt determined at 4.0% voids	5.42			Target				
OPTIMUM DESIGN DATA:---	5.4	2.344	2.444	4.0	15.5	73.7	2.651	2.623
REMARKS:								

Content Gauge Lab Diary
Example of Mix Design Nuclear Calibration

MIX DESIGN NUCLEAR CALIBRATION											⑳
								Pan 1	**Pan 2**	**Pan 3**	**Cal.**
Date	**Plant**	**Bit.**	**Code**	**Wo/Cnt**	**Temp/CF**	**Slope**	**Int.**	**AC/Count**	**AC/Count**	**AC/Count**	**No.**
6/16/21	918-01	7134	19514	7055g/2466	230°F/0.998	3.384	-7.110	3.2/2698	4.2/2933	5.2/3218	1
6/16/21	918-01	7135	19523	6998g/2511	230°F/1.000	4.454	+2.760	3.0/2638	4.0/2868	5.0/3088	2
6/22/21	918-01	7136	19533	6875g/2841	230°F/0.999	3.446	-5.980	4.6/3052	5.6/3342	6.6/3629	3
6/22/21	918-01	7137	19536	7050g/2461	230°F/0.997	3.673	+3.546	3.2/2664	4.2/2881	5.2/3162	4

CALIBRATION

A. Find the asphalt content determined in the design. (SEE FIGURE 5.3 on page 5-126)

B. Add 1% to the optimum asphalt content and mix the sample, using the same ingredient materials as used in the JOB MIX FORMULA, this is Calibration Point 1:

Example: (8000g Batch)

Material From JMF (Fig. 5.3)	Percent Blend		Batch Size (g)		Amount Aggregate (g) per Batch
032CMM16	64.8	x	8000	=	5184
038FAM20	15.8	x	8000	=	1264
037FAM01	16.3	x	8000	=	1304
004MFM01	3.1	x	8000	=	248
	100				8000

	Batch Size		(100 - % AC Req'd From JMF) / 100 (Figure 5.3)				Batch Weight		Amount AC (g) per Batch
% Above Optimum AC	8000	/	0.936	=	8547	-	8000	=	547
% Optimum AC	8000	/	0.946	=	8457	-	8000	=	457
% Below Optimum AC	8000	/	0.956	=	8368	-	8000	=	368

(1) Place material in a gauge pan in two layers totaling the weight equal to W_o.

(2) Use scoop or spatula to rod into the corners.

(3) Do not compact.

(4) Flatten the top of the sample even with the top of the pan with a wood or metal plate.

(5) Place a thermometer in the sample.

(6) Place the gauge pan in an oven at 180° - 290° F (82° - 143° C) until the temperature stabilizes and can be determined. *

(7) Record temperature.

(8) Place calibration point 1 in the gauge:

(9) Enter asphalt content.

(10) Start calibration (16 minutes)

(11) Remove calibration point 1 from the gauge.

*** All calibration points must be run at the same temperature. Production testing must be run at the same temperature as the calibration points. For simplicity, calibration points and production testing are run at the same temperature as the initial dry aggregate count.**

FIGURE 5.3

Date:

SEQ NO:

Hot Mix Aspahlt Design

Design Number:		PAGE 10-10
Lab Preparing the design?(PP,PL,IL,etc.)		PP
Producer Name & Number->	1111-01	Example Company Inc.
Material Code Number->		High ESAL Surface Course, Mix C, N70

Agg. No.	#1	#2	#3	#4	#5	#6	ASPHALT
Size	**032CM16**		**038FA20**	**037FA01**	**004MF01**		
Source (PROD#)							
(NAME)							
(LOC)							
Aggregate Blend	**64.8**	**0.0**	**15.8**	**16.3**	**3.1**	**0.0**	**100.0**

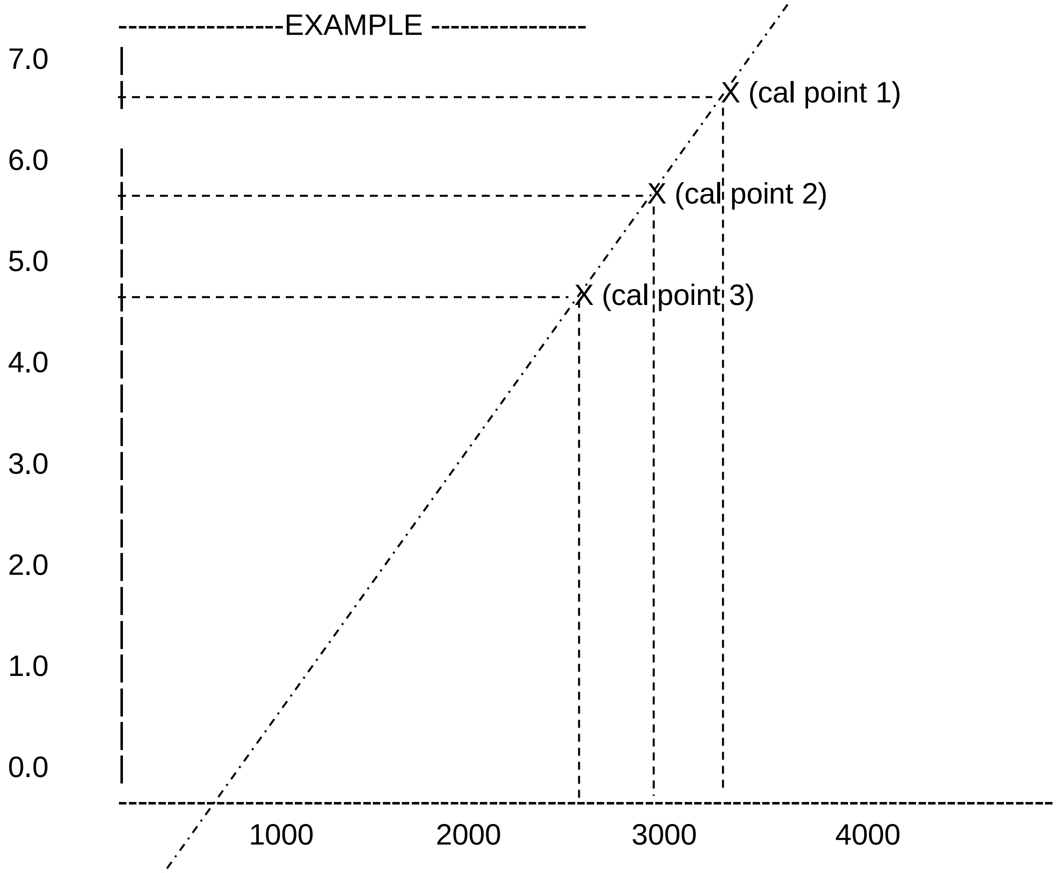
Aggregate No.	#1	#2	#3	#4	#5	#6	Blend	Specifications		FORMULA	FORMULA RANGE	
Sieve Size								Min	Max		Min	Max
25.4 (1)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	--	--	100	100	100
19.0 (3/4)	100.0	100.0	100.0	100.0	100.0	100.0	100.0		100	100	100	100
12.5 (1/2)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	90	100	100	94	106
9.5 (3.8)	99.2	100.0	100.0	100.0	100.0	100.0	99.5		90	99	--	--
4.75 (#4)	33.9	100.0	99.0	100.0	100.0	100.0	57.0	24	65	57	52	62
2.36 (#8)	13.0	100.0	88.4	89.9	100.0	100.0	40.1	16	40	40	35	45
1.18 (#16)	4.5	100.0	74.4	55.5	100.0	100.0	26.8	10	32	27	27	27
600um (#30)	4.1	100.0	55.6	23.7	100.0	100.0	18.4	--	--	18	--	--
300um (#50)	3.7	100.0	20.0	8.3	100.0	100.0	10.0	4	16	10	6	14
150um (#100)	3.3	100.0	3.0	3.4	99.0	100.0	6.2	3	10	6	6	6
75um (#200)	2.8	100.0	1.0	1.8	88.0	100.0	5.0	4	6	5.0	3.5	6.5

Bulk Sp Gr	2.645	1	2.6	2.554	2.67	1
Apparent Sp Gr	2.783	1	2.65	2.682	2.67	1
Absorption, %	1.4	1	1.2	0.5	0	0
					SP GR AC 1.032	

SUMMARY OF TEST DATA

	AC % MIX	BULK SPEC GRAV (Gmb)	MAXIMUM SPEC GR (Gmm)	VOIDS TOT MIX (Pa)	VMA	VOIDS FILLED	EFFECTIVE AC, VOL	AC, % WT	Gse	ABORPTION AC, % WT
MIX 1	4.5	2.294	2.480	7.50	16.49	54.5	8.99	4.04	2.656	0.48
MIX 2	5.0	2.320	2.460	5.69	15.99	64.4	10.29	4.58	2.653	0.44
MIX 3	5.5	2.350	2.440	3.69	15.35	76.0	11.66	5.12	2.650	0.40
MIX 4	6.0	2.380	2.430	2.06	14.72	86.0	12.66	5.49	2.660	0.54

	% AC	d (Gmb)	D (Gmm)	% VOIDS (Pa)	VMA	VFA	Gse	Gsb
Asphalt determined at 4.0% voids	5.42			Target				
OPTIMUM DESIGN DATA:---	5.4	2.344	2.444	4.0	15.5	73.7	2.651	2.623
REMARKS:								



EXAMPLE

Cal pan 1, AC% / count = 6.4% / 3218
Cal pan 2 (Design Asphalt Content) / Count = 5.4% / 2933
Cal pan 3, AC% / count = 4.4% / 2698
Slope x 1000 / Intercept = 3.834 / -7.110
Correlation Coefficient = 0.998

C. Mix sample at the optimum asphalt content, using the same ingredient materials as used in the JOB MIX FORMULA, this is Calibration Point 2:

(1) Place material in a gauge pan in two layers totaling the weight equal to W_o.

(2) Use scoop or spatula to rod into the corners.

(3) Do not compact.

(4) Flatten the top of the sample even with the top of the pan with a wood or metal plate.

(5) Place a thermometer in the sample.

(6) Place the gauge pan in an oven at 180°-290° F (82°-143° C) until the temperature stabilizes and is within 10° F (6° C) of predetermined temperature.

(7) Record temperature.

(8) Place calibration point 2 in the gauge.

(9) Enter asphalt content.

(10) Start calibration (16 minutes).

(11) Remove calibration point 2 from the gauge.

D. Subtract 1% from the optimum asphalt content and mix the sample, using the same ingredient materials as used in the JOB MIX FORMULA, this is Calibration Point 3:

(1) Place material in a gauge pan in two layers totaling the weight equal to W_o.

(2) Use scoop or spatula to rod into the corners.

(3) Do not compact.

(4) Flatten the top of the sample even with the top of the pan with a wood or metal plate.

(5) Place a thermometer in the sample.

(6) Place the gauge pan in an oven at 180° - 290° F (82° - 143° C) until the temperature stabilizes and is within10° F (6° C) of predetermined temperature.

(7) Record temperature.

(8) Place calibration point 3 in the gauge.

(9) Enter asphalt content.

(10) Start calibration (16 minutes)

(11) Remove calibration point 3 from the gauge.

(12) Record AC/count, slope/intercept, and correlation coefficient. A minimum correlation coefficient of 0.995 is required. If this cannot be achieved by test or retest, you will then have to make up new calibration samples, repeating the steps under the calibration section.

E. This calibration is valid for:

   (1) The specific gauge the calibration was performed on.

   (2) These specific materials, in these proportions.

   (3) The exact location of the gauge where the calibration was performed.

TESTING THE PLANT MIXTURE FOR ASPHALT CONTENT

A. Take a sample for moisture content (1000-1100 grams) *****:

   (1) Place 1000-1100 grams in a pan of known weight.

   (2) Record initial weight.

   (3) Sample is oven dry when the loss in one hour, at. 230° ± 9° F (110° ± 5° C) is less than 0.5 g.

   (4) Percent moisture content is [(original weight minus oven dry weight) divided by the oven dry weight] X 100.

   (5) Record the result, this will be subtracted from the gauge reading:

      (a) For plant operations the average moisture content from the past two tests may be used to subtract from the gauge reading for approximate asphalt content (process control, not QC/QA).

      (b) For test results provided to IDOT a moisture determination must be performed on the split sample of the required test.

- Moisture content determination can be performed while the other sample is being tested for AC content.

B. Place material in a gauge pan in two layers totaling the weight equal to W_o:

   (1) Use scoop or spatula to rod into the corners.

   (2) Do not compact.

   (3) Flatten the top of the mixture even with the top of the pan with a wood or metal plate.

   (4) Place a thermometer in the sample.

C. Place the gauge pan in an oven at 180° - 290° F (82° - 143° C).

D. When the sample is within tolerance of the chosen temperature, place the sample pan in the gauge.

E. Select time.

F. Test.

G. Record result.

REPORT

A. Date.

B. Equipment:

  (1) Manufacturer of gauge.

  (2) Model.

  (3) Serial number.

C. Operators name.

D. Identification of mix.

E Calibration:

  (1) Asphalt content/count (all calibration points).

  (2) Correlation Coefficient.

  (3) Slope/intercept.

  (4) W_o (weight of all samples).

  (5) Temperature of calibration points.

F. Testing of field samples:

  (1) Date of calibration used.

  (2) Slope/intercept.

  (3) W_o (weight of test specimen).

  (4) Gauge reading of asphalt content/count.

  (5) Corrected asphalt content, (asphalt content from gauge reading minus moisture content).

  (6) Temperature of test specimen.

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: December 1, 2022

Standard Method of Test
For
Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method

Reference AASHTO T 287-22

AASHTO Section	***Illinois Modification***
2.1	Replace the individual AASHTO Standards with the appropriate Illinois modified AASHTO Standards:
2.1	Add the following: • AASHTO Standard R 90
2.2 New Section	Manufacturer's instruction manual
3.3	Replace the first sentence with the following: Accurate results are dependent upon proper calibration of the nuclear gauge to the material being tested as covered in Appendix A.
3.4	Replace the second and third sentences with the following: The moisture sample shall be weighed immediately, prior to beginning the test count, and this value shall be recorded as the original sample weight. The sample to be tested for moisture content shall be placed in a 110 ± 5 °C (230 ± 9 °F) oven at the time the mixture test count is being performed. Drying of the moisture sample shall continue until it reaches constant mass. Constant mass (oven dry) is defined as less than 0.5 g loss in 1 hour. This weight shall be recorded as the oven-dry weight. Moisture content is determined as follows: $\text{Moisture Content} = \left(\frac{[\text{Original Sample Weight} - \text{Oven Dry Weight}]}{\text{Oven Dry Weight}}\right) \text{x } 100$
3.4 New Note	Add New **Note 1**: **Note 1**—The moisture content determined from the previous test can be used to adjust the apparent asphalt content for quality control purposes only. The actual moisture content of the current sample shall be determined and used to correct the apparent asphalt content (nuclear gauge reading). The corrected asphalt content is plotted on the control charts and used for acceptance purposes.

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Standard Method of Test
For
Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method

Reference AASHTO T 287-22

AASHTO Section	***Illinois Modification***
4.1	Replace with the following: Nuclear asphalt binder content gauge system, capable of at least a 3-point calibration, consisting of:
4.2	Replace with the following: Mechanical mixer with a minimum 10-kg (22-lb) capacity, capable of producing a completely mixed, well-coated, homogenous asphalt mixture.
4.6.2	Delete.
4.8	Replace with the following: Thermometers for measuring temperature of materials shall have a suitable range to determine 50 – 450 °F (10 – 232 °C). The thermometers may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 1.35 °F (± 0.75 °C) (see Note 2).
4.8 Note 1	Rename as **Note 2**.
Note 2	Replace with the following: **Note 2** - Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; IEC 60584 thermocouple thermometer, Type T, Class 1; or E2877 digital metal stem thermometer.
4.9.1 New Section	Heat-resistant gloves.
5.2	Add the following between the second and third sentences: The location of the gauge for field-testing requires the gauge to be in the exact location used during calibration.
6.1	Replace with the following: Once a calibration is performed on a specific gauge, no mathematical transfer of the calibration to another gauge will be allowed. The original calibration pans shall be used to calibrate the new gauge.

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Standard Method of Test
For
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Reference AASHTO T 287-22

AASHTO Section	***Illinois Modification***
7.2	Replace with the following: If the background count has not changed by more than 1.0 percent from the average of the previous 4 background counts, then the apparatus shall be considered stable and acceptable for use. If the gauge has been moved or the surrounding conditions have changed, additional background counts must be obtained until the 1.0 percent standard is satisfied.
8.	Rename: **PROCEDURE FOR PRODUCTION TESTING**
8.1	Replace with the following: Obtain samples of freshly produced asphalt concrete according to Illinois Department of Transportation document, "Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples".
8.3	Add the following at the end: The material shall be rodded into the corners of the gauge pan to eliminate large voids.
8.4	Replace with the following: Place additional asphalt mixture into the pan until the required mass, as determined in Appendix A, is reached within ± 5 g.
8.6 Note 2	Change to **Note 3**
8.6 New Note	Add New **Note 4**: **Note 4** - Asphalt samples should not remain in the oven to re-heat for longer than 4 hours prior to placement in the gauge. Loss of hydrogen could cause an inaccurate count.
8.7	Add the following at the end of the second sentence: “or according to the manufacturer’s instructions”.
8.7 Note 3	Change to **Note 5**.
8.8	Replace the second sentence with the following: Record the uncorrected asphalt binder content obtained from the reading taken in section 8.7 to the nearest 0.1 percent.

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Standard Method of Test
For
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Reference AASHTO T 287-22

AASHTO Section	***Illinois Modification***
10.1	Replace with the following: The report shall be the Illinois Department of Transportation MI 308 form or on the form generated by the Department's Quality Management Program (QMP) software.
10.2 New Section	*Information to be recorded in a data book or diary:*
10.1.1 through 10.1.13	Rename as sections 10.2.1 through 10.2.13
Annexes	Replace with the following: **APPENDICES**
A1.1	Replace with the following: This appendix covers the preparation of samples for, and the calibration of, nuclear asphalt binder content gauges.
A3.5	Delete.
A3.5.1	Delete.
A3.5.2	Delete.
A3.5.3	Delete.
A4.1	Add at the end of the second sentence: according to the Manual of Test Procedures Appendix B17, *Procedure for Introducing Additives to Hot Mix Asphalt Mixtures and Testing in the Lab,* Section 4.0 (D) (5) Liquid Anti-strip.
A4.2.1	Replace the last paragraph with the following: Asphalt binder contents will be chosen at the optimum asphalt binder content and at increments of ±1.0 percent from the optimum asphalt binder content. The minimum three samples are 1.0 below optimum, optimum, and 1.0 above the optimum asphalt binder content. Additional samples at other binder contents may be required by the Engineer.
A4.3	Delete.

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Standard Method of Test
For
Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method

Reference AASHTO T 287-22

AASHTO Section	***Illinois Modification***
A4.3.1	Delete.
A4.3.2	Delete.
A6.1 Note A3	Replace with the following: **Note A3** - To find an appropriate starting mass, place the dry aggregate in a gauge-sample pan. Fill the sample pan one-half full, evenly distributing the sample in the pan. Level the HMA mixture with a trowel or spatula. Fill the remainder of the pan until the weight of the HMA mixture in the pan equals the dry aggregate weight. If the pan is not full, fill the pan to the point that the HMA mixture is mounded slightly above the top of the pan. Record the weight of the HMA mixture in the pan. This is the weight that is to be used for all calibration and test samples using this calibration. Level the top of the HMA mixture using a spatula or trowel. Use the metal plate or plywood to consolidate the HMA mixture until it is even with the top edge of the pan. All specimens should be compacted at a temperature between 121° and 149° ± 6°C (250° and 300° ± 10°F) to ensure that the mix will compact properly.
A6.4	Add the following after the first sentence: The material shall be rodded into the corners of the pan to eliminate large voids.
A7.2	Replace the last sentence with the following: At a minimum, use 1.0 percent below optimum, optimum, and 1.0 percent above the optimum asphalt binder content when making the calibration-curve pans.
A8.1	Replace the first sentence with the following: Prepare four aggregate samples, or number recommended by the manufacturer, using the target mass determined in Section A6.7.
A8.5	Add the following after the first sentence: The material shall be rodded into the corners of the gauge pan to eliminate large voids.
A8.8 New Note	Add New **Note A4**: **Note A4** - If the gauge does not have temperature compensation capabilities, determine and record the temperature of the HMA mixture compacted into the pan to use as the target temperature for testing field samples.
A8.9 Note A4	Change to **Note A5**:

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Reference AASHTO T 287-22

AASHTO Section	***Illinois Modification***
A10	Delete Entire Section
Appendix B New Section	Dry Aggregate Standard Count
B1 New Section	Turn on the equipment and allow for stabilization of the equipment in accordance with the manufacturer's recommendations.
B2 New Section	Fill the sample pan one-half full of hot dry aggregate dried to constant weight and at the temperature of the aggregate sample used during calibration ±6˚C (±10˚F). Place the dry hot aggregate in a tared sample pan in two equal layers. For each layer, raise and drop the pan approximately one inch, four times. Be sure that the pan bottom strikes evenly. Use a spatula to distribute the aggregate to avoid segregation. Add to or remove aggregate until the weight of aggregate in the pan is equal to the weight of aggregate used in the calibration. Using a straightedge, level the top of the aggregate sample until it is even with the top of the sample pan. Obtain and record the temperature of the sample.
B3 New Section	Place the hot blended aggregate into the gauge and proceed as per manufacturer's instruction for operation of the equipment and the sequence of operation. This dry aggregate count is used to determine changes in aggregates which affect counts.
B3 New Note	Add New **Note B1**: **Note B1** - If a significant change is noted (± 0.5 percent) from the calibration aggregate count, a new calibration should be run.

Standard Method of Test for

Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method

AASHTO Designation: T 287-22

Technically Revised: 2022 **Editorially Revised: 2022**

Technical Subcommittee: 2c, Asphalt–Aggregate Mixtures

1. SCOPE

1.1. This procedure covers the quantitative determination of the asphalt binder content of asphalt mixtures by testing a sample with a nuclear gauge that utilizes neutron-thermalization techniques.

1.2. The values expressed in SI units are to be regarded as the standard. The inch-pound equivalents of the SI units may be approximate.

1.3. Nuclear gauge operations and maintenance are not covered in detail. See the manufacturer's manual for details.

1.4. *This test method involves potentially hazardous materials, operations, and equipment. This method does not purport to address all of the safety concerns associated with its use. All operators will be trained in radiation safety prior to operating nuclear gauges. Some agencies require the use of personal monitoring devices such as a thermoluminescent dosimeter or film badge.*

1.5. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 231, Weighing Devices Used in the Testing of Materials
- M 339M/M 339, Thermometers Used in the Testing of Construction Materials
- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- R 66, Sampling Asphalt Materials
- R 76, Reducing Samples of Aggregate to Testing Size
- R 90, Sampling Aggregate Products
- R 97, Sampling Asphalt Mixtures
- T 11, Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
- T 27, Sieve Analysis of Fine and Coarse Aggregates

- T 110, Moisture or Volatile Distillates in Hot Mix Asphalt (HMA)
- T 255, Total Evaporable Moisture Content of Aggregate by Drying
- T 329, Moisture Content of Asphalt Mixtures by Oven Method

2.2. *ASTM Standards*:

- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E2877, Standard Guide for Digital Contact Thermometers

2.3. *International Electrotechnical Commission Standard*:

- IEC 60584-1: 2013 Thermocouples - Part 1: EMF Specifications and Tolerances

3. SUMMARY OF METHOD

3.1. This procedure can be used for rapid determination of the asphalt binder content of asphalt mixtures. It is suitable for quality control and acceptance testing for construction and for research and development applications. This procedure is useful in the determination of asphalt binder content only and does not provide for gradation analysis.

3.2. This procedure determines the asphalt binder content of a test sample by comparing the measured asphalt binder content with previously established calibration data. The asphalt binder content is expressed as a percentage of the mass of the asphalt mixture.

3.3. Accurate results are dependent on proper calibration of the nuclear gauge to the material being tested as covered in Annex A. This procedure is sensitive to the type and gradation of the aggregate, liquid anti-stripping additive or hydrated lime, and the percentage and source of the asphalt binder.

3.4. This procedure measures the total amount of hydrogen in a sample including the hydrogen present in the form of water. Unless the test sample is totally free of water, the moisture content must be determined according to T 110 or T 329 and the percentage subtracted from the asphalt binder content measured by the nuclear gauge. Alternatively, prior to testing, the sample may be dried to a constant mass in accordance with T 329, thereby nullifying the need for a moisture correction.

3.5. This procedure can be used with recycled asphalt pavement (RAP) incorporated into the asphalt mixture, provided that the RAP is of uniform gradation, asphalt binder content, and asphalt binder type. When RAP is used, the RAP should be mixed in the calibration samples in the same proportion that it will be used on the construction project.

4. APPARATUS

4.1. *Nuclear asphalt binder content gauge system consisting of*:

4.1.1. *Neutron Source*—an encapsulated and sealed radioactive source;

4.1.2. *Thermal neutron detectors*;

4.1.3. *Readout instrument*—displaying, at a minimum, the percent of asphalt binder to the nearest 0.1 percent; and

4.1.4. *Three or more stainless-steel sample pans*—conforming to the gauge requirements.

4.2. Mechanical mixer with a 10-kg (22-lb) capacity, capable of producing a completely mixed, well-coated, homogeneous asphalt mixture.

4.3. Sample containers such as paint cans or unwaxed, nonabsorbent cardboard boxes that can be closed to prevent contamination of the sample and are capable of withstanding the heating of the asphalt mixture to the mixing temperature.

4.4. Sample-quartering apparatus conforming to the requirements of R 76, Method B.

4.5. General-purpose balance or scale conforming to M 231, 20-kg (44-lb) capacity, readable to 0.1 g.

4.6. *Drying Oven*—capable of handling the required number of samples and sample sizes, of either of the following types:

4.6.1. Forced-air convection oven capable of maintaining a temperature of 177 ± 3°C (350 ± 5°F).

4.6.2. Microwave oven, determined not to be detrimental to the aggregate, capable of maintaining a temperature of 177 ± 3°C (350 ± 5°F).

4.7. *Leveling Plate*—flat, rigid plate of metal [minimum thickness of 10 mm (0.4 in.)], Plexiglas [minimum thickness of 12.5 mm (0.5 in.)], or nonabsorptive plywood [minimum thickness of 19 mm (0.75 in.)], slightly larger than the sample pans.

4.8. Thermometer with a temperature range of 10 to 260°C (50 to 500°F) and an accuracy of ±0.5°C (±0.9°F), meeting the requirements of M 339M/M 339 (Note 1).

Note 1—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E2877 digital metal stem thermometer; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; or IEC 60584 thermocouple thermometer, Type T, Class 1.

4.9. Assorted pans, spoons, spatulas, and mixing bowls.

4.10. *Radioactive materials information/calibration packet containing*:

4.10.1. Daily standard count log;

4.10.2. Factory/laboratory calibration data sheet;

4.10.3. Leak test certificate;

4.10.4. Shipper's declaration for dangerous goods;

4.10.5. Procedure memo for storing, transporting, and handling nuclear testing equipment; and

4.10.6. Other radioactive materials documentation conforming to local regulatory requirements.

5. PRECAUTIONS

5.1. *The nuclear asphalt binder content gauge may be sensitive to outside influences and therefore*:

5.1.1. Any other source of neutron radiation shall be kept at least 10 m (33 ft) from the apparatus during use;

5.1.2. The space within 1 m (3.3 ft) of the apparatus shall be kept free of hydrogenous material such as water, plastics, asphalt binder, or asphalt mixtures during use;

5.1.3. All personnel shall be kept at least 1 m (3.3 ft) away from the gauge during testing; and

5.1.4. The gauge shall not be located within 10 m (33 ft) of any water supply tanks, fuel tanks, or other liquid containers subject to fluctuating liquid levels.

5.2. Moving the apparatus to a different location, even within the same laboratory, may cause a change in the background radiation measurements. New background measurements, and possibly recalibration, will be necessary prior to use whenever background conditions have changed. See Sections 6 and 7 for instructions concerning calibration and background measurements.

6. CALIBRATION

6.1. Perform calibrations and cross-calibrations on asphalt mixtures tested in gauges, and transfer calibrations between gauges according to Annex A.

7. STANDARDIZATION

7.1. Obtain and record a background count in accordance with the manufacturer's procedure each day prior to taking test measurements or whenever the gauge has been moved or the conditions within 1 m (3.3 ft) of the gauge have changed. The measurement time for the background count should be the same as that used for the test measurements.

7.2. If the background count has not changed by more than 1 percent from the previous background count, then the apparatus shall be considered stable and acceptable for use. If the gauge has been moved or if the surrounding conditions have changed, additional background counts must be obtained until the 1 percent standard is satisfied.

8. PROCEDURE

8.1. Obtain a representative sample of asphalt mixture in accordance with R 97. If required, reduce the sample to the approximate test size by splitting or quartering according to R 76, Method B. It is recommended that testing be performed while the asphalt mixture is still hot, and not reheated, if possible. If the asphalt mixture cools and reheating is necessary, heat it to the midpoint of the compaction temperature range for the asphalt binder used in the asphalt mixture.

8.2. Determine the mass of a clean gauge-sample pan, and tare the pan on the scale.

8.3. Place the asphalt mixture into the pan until it is about half full. Lightly tamp the asphalt mixture in the pan with a preheated spoon or spatula.

8.4. Place additional asphalt mixture into the pan until the required mass, as determined in Annex A, is reached within ±5 g.

8.5. Place the leveling plate on top of the asphalt mixture immediately after filling the pan. Compact the sample into the pan until it is level with the top of the pan by pressing down on the plate. Sight across the top of the pan to ensure that the asphalt mixture does not protrude above the pan.

8.6. Record the mass of the asphalt mixture compacted into the pan. The mass shall be within ±5 g of the target mass.

Note 2—If the gauge does not have temperature-compensation capability, measure and record the temperature of the compacted specimen. This temperature must be within ±5°C (9°F) of the calibration-test-specimen temperature.

8.7. If the gauge has the ability to store multiple calibrations, activate the calibration for the particular asphalt mixture. Place the pan into the gauge, and perform at least a 4-min count.

Note 3—Longer testing times (counts) may increase the precision of the test results.

8.8. Determine the uncorrected asphalt binder content by direct readout from the gauge, calibration graph, or formula supplied by the manufacturer. Record the uncorrected asphalt binder content from the 4-min reading to the nearest 0.1 percent.

8.9. Using a representative portion of the original sample or a portion of the material removed from the gauge pan, determine the moisture in the asphalt mixture according to T 110 or T 329, and record it to the nearest 0.1 percent. Alternatively, prior to testing, the sample may be dried to a constant mass in accordance with T 329, thereby nullifying the need for a moisture correction.

9. CALCULATION

9.1. When determined, subtract the moisture content from the uncorrected asphalt binder content. Record this value as the corrected asphalt binder content.

10. REPORT

10.1. *Report the following information*:

10.1.1. Make, model, and serial number of the nuclear asphalt binder content gauge;

10.1.2. Date and source of the calibration;

10.1.3. Date of the test;

10.1.4. Name and signature of the operator;

10.1.5. Background count for the day of the test;

10.1.6. Asphalt mixture identification;

10.1.7. Aggregate type and sources;

10.1.8. Asphalt binder grade and source;

10.1.9. When used, source and amount of liquid anti-stripping additive or hydrated lime;

10.1.10. Calibration sample mass and temperature;

10.1.11. Test-sample mass and temperature if the gauge does not have temperature-compensation capability;

10.1.12. Gauge reading; and

10.1.13. Corrected asphalt binder content value to the nearest 0.1 percent.

11. KEYWORDS

11.1. Asphalt binder content; asphalt mixture; background count; calibration; cross-calibration; nuclear density gauge.

ANNEX A

(Mandatory Information)

A1. SCOPE

A1.1. This annex covers the preparation of samples for, and the calibration of, nuclear asphalt binder content gauges. Job-mix formula (JMF) calibration and cross-calibration of master and field gauges are included.

A2. SAMPLING

A2.1. Obtain samples of aggregate according to R 90. Approximately 50 kg (110 lb) will be required for the calibration specimens.

A2.2. Obtain samples of asphalt binder according to R 66. Approximately 4 L (1 gal) will be required.

Note A1—The more accurately the ingredient materials (including liquid anti-stripping additive or hydrated lime) are prepared to match the JMF, the closer the calibration points will be to the production asphalt mixture; and, therefore, the more accurate the results will be.

A3. AGGREGATE PREPARATION

A3.1. When used, hydrate the appropriate amount of lime on the aggregate.

A3.2. Dry the aggregate to a constant mass in accordance with T 255.

A3.3. Separate the aggregate blend by dry-sieving on the specified sieves, including the minus 75-μm (No. 200) material.

A3.4. Calculate the required cumulative mass for each specified sieve using the following formula:

$$X = \frac{T(100 - P)}{100} \qquad (A3.1)$$

where:

X = the required, cumulative batch mass for each specified sieve (g);
T = the initial, total aggregate mass (g); and
P = the percent passing for each specified sieve according to the JMF.

A3.5. *Perform an aggregate dust correction as follows*:

A3.5.1. Prepare a washed-gradation sample from the masses calculated in Section A3.4.

A3.5.2. Perform a washed gradation according to T 27 and T 11.

A3.5.3. Calculate the corrected batch mass for each specified sieve for the calibration points using the following formula:

$$Z_n = \frac{X^2}{Y} \quad (A3.2)$$

where:

Z_n = the adjusted, cumulative batch mass for any sieve size, n (g);
X = the prewash, cumulative batch mass for each specified sieve (g); and
Y = the post-wash, cumulative batch mass for each specified sieve (g).

A3.6. Blend the aggregate together at the proper proportion to match the JMF using the masses calculated in Section A3.5.3.

A4. ASPHALT BINDER PREPARATION

A4.1. Heat a minimum of 2 L (0.5 gal) of asphalt binder to the midpoint of the mixing temperature range in a covered container(s). When used, add the appropriate amount of liquid anti-stripping additive to the asphalt binder. Use the asphalt binder as soon as it reaches the midpoint of the mixing temperature range. If this operation is not possible, maintain the asphalt binder at this temperature for no more than 4 h. Do not cool and reheat the asphalt binder.

A4.2. *Method A*—Asphalt binder percent by mass of the asphalt mixture.

A4.2.1. Calculate the mass of asphalt binder for each calibration point as follows:

$$B = (E)(P_{bm}) \quad (A4.1)$$

where:

B = the mass of the asphalt binder to the nearest 0.1 g;
E = the mass of the asphalt mixture (g); and
P_{bm} = the percent of asphalt binder by total mass of the asphalt mixture, expressed as a decimal.

Asphalt binder contents will be chosen at the optimum asphalt binder content and at increments of ±0.8 percent from the optimum asphalt binder content. The minimum four samples are at 0.8 percent below optimum, at optimum, at 0.8 percent above optimum, and at 1.6 percent above optimum.

A4.2.2. Calculate the mass of aggregate required for each calibration point as follows:

$$A = E - B \quad (A4.2)$$

where:

A = the mass of the aggregate to the nearest 0.1 g.

A4.3. *Method B*—Asphalt binder percent by mass of the aggregate.

A4.3.1. Calculate the mass of aggregate for each calibration point as follows:

$$A = \frac{E}{1 + P_{ba}} \quad (A4.3)$$

where:

P_{ba} = the percent of asphalt binder by mass of the aggregate, expressed as a decimal.

Asphalt binder contents will be chosen at the optimum asphalt binder content and at increments of ±0.8 percent from the optimum asphalt binder content. The minimum four samples are at

0.8 percent below optimum, at optimum, at 0.8 percent above optimum, and at 1.6 percent above optimum.

A4.3.2. Calculate the mass of asphalt binder required for each calibration point as follows:

$$B = (A)(P_{ba}) \qquad (A4.4)$$

A5. PREPARATION FOR SPECIMENS

A5.1. The aggregate and asphalt binder materials must be heated to the midpoint of the mixing temperature range for that asphalt binder. Once these materials have stabilized at that temperature, proceed with the following steps:

A5.2. Determine the mass of the heated mixing bowl to the nearest 0.1 g.

A5.3. Place a heated aggregate specimen, of the required mass to the nearest 0.1 g, in the mixing bowl.

A5.4. Form a crater in the aggregate large enough to hold the required mass of asphalt binder.

A5.5. Place the mixing bowl on the scale. Add the required, preheated asphalt binder mass, to the nearest 0.1 g, into the aggregate crater.

A5.6. Mechanically mix the aggregate and asphalt binder rapidly for a minimum of 2 min until they are thoroughly blended. Check the bottom and sides of the bowl for unmixed aggregate and asphalt binder. If necessary, remix the sample by hand until it is thoroughly mixed.

Note A2—Hand-mixing is not recommended. However, mixing may be performed by hand in a large bowl. In this case, the mixing time shall be a minimum of 5 min, but it may be longer to ensure thorough mixing.

A5.7. Remove the asphalt mixture from the bowl, and determine the mass of the empty bowl to ensure that all material has been removed. The mass of the bowl shall be within ±5 g of the mass determined in Section A5.2. If it is not, scrape the bowl with a spatula, and deposit the excess into the sample, until the mass of the bowl is within the tolerance.

A6. TARGET MASS DETERMINATION

A6.1. An initial, or "butter" batch is prepared to determine the mass to be used for the calibration samples using an asphalt binder/aggregate blend approximating the real batches. Based on experience with aggregate specific gravity and gradation, the target mass will be from 6000 to 9000 g.

Note A3—To find an approximate starting mass, place the dry aggregate in a gauge-sample pan. Fill the pan half full; then drop it from a height of 25 mm (1 in.). Fill the pan just over full, and strike it off even with the top. Determine this mass, and add 10 percent to obtain an approximate starting mass.

A6.2. Mix the preheated aggregate and asphalt binder according to Section A5.

A6.3. Determine the mass of a clean gauge-sample pan, and tare the pan on the scale.

A6.4. Place the asphalt mixture into the pan until it is about half full. Lightly tamp the asphalt mixture in the pan with a preheated spoon or spatula.

A6.5. Place the remaining asphalt mixture into the pan so that the asphalt mixture is mounded about 13 mm (0.5 in.) above the top of the pan.

A6.6. Place the leveling plate on top of the asphalt mixture immediately after filling the pan. Compact the sample into the pan until it is level with the top of the pan by pressing down on the plate. Sight across the top of the pan to ensure that the asphalt mixture does not protrude above the pan.

A6.7. Determine and record the mass of the asphalt mixture compacted into the pan. This value is the target mass. The subsequent calibration and sample specimens must be within ±5 g of this mass.

A7. CALIBRATION (GENERAL)

A7.1. The type of aggregate, source and grade of asphalt binder, liquid anti-stripping additive or hydrated lime, and asphalt mixture gradation will influence the test results obtained using this procedure. Accordingly, a calibration curve must be developed for each combination of these factors.

A7.2. The calibration curve must cover the range of expected values found in field samples. The limits for the calibration curve must consider the allowable range of asphalt binder content plus the allowable aggregate moisture (which reads as asphalt binder in the gauge). At a minimum, use 0.8 below, optimum, 0.8 above, and 1.6 percent above the optimum asphalt binder content when making the calibration-curve pans.

A8. JMF CALIBRATION

A8.1. Prepare four aggregate samples using the target mass determined in Section A6.7. Place them in separate pans designed for, and capable of, transferring the dry aggregate into a mixing bowl with a minimum loss of aggregate. Place them in an oven set at the midpoint of the mixing temperature range for the asphalt binder to be used.

A8.2. Determine the mass of the aggregate and asphalt binder for each calibration sample according to Sections A3 and A4, respectively.

A8.3. Mix the preheated aggregate and asphalt binder according to Section A5.

A8.4. Determine the mass of a clean gauge-sample pan, and tare the pan on the scale.

A8.5. Place the asphalt mixture into the pan until it is about half full. Lightly tamp the asphalt mixture in the pan with a preheated spoon or spatula.

A8.6. Place the remaining asphalt mixture into the pan so that the asphalt mixture is mounded about 13 mm (0.5 in.) above the top of the pan.

A8.7. Place the leveling plate on top of the asphalt mixture immediately after filling the pan. Compact the sample into the pan until it is level with the top of the pan by pressing down on the plate. Sight across the top of the pan to ensure that the asphalt mixture does not protrude above the pan.

A8.8. Determine and record the mass of the asphalt mixture compacted into the pan. The mass shall be within ±5 g of the target mass determined in Section A6.7.

A8.9. Place the pan into the gauge, and proceed in accordance with the manufacturer's instructions for the operation of the equipment and the sequence of operations.

Note A4—Do not forget to perform a background count according to the manufacturer's instructions.

A8.10. Repeat Sections A8.2 through A8.9 for the other calibration samples.

A9. PRESENTATION OF CALIBRATION DATA

A9.1. *For gauges that generate the calibration internally to the gauge:*

A9.1.1. Print or otherwise record the formula coefficients, the coefficient of fit, and the calculated percent difference for each calibration point. If the coefficient of fit is less than 0.998 for a dense-graded asphalt mixture or 0.995 for an open-graded asphalt mixture, or any calibration point has a calculated percent difference greater than 0.09 percent, the calibration is not acceptable and must be performed again.

A9.1.2. Store the acceptable calibration in the gauge's memory, using the JMF and an easily recognizable calibration number, according to the manufacturer's instructions.

A9.2. *For gauges that do not generate the calibration internally to the gauge:*

A9.2.1. Prepare a calibration curve by plotting the gauge readings for the calibration samples versus asphalt binder content on linear graph paper, choosing convenient scale factors for the gauge readings and asphalt binder content.

A10. CROSS-CALIBRATION (WHEN APPLICABLE)

A10.1. The formula coefficients are entered into the field gauge in the transfer mode during the cross-calibration process. The new formula coefficients, when printed, will not resemble the values entered because they will change based on this relationship. For more detailed information on the formula coefficients, refer to the manufacturer's instructions. If required, a "straight" calibration may be performed and used instead of the transfer program. This option requires that the sample pans used for the calibration be tested in another gauge if the testing must be verified by the agency.

Note A5—Some agencies cross-calibrate gauges. This process creates a relationship between the field gauge and the gauge used in the JMF calibration, allowing the testing of production asphalt mixture without the need to perform calibrations in the field. When several gauges are cross-calibrated, the asphalt mixture calibrations may be transferred to each gauge.

A10.2. Prepare six calibration samples using a locally available, agency-approved aggregate, with asphalt binder contents between 3 and 8 percent at 1-percent increments. Mix the samples so that each pan of asphalt mixture equals the target mass ±5 g as determined for the aggregate. Test each sample in the master gauge using 16-min counts in the normal calibration mode. After all samples are tested, the gauge will automatically calculate a coefficient of fit. The coefficient of fit must be at least 0.999. Seal each pan to prevent a change in hydrogen content, and repeat the procedure. Sealed pans must meet the same criteria as above.

Note A6—To seal the pan, cut a piece of tin the size of the top of the sample pan. Seal the edges of the pan and tin lid with an epoxy. This process will seal any moisture out.

A10.3. Test each of the six sealed calibration samples in the field gauge while it is in the cross-calibration mode. For each calibration sample, input the data obtained from the master gauge into the field gauge. The master and field gauges are now cross-calibrated.

Note A7—Annually, or whenever a field gauge differs from the master gauge, a new cross-calibration must be performed using the sealed pans originally produced for the gauge standardization. These six pans must be checked monthly in the master gauge to verify that the counts have not changed substantially.

BULK SPECIFIC GRAVITY

DEFINITIONS

BULK SPECIFIC GRAVITY G_{mb} (d)

The generic definition of specific gravity is "The ratio of the mass (weight) of any volume of material to the mass (weight) of an equal volume of water". A more technically complete definition is "The ratio of the weight in air of a unit volume of a permeable material (including both permeable and impermeable voids normal to the material) at a stated temperature to the weight in air of equal density of an equal volume of gas-free distilled water at a stated temperature." When this is applied to compacted asphalt, the volume consists of:

1) Solid aggregate
2) Asphalt cement
3) Voids (between particles)
4) Pore space in the aggregate particles which are filled with absorbed asphalt and trapped air

AIR VOIDS

The total volume of the small pockets of air between the coated aggregate particles throughout a compacted paving mixture, expressed as percent of the bulk volume of the compacted paving mixture.

PURPOSE OF TEST

A. To determine the percent voids (density) using a standard test procedure. Illinois adopts AASHTO and ASTM Standards for testing purposes in the QC/QA program. Modifications are made to these standards to meet IDOT requirements.

SUPERPAVE GYRATORY COMPACTION

A. Purpose of Gyratory Compaction

1. What is a Gyratory Compactor

   The Gyratory Compactor is the piece of equipment used to fabricate laboratory test specimens for volumetric testing.

2. How Does it Work

   The gyratory compacts a much larger specimen (approximately 4 times heavier than a Marshall brick) by applying a constant 600 kPa vertical pressure to the sample, while the specimen mold is gyrated (wobbled) at an external angle of 1.25 degrees to a specified number of gyrations. The specified **N**umber of gyrations is referred to as the $\mathbf{N}_{\mathbf{design}}$ value of the mix.

3. The gyratory compactor can be employed to simulate field compaction on the roadway (i.e. rolling train and traffic) during the mix design process. A unique feature of the gyratory is that it allows the air voids/density to be determined at any gyration. This allows a proposed mixture to be evaluated at three important points during the laboratory compaction process. These points (or **N**umber of gyrations) are referred to as **N_{ini}**, **N_{des}** and **N_{max}**. The air voids/density of the specimen at each of these stages of compaction represents the air voids/density in the pavement at different times of the pavement life.

N_{ini}	simulates --	density behind the paver screed
N_{des}	simulates --	density after several years of traffic
N_{max}	simulates --	density at the end of pavements design life

N_{ini}

The density of the specimen at the N_{ini} number of gyrations should be less than 89% (or greater than 11% air voids). Mixtures resulting in specimen densities higher than 89% are considered “tender mixes”. Tender mixes will usually move considerably when rolled making it difficult to achieve the proper density.

N_{des}

The density of the specimen at the N_{des} number of gyrations, unless otherwise specified, must be 96% (4% Air Voids). The N_{des} number of gyrations is the design compactive effort and is analogous to the 50 or 75 blow in the Marshall procedure. However, the gyratory is not limited to two, but rather, numerous design compactive efforts. The correct N_{des} is determined from a chart (referred to as the N_{des} chart) and is based on the temperature and traffic conditions at the location where the pavement will be placed.

N_{max}

The density of the specimen at the N_{max} number of gyrations must be less than 98% (or greater than 2% air voids). Mixtures resulting in specimen densities higher than 98% are considered likely to rut before the end of the design life.

This information can be a very helpful tool in determining the attributes of a mixture during the mix design process but is not required in the design process or for mixture production control.

B. Gyratory Compactive Efforts

Ndesign Table

In the past, the laboratory compactive effort was defined by Class I and Type, (Type 1, Type 2, or Type 3) using the Marshall compaction method. The Marshall compaction method was phased out of the QC/QA program in 2000. In Superpave, the compactive effort is expressed as a Ndesign number, which is selected based on the estimated 20-year ESAL loading of the traffic lane.

The following Ndesign table lists the compactive effort required for the different levels of traffic loading, as well as describes the typical roadway application. These are, however, just guidelines; consult the Materials Engineer for the appropriate Ndesign value.

This table is per AASHTO R35, Illinois Modification to Table 1.

Table 1 – N_{design} Table

Design ESALs (millions) Based on 20-year design	N_{des}	Typical Roadway Application
< 0.3	30	Roadway with very light traffic volume such as local roads, county roads, and city streets where truck traffic is prohibited or at a very minimal level (considered local in nature; not regional, intrastate, or interstate). Special purpose roadways serving recreational sites or areas may also be applicable.
0.3 to 3	50	Includes many collector roads or access streets. Medium-trafficked city streets and the majority of county roadways.
3 to 10	70	Includes many two-lane, multi-lane, divided, and partially or completely controlled access roadways. Among these are medium-to-highly trafficked streets, many state routes, U.S. highways, and some rural interstates.
≥ 10	90	May include the previous class of roadways which have a high amount of truck traffic. Includes U.S. Interstates, both urban and rural in nature. Special applications such as truck-weighing stations or truck-climbing lanes on two-lane roadways may also be applicable to this level.

C. Overview of Compaction Procedure

a) Gyratory Calibration

The gyratory should be calibrated for the following items according to the manufacturer's instructions. Refer to AASHTO T312 for calibration requirements is located in this chapter.

(1) Angle – Using Dynamic Angle Validator (DAV-2)

(2) Pressure – Use load cell

600 kPa ± 18 kPa

(3) Height – Use reference standard or gauge block

(4) Rate of Gyration – Use calibrated timer

30.0 gyrations ± 0.5 gyrations

Minimum Frequency for Calibration

Angle	Once/month
Pressure	Once/month
Height	Once/month
Rate of Gyration	Once/month

b) Sample Size*

2 - Gyratory Samples @ 4,800g each	9,600g
2 - G_{mm} Samples @ 1,200g each minimum	3,000g.
(Reference AASHTO T-209 for sample size)	
1 - Ignition Sample @ 1,200g to 2500g	1,500g
(Reference AASHTO T-308 for sample size)	
1 - Backup Sample	19,900g
	34,000g
Department Split	34,000g
Total	68,000g

Total Sample Size = 150 lbs. or 68,000g (68 kg)**

* Sample sizes are approximate. Actual sample size is determined by testing requirements, type of ingredients used and/or maximum nominal aggregate.

** Samples taken for PFP (Payment for Performance) or QCP (Quality Control for Performance) purposes need to be at least 200 lbs. (91 kg) in size.

D. Specimen Compaction

Compact Specimens according to Illinois-Modified AASHTO T-312

The Illinois Modifications and AASHTO T 312 are found in the back of this chapter.

(1) While mixture specimens are heating to compaction temperature, prepare the compactor. Turn on the power to the compactor. Verify that the data acquisition device (computer and/or printer) is functioning. Set compactor in the desired manor for testing procedure being completed.

A. Gyrate to NDes

- Weight – Two samples at an approximate weight of 4800 g. (Weights will be adjusted based on mix type)
- Compaction Temperature – Heat to a compaction temperature of 295 ± 5°F (146 ± 3°C) for unmodified material and 305 ± 5°F (152 ± 3°C) for modified binders.
- Gyration - Set machine to N_{des} number of gyrations, reference table on page 6-3 for design number. Final sample height at the number of gyrations should be 115 ± 5 mm.

B. Gyrate to target height and air void level (IFIT, Hamburg, TSR, etc.)

- Weight – Weight and number samples is dependent upon test procedure and will be adjusted to achieve target air voids at the specified height. This number must include pilot samples. Refer to page 6-16 for Superpave Gyratory Compactor (SGC) specimen weight estimate formula.

  Example: TSR – 8 or more samples at approximately 3800 g.
- Compaction Temperature – Heat to a compaction temperature of 295 ± 5°F (146 ± 3°C) for unmodified material and 305 ± 5°F (152 ± 3°C) for modified binders.
- Height – Set machine to height specified for each test procedure.
  - TSR – Test procedure AASHTO T-283, specified height 95±5 mm.
  - Hamburg – Test procedure AASHTO T-324, specified height 160 ± 1 mm.
  - I-FIT – Illinois Modified AASHTO T 393, specified height of 160 ± 1 mm. However; if the specimen height cannot be increased or if a SGC has difficultly in compacting 160 mm specimens, then two SGC specimens at 115±1 mm tall may be compacted and used instead.
- Air Void Level – Air void targets are per individual test procedure and may vary based on mixture type.
  - TSR – Test procedure AASHTO T-283, specified air void level is 7.0 ± 1.0%.
  - Hamburg – Test procedure AASHTO T-324, specified air void level is 7.5 ± 0.5%.
  - I-FIT – Illinois Modified AASHTO TP 393, specified air void level is 7.5 ± 0.5%. Note: The air void shall be determined for each individual semicircular I-FIT Specimen

(2) Approximately 30 minutes before compacting the first sample, place the molds and base/top in the oven at the specified compaction temperature.

Compactor molds are to be a harden steel and with dimensions of at least 250 mm (10") tall and 149.90–150.00 mm (6 ") inside diameter at room temperature.

(3) When sample has reached the compaction temperature, 295±5°F for non-modified binders and 305±5°F for modified binders, the samples are ready to be remove from oven and compacted.

Note: Once everything is at proper temperature it is important that the compaction process be completed as quickly as possible so the molds and samples don't lose temperature after removal from the ovens. Allowing the molds or samples to cool before completing the compaction process will adversely affect the test results. **Be prepared and ready to go when starting the compaction process!**

(4) Remove a mold and base plate from the oven. Place the base plate in the mold. **Place the first paper disk on top of the base plate.**

(5) Place the mixture, at the proper compaction temperature, into a large loading chute. The sample should be loaded into the mold in one smooth, continuous motion in one lift without spillage or segregation. The dimensions of the loading chute are: 22" (560 mm) long and with a minimum capacity of 130 in^3 (2,130 cm^3) as seen in the picture.

Place the second paper disk on top of the leveled sample, before loading the mold into the compactor.

(6) Load the mold containing the sample into the compactor centering the mold under the loading ram and then close the compactor door. For safety purposes, most compactors will have a safety switch that detects whether the compactor door is closed or open and will not allow continued operation until the compactor door properly closed.

During this step, handle the mold and base plate so that the base plate remains in the bottom of the mold. If required by the compactor manufacturer, at the start of the compaction procedure, lightly oil the bearing surfaces at the recommended frequency.

(7) Double check that the proper settings have been correctly input for the mixture being tested. Improper settings will result in non-representative test results.

Press the start button and the compaction process will begin automatically. Ram loading system will extend the ram into the mold cylinder making contact with the plate(s) encompassing the specimen in the mold. The ram will cease movement when the specimen offers **600 kPa** of resisting pressure and will then begin to apply the external and internal angle. Once the angles are applied the compactor will begin gyrating the specimen.

(8) The compaction process will proceed until the set number of gyrations has been reached. During compaction, the ram loading system will continue updating the ram position so that the ram pressure remains constant at **600 kPa**. The specimen height during compaction is continually monitored by a transducer. Once per gyration, the transducer sends a height measurement to the data acquisition device (printer).

Once the set number of gyrations has been reached the compaction will cease. The compactor will release the angle of gyration, squaring the specimen, and then proceed to raise retracting the ram into a parked position to facilitate mold and sample removal.

(9) Once the compaction process is completed, the technician will remove the mold containing the compacted specimen from the compactor. The specimen is then extruded from the mold using a suitable extruder.

A 5-to-15-minute cooling period may be necessary to facilitate removal from the mold without undue distortion. This is especially true with 30 or 50 gyration mixtures.

(10) Remove paper disks from the top and bottom of the specimen. Forgetting to remove the paper disks could affect test results. The paper disks need to be removed as soon as possible, while the sample is still warm.

Place the specimen on a countertop or rack flat-side down (to prevent distortion) where it will not be disturbed during cooling. The specimen is cooled to room temperature.

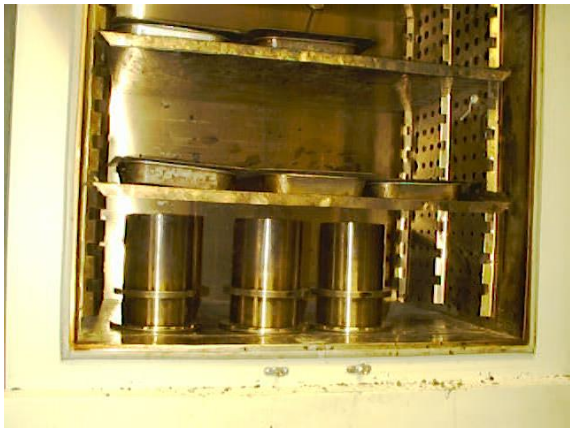
(11) Place the mold and base plate back in the 310° F oven at the compaction temperature for at least 5 minutes. This allows the mold to return to the proper temperature prior to reuse.

Having additional molds available for use will preclude this step.

(12) Repeat compaction procedure for each required specimen.

Once the specimen(s) have cooled to room temperature, 77 ± 9°F (25 ± 5°C), they should be identified with a suitable marker. This is per AASHTO T 166, Illinois Modification.

A paint stick, keel or crayon will work for this purpose.



(13) Once specimens have reached room temperature, determine the bulk specific gravity of the compacted specimens using AASHTO T166, Method A.

(14) Data gathered during compaction process by the gyratory compactor includes the specimen height after each gyration and needs to be available for inspection. Either a hard copy or e-copy of this data needs to be retained for documentation purposes. The N_{des} height will be identified and documented for each specimen to verify specification compliance.

Specimens used for determination of volumetric properties are required to be compacted to a finished height of 115 ± 5 mm at the desired number of gyrations so sample weights can be adjusted during the splitting process to achieve this finished compacted height.

As discussed earlier in this chapter, during the mix design process, the information gathered at this time can be used to compute the estimated and corrected bulk specific gravities (G_{mb}) at N_{ini}, N_{des} and N_{max}, as well as the corrected air voids and densities.

E. Illinois Method for Field Control

a) Compact two (2) specimens to N_{des} as determined from the Illinois' N_{des} Table or the Materials Engineer.

b) Cool both specimens to room temperature 77±9°F (25±5°C)

c) Run the Illinois Modified AASHTO T166 procedure for Bulk Specific Gravities on both specimens

d) Determine Air Void and Densities of both specimens

SPECIFIC GRAVITY (per Illinois Modified AASHTO 166)

1. Brush specimen(s) to remove loose particles.

2. Obtain specimen heights – Heights are obtained from the height printout sheet from Superpave Gyratory Compactor.

3. Obtain and record the original dry weight of the specimen by placing the specimen on zeroed scale and record the weight to nearest 0.1 gram. **(A)**

4. In a constant temperature water bath* [77° ± 1.8° F (25° ± 1°C)], immerse the specimen on its curved side for 4 minutes ± 1 minute.

5. After soaking for 4 minutes ± 1 minute, transfer the specimen to an under-water sample basket, that is attached to a scale, in a constant temperature water bath* [77° ± 1.8° F (25° ± 1° C)]. The sample must remain on its curved side.

6. After the scale stabilizes, obtain and record the submerged sample weight to the nearest 0.1 gram. **(C)**

7. Remove specimen from water container and pat 'dry' with damp towel to SSD condition (specimen will have a glossy look). Obtain and record the SSD weight to nearest 0.1 gram. **(B)**

8. Calculation the bulk specific gravity, VMA, density and air voids of the specimen.

* Constant temperature water baths shall meet the requirements found on the "Bituminous Concrete QC/QA Laboratory Equipment" list found in the appendixes in this manual per ASSHTO T166, Illinois Modifications.

FIELD VMA:

Field VMA (**V**oids in the **M**ineral **A**ggregate during production) is a calculation and not a physically measured property of the HMA mixture. Field VMA gives an accurate indication of the effective asphalt binder coating of the aggregate material in the mixture. When performing quality control testing on Hot-Mix asphalt, Field VMA must be calculated on all production and design specimens.

Field VMA is determined by using the bulk specific gravity (G_{mb}), the asphalt binder content (P_b) of the specimen and the Bulk Specific Gravity of the combined dry aggregates (G_{sb}) when calculating the field VMA. The G_{sb} used in the Field VMA calculation shall be obtained from the mix design.

Field VMA is required to be calculated and reported on the IDOT MI305 daily output report form on every required production sample.

CALCULATIONS:

Bulk Specific Gravity = $\frac{\mathbf{A}}{(\mathbf{B}-\mathbf{C})}$ **round to three decimal places (x.xxx)**

Where: **A** = Original Dry Weight
B = SSD weight
C = Submerged sample weight

Field VMA = $100 - \left(\frac{(\mathrm{Gmb})(100-\mathrm{Pb})}{\mathrm{Design\ Gsb}}\right)$ **round to one decimal place (xx.x)**

Where: G_{mb} = Bulk specific gravity of the mix
P_b = Asphalt binder content of specimen
G_{sb} = Design bulk specific gravity of the combined dry aggregates of the mixture

Percent Density = $\frac{\mathrm{Gmb}}{\mathrm{Gmm}} \times 100$ **round to one decimal place (xx.x)**

Where: G_{mb} = Bulk Specific Gravity of the mixture
G_{mm} = Maximum Specific Gravity of the mixture

Percent Air Voids = $\left(1.0 - \frac{\mathrm{Gmb}}{\mathrm{Gmm}}\right) \times 100$ **round to one decimal place (x.x)**

Where: G_{mb} = Bulk Specific Gravity of the mixture
G_{mm} = Maximum Specific Gravity of the mixture

NOTE: Illinois Modified AASHTO T 312, section 12, the following precision is required for HMA test results:

Air voids	to the nearest 0.1%
Weight	to the nearest 0.1 gram
Bulk Specific Gravity	to the nearest 0.001
Maximum Specific Gravity	to the nearest 0.001
Percent Density	to the nearest 0.1%
Field VMA	to the nearest 0.1

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LAB PRACTICE CALCULATION WORKSHEET

Use this given information to complete the lab exercise below:

Mix Design G_{sb} = 2.608

Mixture %P_b = 5.7%

Max. SG = 2.450

Sample #	Formula		1	2	Average
Orig. Dry Wt.		(A)	4742.5	4736.9	
SSD Wt.		(B)	4751.3	4748.1	
Sub. Wt.		(C)	2730.1	2736.6	
Bulk SG	$\frac{\mathbf{A}}{(\mathbf{B}-\mathbf{C})}$	G_{mb}			
% Voids	$\left(1.0 - \frac{\mathbf{Gmb}}{\mathbf{Gmm}}\right) \mathbf{x}\, \mathbf{100}$				
VMA	$\mathbf{100} - \left(\frac{(\mathbf{Gmb})(\mathbf{100}-\mathbf{Pb})}{\mathbf{Design\ Gsb}}\right)$	VMA			
Max. SG		G_{mm}			
Density	$\frac{\mathbf{Gmb}}{\mathbf{Gmm}}\, \mathbf{x}\, \mathbf{100}$				

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QC/QA LAB WORKSHEET FOR COMPACTED ASPHALT MIXTURE

Sample #	Formula		1	2	Average
Orig. Dry Wt.		(A)	______	______	
SSD Wt.		(B)	______	______	
Sub. Wt.		(C)	______	______	
Bulk SG	$\frac{\mathbf{A}}{(\mathbf{B}-\mathbf{C})}$	G_{mb}	______	______	______
% Voids	$\left(1.0 - \frac{\mathbf{Gmb}}{\mathbf{Gmm}}\right) \mathbf{x\ 100}$		______	______	______
VMA	$\mathbf{100} - \left(\frac{(\mathbf{Gmb})(\mathbf{100}-\mathbf{Pb})}{\mathbf{Design\ Gsb}}\right)$	VMA	______	______	______
Max. SG		G_{mm}	______	______	______
Density	$\frac{\mathbf{Gmb}}{\mathbf{Gmm}} \mathbf{x\ 100}$		______	______	______

Compacting an SGC Specimen to a Specific Height and Air Void Level

The Department may request additional SGC specimens be compacted to a specified height and air void level for rut testing in Springfield at the BMPR (Bureau of Materials and Physical Research). The contractor is now required to perform this test on any designs that are submitted for approval of use on IDOT projects. The test is called the "Hamburg Wheel Test" Test specimens must be compacted to a height of 62 mm and contain a target air void level of 7.5 ± 0.5%. The following procedure explains how to compact a SGC specimen to a specified height and void level.

Procedure for Compacting SGC Specimens to a Specified Height and Void Level.

1. Determine the Target G_{mb}:

   $$\text{Corrected } G_{mb} = \frac{100 - V}{100} \times G_{mm}$$ Where: V = target void level

   $$= \frac{100 - 7.5}{100} \times G_{mm}$$

2. Assume a Correction Factor "C":

   Assuming a Correction Factor "C" of 1.0180 should suffice in most cases.

3. Determine estimated G_{mb}:

   $$\text{Estimated } G_{mb} = \frac{\text{Corrected } G_{mb}}{C}$$ Where: C = Correction Factor from step #2

   $$= \frac{\text{Corrected } G_{mb}}{1.0180}$$

4. Determine weight of SGC sample needed:

   Specimen Weight = estimated G_{mb} x 17.67 x h   Where: h = target height

   $$17.67 = \frac{\pi (150)^2}{4000}$$

5. Gyratory Setup

   a) Follow the gyratory manufacture's procedure to produce compacted specimens at desired heights.

   b) When compacting a sample, the SGC should stop when the target height is reached.

   c) If the SGC specimen does not result in the desired level of air voids, discard the sample, adjust the sample weight accordingly, and compact a new specimen

HAMBURG WHEEL TEST

The Hamburg Wheel test is now required on all designs submitted to the Department for verification by a Contractor and/or Consulting Agency. The Department will run the Hamburg Wheel test on the submitted mix designs the first time. If the first Hamburg Wheel test, performed by the Department, fails the Contractor and/or Consulting Agency will be responsible to perform any additional Hamburg Wheel testing and submit this information to the Department for mix design verification.

At this time, it is the solely decision of the Contractor as to whether they need to purchase a Hamburg Wheel unit or subcontract the needed testing out to an independent agency.

The Hamburg Wheel unit is a large temperature-controlled water bath that runs a weighted wheel back and forth on submerged samples at a determined number of passes for each mixture. The test uses a total of four gyratory samples, two samples per mold. Samples are created in the lab using the method described on page 6-16 in this chapter and are cut on one side to properly fit the mold that holds the samples during the test. This cut side allows the two samples to be placed next to each other creating a larger surface for the weighted wheel to travel back and forth during the test. It is important that the samples be cut precisely to fit the mold. The number of passes the Hamburg Wheel makes during testing is determined by the PG Grade of asphalt used in the mix. Below is a table that shows the grades and number of passes required:

Illinois Modified AASHTO T 324 Requirements [1/]

PG Grade	Minimum Number of Wheel Passes
PG 58-xx or lower	5,000
PG 64-xx	7,500
PG 70-xx	15,000 [2/]
PG 76-xx (or higher)	20,000 [2/]

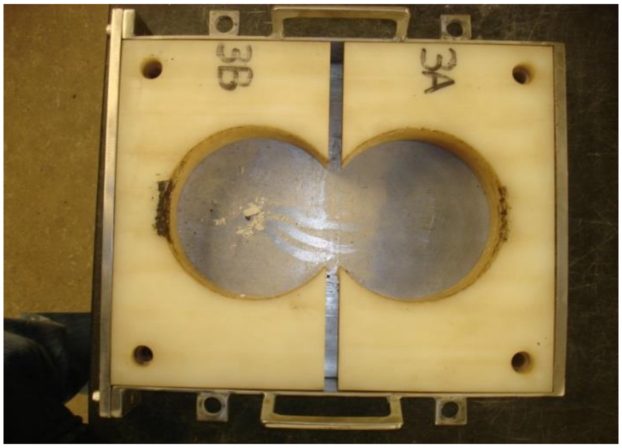
1/ When WMA is produced at temperatures of 275± 5°F (135±3°C) or less, loose mix shall be oven aged at 270 ± 5°F (132±3°C) for two hours prior to gyratory compaction of Hamburg Wheel specimens.

2/ For IL -4.75 binder course, the minimum number of wheel passes shall be reduced by 5,000.

The amount of deformity incurred during the test determines whether the mixture is suitable for use on Illinois roads and whether the Contractor will have to redesign the mix. The next page of this manual shows some pictures taken during a Hamburg Wheel test.

The Hamburg Wheel unit

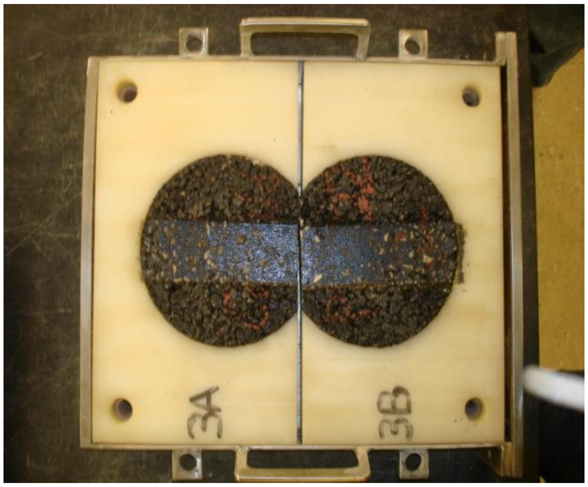
The unit can run two tests at one time



The mold used to hold the sample during testing

The sample has to be cut to properly fit the mold

Sawing the samples



A completed test

Determining the Fracture Potential of Asphalt Mixtures Using the Illinois Flexibility Test (I-FIT)

INTRODUCTION

The objective of this section is to introduce Illinois Modified AASHTO T 393: *Determining the Fracture Potential of Asphalt Mixtures Using the Illinois Flexibility Index Test (I-FIT)*. Upon completion of this section, students shall be able to *i) process material ii) prepare test specimens iii) operate major testing equipment iv) analyze and report test data*.

All content presented in this section is based upon Illinois Modified AASHTO T 393 and this test method should be referenced for all details.

DEFINITIONS

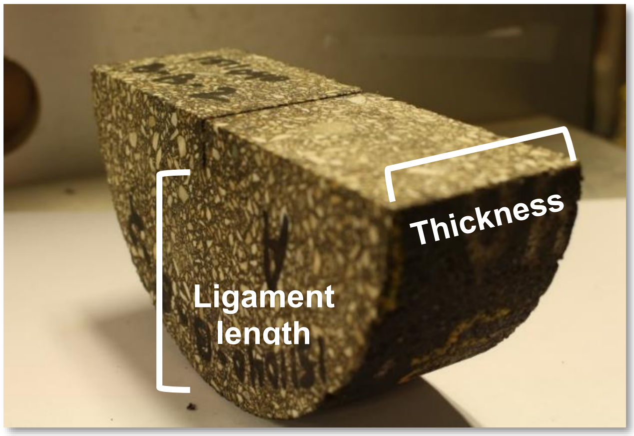
The flexibility index is a quantification of an asphalt mixture's damage resistance and cracking potential. The higher the flexibility index, the more resistant the material is to damage. Each mix design subject to the I-FIT requirement must have at least the minimum flexibility index specified in order to pass. The flexibility index is calculated using the fracture energy, the post-peak slope, and the ligament area.

The minimum flexibility index (FI) shall be as follows:

Illinois Modified AASHTO T 393		
Mixture	Short Term Aging, Minimum FI	Long Term Aging Minimum FI[2/]
HMA[1/]	8.0	5.0
SMA	16.0	10.0
IL-4.75	12.0	-

1/ All mix designs, except for SMA and IL-4.75 mixtures.
2/ Required for surface courses only.
3/ Production long term aging FI for HMA shall be a minimum of 4.0.

The fracture energy, G_f, is the energy required to develop a unit surface area of cracking.



The post-peak slope, m, is the tangential slope at the first inflection point past the peak load in the load-displacement curve.

The ligament area, $area_{lig}$, is the cross-sectional area of the specimen which the crack propagates through, calculated using the ligament length and the specimen thickness.

The ligament length is the length between the tip of the specimen notch and the top-most point of the specimen.

EQUIPMENT

Loading Device

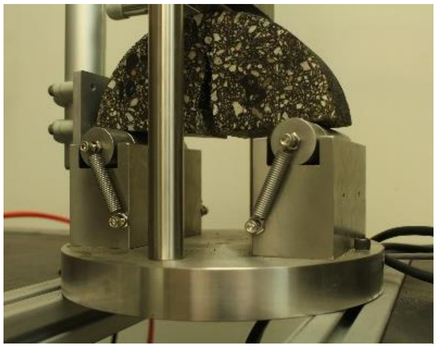
The I-FIT test method requires a testing setup comprised of a loading and data acquisition system. For loading specimens, it is preferred that a closed-loop servo-hydraulic axial loading device be used. An electromechanical screw driven loading device may also be used if it compares well to its closed-loop, servo-hydraulic counterpart. All loading devices must have a minimum capability of 10 N with a minimum resolution of 5 N.

Testing Fixture

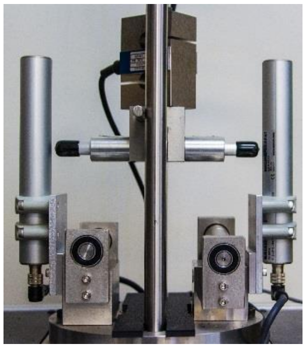
In addition to the loading device, a testing fixture is required. This must be comprised of a loading head, a steel base plate, and two 25 mm diameter steel rollers. The loading head must possess a contact curvature with a 12.5 mm radius. There are two approved setups for the rollers: Method A and Method B.

Method A involves mounting the rollers on bearings such that they roll in place. One of the two rollers shall pivot on an axis perpendicular to the axis of loading to provide tolerance for slight variation in specimen dimensions. The two rollers shall be 120 mm apart.

Method B involves fixing the two roller supports using springs, still maintaining an initial distance of 120 mm between the two rollers. During testing, the rollers remain in contact with the specimen.



Method B



Method A

Data Acquisition

Displacement and loading data must be collected during testing, at a minimum sampling frequency of 20 Hz. If the internal displacement measuring device (the loading device's stroke transducer) does not have a precision of at least 0.01 mm, an external displacement measuring device may be used such as LVDT's. Feedback of data to the control system must enable a constant loading rate of 50 ± 1 mm/min.

SAMPLING

When sampling material for specimen preparation, it is critical to ensure proper procedure is employed. Samples should be representative of the larger source and precaution should be taken to avoid segregation. Improperly sampled material may skew results drastically. Whenever sampling, Illinois Modified test procedures or equivalent relevant ASTM/AASHTO procedures should be followed.

Upon sampling, material shall be re-blended sufficiently to mitigate any segregation that occurred during sampling, transport, or processing. Illinois Modified test procedures or equivalent prevailing ASTM/AASHTO procedures should be followed when splitting and re-blending material down to testing size. For the purpose of preparing I-FIT specimens, experience has shown that a useful target weight for individual splits is 6800g.

SPECIMEN PREPARATION

Compaction

Specimens are fabricated from Superpave-gyratory compacted cylinders prepared using Illinois Modified AASHTO T312, taking care to transfer material into the gyratory mold properly. Cylinders are to be 160 mm ± 1 mm in height with a diameter of 150 mm ± 1 mm.

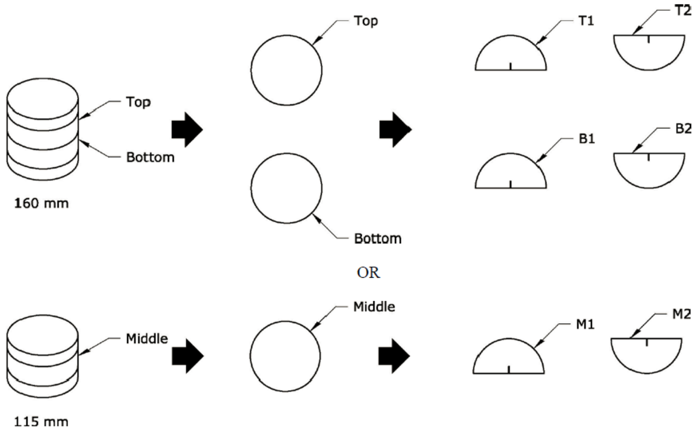
When compacting specimens, target air voids should be slightly higher than those desired in the final I-FIT specimen due to densification from cylinder to specimen. A typical starting weight for compaction of 160mm (Note 1) high specimens is 6800 g in order to target the recommended 8% voids. Upon compaction, the cylinders are to be left to cool in ambient temperature or under a fan. Once cooling of the cylinder is complete, verify the air void content of the cylinder per AASHTO T269.

If field cores are to be tested, they are to be cored to a diameter of 150 mm ± 8 mm in accordance with prevailing Illinois Modified test procedures. If the lift thickness is less than 75 mm, at least two cores shall be extracted for testing.

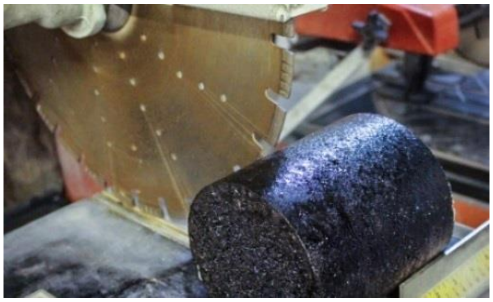
(Note 1) A compaction height of 115 mm is allowed if the gyratory machine cannot compact to 160 mm.

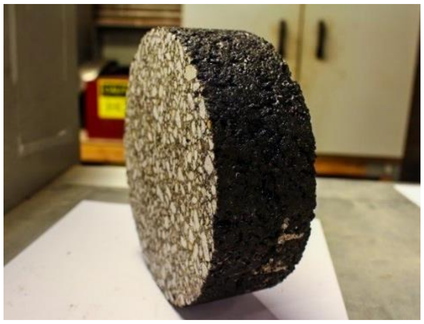
Fabrication

Once the cylinders are compacted and allowed to cool, three primary cuts are to be completed on the cylinder: slicing, halving, and notching. Using diamond impregnated blades and cooling the blades through the use of water is recommended to avoid excessive damage to the specimen or the blade. Whenever making cuts, it is important to avoid sawing too quickly, otherwise, the blade may wander and cuts may be imprecise. Caution should always be exercised and safe sawing procedure should be followed.



Slicing of compacted cylinders may be conducted with a masonry saw. When selecting a saw and blade, it is important to select dimensions that will allow for one smooth cut through the entire 150 mm diameter of the compacted cylinders. Two 50 mm ± 1 mm slices are to be cut from each 160 mm high cylinder. In the case of field cores, where there may not sufficient thickness to extract 50 mm slices, a slice thickness of 25 to 50 mm may be used. Slices, whether from field cores or compacted cylinders, are to be extracted from the middle portion of the specimen to ensure density uniformity. Fabricated slices are to have smooth faces on both sides.





Once the slices are complete, they are to be measured to confirm 50.0 ± 1.0 mm. After verifying that the slices meet the required tolerance, halving of the slices is the next step. This can be done with the same masonry saw used for slicing or with a wet tile saw. Slices should be sawed cleanly in half to produce semi-circular specimens. The air void content is then verified to ensure compliance with the 7.5 ± 0.5% requirement in accordance with specification Illinois Modified AASHTO T269. If the voids of one of the four specimens is outside 7.5 ± 0.5% range then the test may be conducted using the remaining three specimens that are within air void tolerance. If this tolerance is not met on more than one of the four specimens, a new weight must be estimated using the theoretical maximum specific gravity of the mix and previous trial compaction results.

1. Determine the Target G_{mb}

$$Corrected\ G_{mb} = \frac{100 - V}{100} * G_{mm}$$

where: V = target void level

2. Assume a Correction Factor “C”. In most scenarios, an assumption of 1.0180 should suffice.
3. Determine estimated G_{mb}

$$estimated\ G_{mb} = \frac{Corrected\ G_{mb}}{C}$$

4. Determine weight of SGC sample needed

$$specimen\ weight = estimated\ G_{mb} * \frac{\pi * (150)^2 * h}{4000} = estimated\ G_{mb} * 17.67 * h$$

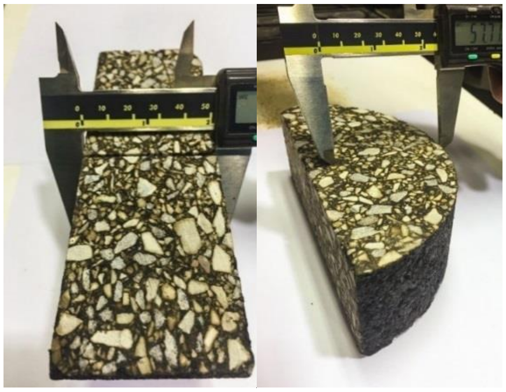
where: h = target height

Example: G_{mm} = 2.400 V = 8.0% h = 160 mm

1. $corrected\ G_{mb} = \frac{100-8.0}{100} * 2.400 = 2.208$
2. $estimated\ G_{mb} = \frac{2.208}{1.0180} = 2.169$
3. $estimated\ weight = 2.169 * 17.67 * 160 = 6132.2\ grams$

The final stage of fabrication is the notching of the semi-circular specimens. Notches are fabricated to a length of 15 mm ± 1 mm and to a width of ≤ 2.25mm (Note 2). To ensure this tight tolerance, a tile saw blade is used. There are a variety of jigs and fixtures available for use when performing this crucial cut. It is recommended that the operator employ some method of securing the specimen during notching to ensure an even notch throughout the specimen.

Once specimens have been notched, dimensioning of specimens must be performed for use in the analysis later. There are three dimensions to be measured before testing specimens: notch depth, ligament length, and specimen thickness. Notch depth is measured on both faces of the specimen and an average value is recorded to the nearest 0.5 mm. Ligament length can be measured directly on both faces of the specimen and averaged or calculated indirectly by subtracting the notch depth from the radius of the specimen on both sides and averaged. Specimen thickness is measured to the left and right of the notch and again at the rounded segment of the specimen. All three values are averaged and reported to the nearest 0.1 mm.



(Note 2) If a notch ends in a piece of aggregate 9.5 mm or larger and if this is seen on both sides of the specimen, it is to be discarded.

Conditioning

Once specimen preparation is complete and dimensions have been recorded, they must be conditioned to a test temperature of 25°C. This can be done in a conditioning chamber, an oven (Note 3), or a water bath (Note 4). Specimens are to be conditioned for 2 ± 0.5 h to a temperature of 25 ± 0.5°C. When testing, it is critical to minimize temperature loss in the specimen. To ensure this, testing is to be completed 5 ± 1 minutes after removing specimens from the conditioning environment. In order to facilitate this, it helps to stagger placement of specimens into the conditioning environment by approximately 10 minutes.

TEST PROCEDURE

Specimens are to be tested individually in the testing fixture after being sufficiently conditioned. The I-FIT test procedure is comprised of applying a contact load of 0.1 kN to the specimen, allowing the contact load to stabilize, ramping up the specimen loading at a displacement rate of 50 mm/min. This increased loading continues as the cracking propagates throughout the specimen and failure occurs. Loading is considered complete when the load reading drops back down to 0.1 kN.

First, all relevant information shall be entered into the machine software. The operator must input the following information:

- Identification information (specimen ID, project ID, operator ID, etc.)
- Specimen Dimensions
- Volumetric properties

Next, the specimen is to be placed into the loading fixture. Specimens should be aligned such that they are loaded in the center, directly on top of the notch. There are various tools available to assist in the alignment of specimens in the loading fixture.

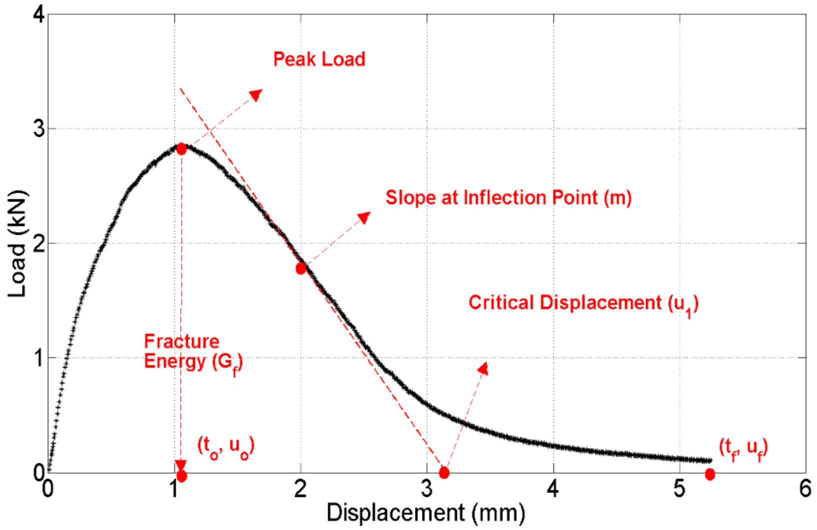
Once the specimen is aligned properly, loading of the specimen may be initiated. The machine software will typically prompt the user to verify that the contact load of 0.1 kN has been established before proceeding. Upon confirmation that this has occurred, the machine will automatically increase the loading at a rate of 50 mm/min and the specimen will begin to experience indirect tension. Loading will continue until the load level climbs down to 0.1 kN once more.

After the test is complete, the operator must save the output data file of the test to the desired location. This output file will be used at a later stage for analysis of the test results.

(Note 3) Exercise caution when using the oven due to potential of uneven temperature distribution.
(Note 4) The same water bath used for Illinois Modified AASHTO T283 can be used for conditioning.

DATA ANALYSIS

Each specimen tested must be analyzed individually using appropriate software. The following figure illustrates the information gathered from successful completion of the I-FIT method:



RESULTS

There are a variety of parameters that are obtained from running the I-FIT method. Primarily, upon running the test successfully, the following information is obtained:

- Fracture Energy, calculated using the expression:

$$G_f = \frac{W_f}{Area_{jig}}$$

where:

G_f = fracture energy (Joules/m^2)

W_f = work of fracture (Joules)

$Area_{jig}$ = ligament area (r-a)*t, (mm^2)

r = specimen radius (mm)

a = notch length (mm)

t = specimen thickness (mm)

- Strength, reported in Psi, equivalent to the highest loading the specimen experiences
- Slope, m, calculated by fitting a tangential line the point of first inflection after the peak load
- Flexibility Index, FI, calculated as follows:

$$FI = \frac{G_f}{|m|} * A$$

where:

G_f = fracture energy (Joules/m^2)

A = conversion and scaling factor, equal to 0.01

m = post-peak slope (kN/mm)

Four specimens are to be tested and the specimen that produces a flexibility index furthest from the average of the four may be discarded and considered an outlier.

REPORTING

Upon completion of testing and analysis of I-FIT specimens, operators typically need to report results. It is recommended that a consistent template be used for reporting data and results. Precision requirements are as follows for each parameter:

- Bulk specific gravity to the nearest 0.001
- Average air void content to the nearest 0.1
- Thickness and ligament length to the nearest 0.1 mm
- Peak load to the nearest 0.1 kN
- Post-peak slope to the nearest 0.1 kN/mm
- Fracture energy to the nearest 1 J/m^2
- Flexibility index to the nearest 0.1

The following is an example of a reporting template:

I-FIT REPORT - Specimen Set 1

Dist.: CBM Date Tested: 3/20/22 Lab Test ID: 1 Contract: 99999

Producer: 1 Trial Location: Illinois Test Type: Design Date Produced: 3/20/22

BIT#: CC Mix Code: 19652R Mix Name: SMA SC N50 12.5 D R

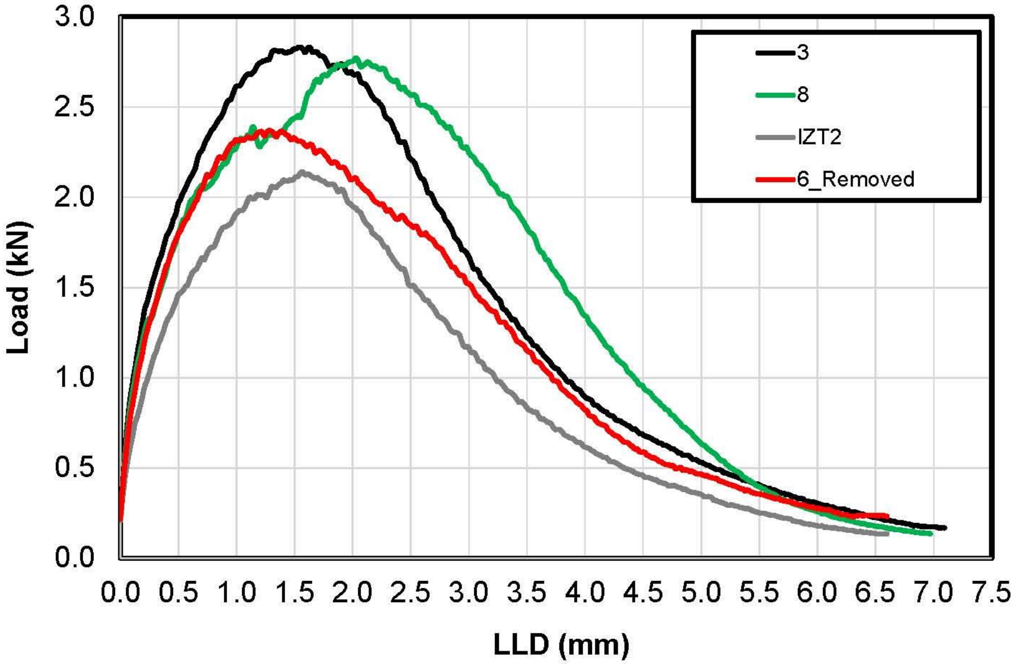
Mix Type: Surf Gsb: 2.658 VMA: 16.3 NMAS: 12.5 Gmm: 2.459 Ndes: 80

AB Source: 1 AB Seq #: 1 Design AB Grade: PG 76-28 AB% 6.0
Plan AB Grade: PG 76-28

Agg % (F)RAP 0.0 RAS 0.0 Long-Term Aged: No ABR % 0.0

Individual Specimen Results	3.00	6.00	8.00	IZT2	Average	COV (%)
Air Voids (%)	7.1	7.5	6.9	7.2	**7.1**	
Fracture Energy (J/m^2)	3224.5	2988.9	3580.6	2289.7	**3031.6**	**22.0**
Post-Peak Slope (kN/mm)	1.2	0.8	1.0	0.9	**1.0**	**15.4**
Flexibility Index	27.5	39.1	37.5	26.3	**30.4**	**20.2**
Specimen 6 Furthest from Mean and Removed from Analysis						
Short-Term Aged FI = 30.4						

Comments:



Specific Gravity and Density
for
Hot-Mix Asphalt

The subjects of specific gravity and density are not difficult. However, metric/English conversion and local usage of the terminology may be confusing. This is intended to describe these concepts in an abbreviated manner. The student is advised to be familiar with the "official" definitions of density and specific gravity.

A note of caution - In some common metric conventions, specific gravity and density may have equal <u>numeric</u> values. In the SI metric convention (used by IDOT) and English system, this is not true. The table below illustrates this.

	DENSITY			SPECIFIC GRAVITY
	ENGLISH	METRIC	SI	ENGLISH, METRIC SI
Water	62.4 #/ft^3	1.0 g/cc	1000 kg/m^3	1.0
Aggregate	156 #/ft^3	2.5 g/cc	2500 kg/m^3	2.5

TERMINOLOGY

DENSITY:

Definition - The mass (weight) of a material per unit volume, expressed in SI units as kg/m^3, [mass (kg) / volume (m^3)]. The English equivalent is pounds per cubic foot. See the examples above.

Significance - The density of an HMA sample is taken into account in the specific gravity calculation in AASHTO T 166 (Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens). AASHTO T 166 compares the mass (weight) of a sample in air and water to directly calculate specific gravity. The density measurement is "invisible" in the formula.

SPECIFIC GRAVITY:

Definition - The ratio of the mass (weight) of any volume of a material to the mass of an equal volume of water. The units of mass and volume in this ratio cancel resulting in a dimensionless measurement. The specific gravity of water is 1.0. Materials heavier than water will have S.G. values greater than 1.0. It is convenient to consider the S.G. as the number of times heavier than water a material is for the same volume. See examples below.

Significance - Two different tests calculate the specific gravity of a mix at different compacted conditions. The results are then used to calculate percent air voids in compacted HMA samples. These are described below.

BULK SPECIFIC GRAVITY, (G_{mb} or Gravity$_{\text{mixture bulk}}$) - The specific gravity of a ***<u>compacted</u>*** HMA mixture that includes trapped air voids. Also known in Illinois as Little d, or "d". G_{mb} is directly calculated by AASHTO T 166.

MAXIMUM SPECIFIC GRAVITY, (G_{mm} or Gravity $_{\text{mixture maximum}}$) - The theoretical maximum specific gravity of an HMA mixture. This is calculated by measuring the density of a "voidless" sample, through the vacuum saturation of a ***loose*** HMA sample (AASHTO T 209). Also known in Illinois as Big D or "D".

Material	Example Specific Gravity	Density (S.G. x Density of Water	
		SI	English
Water	1.000	1,000 kg/m^3	62.4 #/ft^3
Aggregate	2.716 (G_{sb})	2,716 kg/m^3	169.5 #/ft^3
Asphalt Cement	1.030 (G_b)	1,030 kg/m^3	64.3 #/ft^3
Hot-Mix Asphalt	2.442 (G_{mb}) 2.535 (G_{mm})	2,442 kg/m^3 2,535 kg/m^3	152.4 #/ft^3 158.2 #/ft^3

AIR VOIDS vs. DENSITY: The design, plant control, and field control of HMA includes the analysis of air voids in the mix. Different terms are customarily used to describe laboratory and field voids.

For lab-compacted mix, the terms "air voids" or "voids" are used to describe the percent air voids in a specimen.

For field-compacted mix, "density", "percent density", and "in place" or "field voids" are the terms that also define percent air voids. Many times people in the field will use the term "density" when they are really talking about percent density. When discussing field compaction, percent density is usually expressed as a percentage of the maximum theoretical density. See the calculations below for further explanation.

CALCULATIONS

The following three formulas apply to lab and field void calculations. In all cases, the percent air voids is computed using the measured Bulk Specific Gravity and Maximum Specific Gravity.

d/D **or** **G_{mb}/G_{mm}**	Yields a decimal that indicates the amount of compaction of the mix relative to the maximum density (D). e.g. 2.442 ÷ 2.535 = 0.963
d/D x 100 **or** **G_{mb}/G_{mm} x 100**	Converts this decimal to a percentage. (0.963 x 100 = 96.3%) Here the phrase "96.3% density" is actually an abbreviation of "96.3% of theoretical maximum density. Thus, there are two related uses for the term "Density" in describing HMA. One is the mass/volume as defined earlier. The second represents the percent of field compaction.
(100) - (d/D x 100) **or** **(100) - (G_{mb}/G_{mm} x 100)**	Converts the percent theoretical density to percent air voids. (100) - (96.3) = 3.7%. This is the normal convention for expressing lab air voids.

Illinois Modified Test Procedure
Effective Date: May 1, 2007
Revised Date: December 1, 2023

Standard Method
for

Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor

Reference AASHTO T 312-22

AASHTO Section	***Illinois Modification***
2.1	Replace with the following: *Referenced Illinois modified AASHTO Standards:* ■ M 231, Weighing Devices Used in the Testing of Materials ■ R 30, Mixture Conditioning of Hot Mix Asphalt (HMA) ■ R 35, Superpave Volumetric Design for Asphalt Mixtures ■ T 166, Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens ■ T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures ■ R 76 Reducing Samples of Aggregate to Testing Size
2.3 New Section	*Referenced Illinois modified ASTM Standards:* ■ D1188, Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Coated Samples
2.4 New Section	*Illinois Procedures:* ■ Illinois Procedure for Internal Angle Calibration of Superpave Gyratory Compactors (SGCs) using the Dynamic Angle Validator (DAV-2)
4.1	Replace the fourth sentence with the following: The compactor shall tilt the specimen molds at an average internal angle of 1.16 ± 0.02 degrees (20.2 ± .035 mrad) determined by the Illinois Procedure for Internal Angle Calibration of the Superpave Gyratory Compactor using the Dynamic Angle Validator (DAV-2).
4.4	Replace the first sentence with the following: Thermometers for measuring temperature of aggregate, binder, and asphalt mixtures shall have a suitable range to determine 50 – 450 °F (10 – 232 °C). The thermometers may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 1.35 °F (0.75 °C) (see Note 3).
Note 3	Replace with the following: **Note 3** - Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; IEC 60584 thermocouple thermometer, Type T, Class 1; or E2877 digital metal stem thermometer.

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Reference AASHTO T 312-22

AASHTO Section	***Illinois Modification***
4.8	Add the following at the end: In addition, the hold-down clamps on the PINE AFG-2 compactor should be adjusted according to the manufacturer's instructions to minimize variability in the characteristics of the final compacted specimen.
4.9 New Section.	*Mold-loading Chute*—A mold-loading chute having a minimum length of 22 in. (560 mm) and a minimum capacity of 130 in.^{3} (2,130 cm^3). It shall be capable of loading an entire gyratory sample in one motion without spillage or segregation. Surfaces of the mold-loading chute that will come in contact with the HMA shall be lightly coated with an asphalt release agent on the current IDOT Qualified Product List or cooking spray to prevent a buildup and loss of asphalt binder and fines. The release agent or cooking spray shall not contain any solvents or petroleum-based products that could affect asphalt binder properties.
6.	Replace entire section with the following: *Calibration*—The gyratory compactor internal angle shall be calibrated according to the "Illinois Procedure for Internal Angle Calibration of Superpave Gyratory Compactors (SGCs) using the Dynamic Angle Validator (DAV-2)". The ram pressure, height and rate of gyration shall be calibrated according to the manufacturer's instructions and shall be completed prior to the internal angle calibration. The internal angle, ram pressure, height and rate of gyration shall be calibrated at a minimum frequency of once per month. The monthly internal angle calibration may be conducted utilizing the external angle verification as outlined in the "Illinois Procedure for Internal Angle Calibration of Superpave Gyratory Compactors (SGCs) using the Dynamic Angle Validator (DAV-2)".
8.1.2.1	Replace with the following: The mixing temperature for unmodified asphalt shall be 295 ± 5 °F (146 ± 3 °C). The mixing temperature for polymer-modified asphalt shall be 325 ± 5 °F (163 ± 3 °C).
8.1.2.1 NOTE 4	Delete.

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Reference AASHTO T 312-22

AASHTO Section	***Illinois Modification***
8.1.4.1 New Section	When necessary, reduce the sample according to Illinois Test Procedure 248 and the following: Place the splitter on a level surface. The splitter and accessory equipment may be heated, not to exceed 110°C (230°F), as determined by a noncontact temperature device. Surfaces of the mechanical splitter that will come in contact with the HMA shall be lightly coated with an asphalt release agent on the current IDOT Qualified Product List or cooking spray to prevent a buildup and loss of asphalt binder and fines. The release agent or cooking spray shall not contain any solvents or petroleum-based products that could affect asphalt binder properties.
8.1.7.1	Revise as follows: The compaction temperature shall be 295 ± 5 °F (146 ± 3 °C) for unmodified binder; 305 ± 5 °F (152 ± 3 °C) for modified binder.
8.2.3	Replace with the following: Reduce the sample according to IL modified AASHTO R 76 and the following: Place the splitter on a level surface. The splitter and accessory equipment may be heated, not to exceed 110°C (230°F), as determined by a noncontact temperature device. Surfaces of the mechanical splitter that will come in contact with the HMA shall be lightly coated with an asphalt release agent on the current IDOT Qualified Product List or cooking spray to prevent a buildup and loss of asphalt binder and fines. The release agent or cooking spray shall not contain any solvents or petroleum-based products that could affect asphalt binder properties.
8.2.5	Revise with the following: Bring the HMA to the compaction temperature range by careful, uniform heating in an oven set at the specified compaction temperature immediately prior to molding.
9.2	Revise the first sentence as follows: Place the mixture into the mold in one lift using the mold-loading chute.

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Standard Method
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Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor

Reference AASHTO T 312-22

AASHTO Section	***Illinois Modification***
9.4	Revise as follows: Apply a 1.16 ± 0.02° (20.2 ± 0.35 mrad) average internal angle to the mold assembly and begin the gyratory compaction.
A1.1	Replace the first sentence in paragraph 3 with: The inside diameter of the molds may be measured using either a two-point bore gauge, a three-point bore gauge, or a Coordinate Measuring Machine (CMM).
Note A1	Replace with: Because CMMs are typically limited to manufacturers, it is considered best practice for a lab to also use the two-point or the three-point bore method as a check before putting a mold into service.
A1.2 New Section	Each district shall own and operate an Internal Bore Gauge. A Three-Point gauge is recommended although a Two-Point gauge is allowed. Care must be exercised during operation to ensure accuracy and precision regardless which gauge is selected.
A2.1	Replace the first sentence with the following: Internal Bore Gauge – Minimum resolution shall be 0.0025 mm (0.0001 in).
A4.1	Replace with the following: *Standardize the bore gauge* – The bore gauge shall be standardized with the master ring prior to each use.
A4.1.2	Replace the fifth sentence with the following: When using the three-point gauge, while extending the gauge contacts, use a small circular motion at the top of the gauge to align the contact tips with the master ring bore.
A4.1.2	Add the following at the end: Do not use the small circular motion when using a two-point gauge. Instead, position the two probes in the calibration ring so that they are horizontal. Then, while remaining horizontal, slightly move one of the probes from side to side to ensure that the maximum inside diameter is measured.

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Reference AASHTO T 312-22

AASHTO Section	***Illinois Modification***
Figure A4.1 Heading	Replace with the following: Techniques for using the Two-Point Gauge (left) and Three-Point Bore Gauge (right) with the Calibrated Master Ring
Note A4	Replace with the following: The circular motion depicted in Figure A4.1, applied to the top of the three-point gauge while tightening the contact tips against the bore surface, is necessary to eliminate errors from misalignment.
A4.3	Replace from the third sentence of the second paragraph to the end of the section with the following: At each elevation, measurements designated as “A” shall have one of the gauge contacts aligned with the mark made in A3.3, measurements designated as “B” shall have the contact rotated from the mark 90 degrees for a Three-Point gauge or 120 degrees for a Two-Point gauge, and measurements designated as “C” shall have the contact rotated from the mark 180 degrees for a Three-Point gauge or 240 degrees for a Two-Point gauge. For best accuracy and consistency, each bore measurement should use the same firmness and technique applied in Section A4.1.2 for gauge standardization.
A4.3.2	Replace the first sentence with the following: Release the gauge; rotate it 90 degrees (Three-Point gauge) or 120 degrees (Two-Point gauge) and obtain the measurement in this orientation.
A4.3.3	Replace the first sentence with the following: Release the gauge and for a Three-Point gauge rotate it an additional 90 degrees (180 degrees from “1A”) or for a Two-Point gauge rotate it an additional 120 degrees (240 degrees from “1A”) and obtain a third measurement at the same elevation.
A4.3.3 Note A5	Replace the first sentence with the following: Figure A4.2 shows the Three-Point gauge in the mold positioned for each measurement.

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Standard Method of Test for

Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor

AASHTO Designation: T 312-22

AASHTO

Technically Revised: 2022 **Editorially Revised: 2022**

Technical Subcommittee: 2d, Proportioning of Asphalt–Aggregate Mixtures

1. SCOPE

1.1. This standard covers the compaction of cylindrical specimens of asphalt mixtures using the Superpave gyratory compactor.

1.2. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.3. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 231, Weighing Devices Used in the Testing of Materials
- M 339M/M 339, Thermometers Used in the Testing of Construction Materials
- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- R 30, Laboratory Conditioning of Asphalt Mixtures
- R 35, Superpave Volumetric Design for Asphalt Mixtures
- R 47, Reducing Samples of Asphalt Mixtures to Testing Size
- R 97, Sampling Asphalt Mixtures
- T 166, Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
- T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures
- T 275, Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Paraffin-Coated Specimens

- T 316, Viscosity Determination of Asphalt Binder Using Rotational Viscometer
- T 344, Evaluation of Superpave Gyratory Compactor (SGC) Internal Angle of Gyration Using Simulated Loading

2.2. *ASTM Standards*:

- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E2877, Standard Guide for Digital Contact Thermometers

2.3. *International Electrotechnical Commission Standard*:

- IEC 60584-1: 2013 Thermocouples - Part 1: EMF Specifications and Tolerances

2.4. *Other Standards*:

- ANSI/ASME B89.1.6, Measurement of Qualified Plain Internal Diameters for Use as Master Rings and Ring Gages
- ANSI/ASME B89.4.19, Performance Evaluation of Laser-Based Spherical Coordinate Measurement Systems
- ASME B46.1, Surface Texture (Surface Roughness, Waviness, and Lay)

3. SIGNIFICANCE AND USE

3.1. This standard is used to prepare specimens for determining the mechanical and volumetric properties of asphalt mixtures. The specimens simulate the density, aggregate orientation, and structural characteristics obtained in the actual roadway when proper construction procedure is used in the placement of the paving mix.

3.2. This test method may be used to monitor the density of test specimens during their preparation. It may also be used for field control of an asphalt mixture production process.

4. APPARATUS

4.1. *Superpave Gyratory Compactor*—An electrohydraulic or electromechanical compactor with a ram and ram heads as described in Section 4.3. The axis of the ram shall be perpendicular to the platen of the compactor. The ram shall apply and maintain a pressure of 600 ± 18 kPa perpendicular to the cylindrical axis of the specimen during compaction (Note 1). The compactor shall tilt the specimen molds at an average internal angle of 20.2 ± 0.35 mrad (1.16 ± 0.02 degrees), determined in accordance with T 344. The compactor shall gyrate the specimen molds at a rate of 30.0 ± 0.5 gyrations per minute throughout compaction.

Note 1—This stress calculates to 10 600 ± 310 N total force for 150-mm specimens.

4.1.1. *Specimen Height Measurement and Recording Device*—When specimen density is to be monitored during compaction, a means shall be provided to continuously measure and record the height of the specimen to the nearest 0.1 mm during compaction once per gyration.

4.1.2. The system may include a connected printer capable of printing test information, such as specimen height per gyration. In addition to a printer, the system may include a computer and suitable software for data acquisition and reporting.

4.1.3. The loading system, ram, and pressure indicator shall be capable of providing and measuring a constant vertical pressure of 600 ± 60 kPa during the first five gyrations, and 600 ± 18 kPa during the remainder of the compaction period.

4.2. *Specimen Molds*—Specimen molds shall have steel walls that are at least 7.5 mm thick and are hardened to at least a Rockwell hardness of C48. The initial inside finish of the molds shall have a root mean square (rms) of 1.60 μm or smoother when measured in accordance with ASME B46.1 (see Note 2). New molds shall be manufactured to have an inside diameter of 149.90 to 150.00 mm. The inside diameter of in-service molds shall not exceed 150.2 mm. Molds shall be at least 250 mm in length. The inside diameter and length of the molds shall be measured in accordance with Annex A.

Note 2—One source of supply for a surface comparator, which is used to verify the rms value of 1.60 μm, is GAR Electroforming, Danbury, Connecticut.

4.3. *Ram Heads and End Plates*—Ram heads and end plates shall be fabricated from steel with a minimum Rockwell hardness of C48. The ram heads shall stay perpendicular to their axis. The platen side of each end plate shall be flat and parallel to its face. All ram and end plate faces (the sides presented to the specimen) shall be flat to meet the smoothness requirement in Section 4.2 and shall have a diameter of 149.50 to 149.75 mm.

4.4. *Thermometers*—Thermometers for measuring temperature of aggregates, binder, and asphalt mixtures shall meet the requirements of M 339M/M 339 with a temperature range of at least 10 to 230°C, and an accuracy of ±2.5°C (±4.5°F) (see Note 3).

Note 3—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type J, any Class, or Type K, Class 1 or 2; IEC 60584 thermocouple thermometer, Type J, any Class, or Type K, Class 1 or 2; ASTM E2877 digital metal stem thermometer; or dial gauge metal stem (bi-metal) thermometer.

4.5. *Balance*—A balance meeting the requirements of M 231, Class G 5, for determining the mass of aggregates, binder, and asphalt mixtures.

4.6. *Oven*—An oven, thermostatically controlled to ±3°C, for heating aggregates, binder, asphalt mixtures, and equipment as required. The oven shall be capable of maintaining the temperature required for mixture conditioning in accordance with R 30.

4.7. *Miscellaneous*—Flat-bottom metal pans for heating aggregates, scoop for batching aggregates, containers (grill-type tins, beakers, containers for heating asphalt), large mixing spoon or small trowel, large spatula, gloves for handling hot equipment, paper disks, mechanical mixer (optional), lubricating materials recommended by the compactor manufacturer.

4.8. *Maintenance*—In addition to routine maintenance recommended by the manufacturer, check the Superpave gyratory compactor's mechanical components for wear, and perform repair, as recommended by the manufacturer.

5. HAZARDS

5.1. Use standard safety precautions and protective clothing when handling hot materials and preparing test specimens.

6. STANDARDIZATION

6.1. Items requiring periodic verification of calibration include the ram pressure, angle of gyration, gyration frequency, LVDT (or other means used to continuously record the specimen height), and oven temperature. Verification of the mold and platen dimensions and the inside finish of the mold are also required. When the computer and software options are used, periodically verify the data-processing system output using a procedure designed for such purposes. Verification of calibration, system standardization, and quality checks may be performed by the manufacturer, other agencies providing such services, or in-house personnel. Frequency of verification shall follow the manufacturer's recommendations.

6.2. The angle of gyration refers to the internal angle (the tilt of the mold with respect to the end plate surface within the gyratory mold). The calibration of the internal angle of gyration shall be verified in accordance with T 344.

7. PREPARATION OF APPARATUS

7.1. Immediately prior to the time when the asphalt mixture is ready for placement in the mold, turn on the main power for the compactor for the manufacturer's required warm-up period.

7.2. Verify the machine settings are correct for angle, pressure, and number of gyrations.

7.3. Lubricate any bearing surfaces as needed per the manufacturer's instructions.

7.4. When specimen height is to be monitored, the following additional item of preparation is required. Immediately prior to the time when the asphalt mixture is ready for placement in the mold, turn on the device for measuring and recording the height of the specimen, and verify the readout is in the proper units, mm, and the recording device is ready. Prepare the computer, if used, to record the height data, and enter the header information for the specimen.

8. ASPHALT MIXTURE PREPARATION

8.1. *Laboratory Prepared*:

8.1.1. Weigh the appropriate aggregate fractions into a separate pan, and combine them to the desired batch weight. The batch weight will vary based on the ultimate disposition of the test specimens. If a target air void level is desired, as would be the case for Superpave mix analysis and performance specimens, batch weights will be adjusted to create a given density in a known volume. If the specimens are to be used for the determination of volumetric properties, the batch weights will be adjusted to result in a compacted specimen having dimensions of 150 mm in diameter and 115 ± 5 mm in height at the desired number of gyrations.

Note 4—It may be necessary to produce a trial specimen to achieve this height requirement. Generally, 4500 to 4700 g of aggregate are required to achieve this height for aggregates with combined bulk specific gravities of 2.550 to 2.700, respectively.

8.1.2. Place the aggregate and binder container in the oven, and heat them to the required mixing temperature.

8.1.2.1. The mixing temperature range is defined as the range of temperatures where the unaged binder has a viscosity of 0.17 ± 0.02 Pa·s when measured in accordance with T 316.

Note 5—Modified asphalts may not adhere to the equiviscosity requirements noted, and the manufacturer's recommendations should be used to determine mixing and compaction temperatures.

8.1.3. Charge the mixing bowl with the heated aggregate from one pan and dry-mix thoroughly. Form a crater in the dry-blended aggregate, and weigh the required amount of binder into the mix. Immediately initiate mixing.

8.1.4. Mix the aggregate and binder as quickly and thoroughly as possible to yield an asphalt mixture having a uniform distribution of binder. As an option, mechanical mixing may be used.

8.1.5. After completing the mixture preparation, perform the required mixture conditioning in accordance with R 30.

8.1.6. Place the compaction mold(s) in an oven at the required compaction temperature for a minimum of 30 min prior to the estimated beginning of compaction (during the time the mixture is being conditioned in accordance with R 30). Place any additional compaction surfaces, such as base plates and upper plates, into the oven with and for the same time frame as the molds, according to the manufacturer's instructions.

8.1.7. Following the mixture conditioning period specified in R 30, if the mixture is at the compaction temperature, proceed immediately with the compaction procedure as outlined in Section 9. If the compaction temperature is different from the mixture conditioning temperature used in accordance with R 30, place the mix in another oven at the compaction temperature for a brief time (maximum of 30 min) to achieve the required temperature.

8.1.7.1. The compaction temperature is the midpoint of the range of temperatures where the unaged binder has a viscosity of 0.28 ± 0.03 Pa·s when measured in accordance with T 316. (See Note 5.)

8.2. *Plant Produced*:

8.2.1. Place the compaction mold(s) in an oven at the required compaction temperature (see Section 8.1.7.1). Place any additional compaction surfaces, such as base plates and upper plates, into the oven with and for the same time frame as the molds, according to the manufacturer's instructions.

8.2.2. Obtain the sample in accordance with R 97.

8.2.3. Reduce the sample in accordance with R 47.

8.2.4. Place the sample into a pan to a uniform thickness.

8.2.5. Bring the asphalt mixture to the compaction temperature range by careful, uniform heating in an oven immediately prior to molding.

9. COMPACTION PROCEDURE

9.1. When the compaction temperature is achieved, remove the heated mold and any compaction surfaces from Section 8.1.6 or 8.2.1 from the oven. Place the base plate and a paper disk in the bottom of the mold.

9.2. Place the mixture into the mold in one lift. Care should be taken to avoid segregation in the mold. After all the mix is in the mold, level the mix, and place another paper disk on top of the leveled material. Complete any remaining mold assembly, load the mold into the compactor, and center the loading ram according to the manufacturer's instructions.

9.3. Apply a pressure of 600 ± 18 kPa on the specimen.

9.4. Apply a 20.2 ± 0.35 mrad (1.16 ± 0.02 degrees) average internal angle to the mold assembly and begin the gyratory compaction.

9.5. Allow the compaction to proceed until the desired number of gyrations specified in R 35 is reached and the gyratory mechanism shuts off.

9.6. Remove the angle from the mold assembly, remove the ram pressure, and retract the loading ram in the order specified by the SGC manufacturer (the preceding steps may be done automatically by the compactor on some models of SGCs). Remove the mold from the compactor (if required) and extrude the specimen from the mold.

Note 6—No additional gyrations with the angle removed are required unless specifically called for in another standard referencing T 312. The extruded specimen may not be a right-angle cylinder. Specimen ends may need to be sawed to conform to the requirements of specific performance tests.

Note 7—The specimens can be extruded from the mold immediately after compaction for most asphalt mixtures. However, a cooling period of 5 to 10 min in front of a fan may be necessary before extruding some specimens to ensure the specimens are not damaged.

9.7. Remove the paper disks from the top and bottom of the specimens.

Note 8—Before reusing the mold, place it in an oven for at least 5 min. The use of multiple molds will speed up the compaction process.

10. DENSITY PROCEDURE

10.1. Determine the maximum specific gravity (G_{mm}) of the loose mix in accordance with T 209 using a companion sample. The companion sample shall be conditioned to the same extent as the compaction sample.

10.2. Determine the bulk specific gravity (G_{mb}) of the specimen in accordance with T 166 or T 275 as appropriate.

10.3. When the specimen height is to be monitored, record the specimen height to the nearest 0.1 mm after each revolution.

11. DENSITY CALCULATIONS

11.1. Calculate the uncorrected relative density ($\%G_{mmux}$) at any point in the compaction process using the following equation:

$$\%G_{mmux} = \frac{W_m}{V_{mx} G_{mm} G_m} \times 100 \qquad (1)$$

where:

$\%G_{mmux}$ = uncorrected relative density at any point during compaction expressed as a percent of the maximum theoretical specific gravity;
W_m = mass of the specimen, g;
G_{mm} = theoretical maximum specific gravity of the mix;
G_m = unit weight of water, 1 g/cm^3;
x = number of gyrations; and
V_{mx} = volume of the specimen, in cm^3, at any point based on the diameter (d) and height (h_x) of the specimen at that point (use "mm" for height and diameter measurements).

It can be expressed as:

$$V_{mx} = \frac{\pi d^2 h_x}{4 \times 1000} \qquad (2)$$

Note 9—This formula gives the volume in cm³ to allow a direct comparison with the specific gravity.

11.2. At the completion of the bulk specific gravity test (G_{mb}), determine the relative density ($\%G_{mmx}$) at any point in the compaction process as follows:

$$\%G_{mmx} = \frac{G_{mb} h_m}{G_{mm} h_x} \times 100 \qquad (3)$$

where:

$\%G_{mmx}$ = corrected relative density expressed as a percent of the maximum theoretical specific gravity;
G_{mb} = bulk specific gravity of the extruded specimen;
h_m = height in millimeters of the extruded specimen; and
h_x = height in millimeters of the specimen after x gyrations.

12. REPORT

12.1. *Report the following information in the compaction report, if applicable*:

12.1.1. Project name;

12.1.2. Date of the test;

12.1.3. Start time of the test;

12.1.4. Specimen identification;

12.1.5. Percent binder in specimen, nearest 0.1 percent;

12.1.6. Average diameter of the mold used (d), nearest 1.0 mm;

12.1.7. Mass of the specimen (W_m), nearest 0.1 g;

12.1.8. Maximum specific gravity (G_{mm}) of the specimen by T 209, nearest 0.001;

12.1.9. Bulk specific gravity (G_{mb}) of the specimen by T 166 or T 275, nearest 0.001;

12.1.10. Height of the specimen after each gyration (h_x), nearest 0.1 mm;

12.1.11. Relative density ($\%G_{mm}$) expressed as a percent of the theoretical maximum specific gravity (G_{mm}), nearest 0.1 percent; and

12.1.12. Gyration angle, nearest 0.2 mrad (0.01 degrees), and the method used to determine or verify the gyration angle.

13. PRECISION AND BIAS

13.1. *Precision*:

13.2. *Single-Operator Precision*—The single operator standard deviations (1s limits) for relative densities at N_{ini} and N_{des} for mixtures containing aggregate with an absorption of less than 1.5 percent are shown in Table 1. The results of two properly conducted tests on the same material, by the same operator, using the same equipment, should be considered suspect if they differ by more than the d2s single operator limits shown in Table 1.

13.3. *Multi-Laboratory Precision*—The multi-laboratory standard deviations (1s limits) for relative densities at N_{ini} and N_{des} for mixtures containing aggregate with an absorption of less than 1.5 percent are shown in Table 1. The results of two properly conducted tests on the same material, by different operators, using different equipment, should be considered suspect if they differ by more than the d2s multi-laboratory limits shown in Table 1.

Table 1—Precision Estimates[a]

	1s limit Relative Density, %	d2s limit Relative Density, %
Single-operator precision:		
12.5-mm nominal max agg.	0.3	0.9
19.0-mm nominal max agg.	0.5	1.4
Multi-laboratory precision:		
12.5-mm nominal max agg.	0.6	1.7
19.0-mm nominal max agg.	0.6	1.7

[a] Based on an interlaboratory study described in NCHRP Research Report 9-26 involving 150-mm diameter specimens with 4 to 5 percent air voids, 26 laboratories, two materials (a 12.5-mm mixture and a 19.0-mm mixture), and three replicates. Specimens were prepared in accordance with T 312-04. The angle of gyration was verified using Method A, external angle.

13.4. *Bias*—No information can be presented on the bias of the procedure because no material having an accepted reference value is available.

14. KEYWORDS

14.1. Compaction; density; gyratory.

ANNEX A—EVALUATING SUPERPAVE GYRATORY COMPACTOR (SGC) MOLDS

(Mandatory Information)

A1. SCOPE

A1.1. This Annex covers the evaluation of the molds as a check for compliance with the requirements outlined in Sections 4.2 and 4.3. Measurements of the mold inside diameter and end-plate diameters as well as visual inspection of critical surface conditions are included.

Minimum frequency of this evaluation is 12 months or 80 hours of operation.

The inside diameter of the molds may be measured using a three-point bore gauge or a Coordinate Measuring Machine (CMM). See Annexes A4 and A5 for additional procedures for using these devices.

Note A1—Because CMMs are typically limited to manufacturers, it is considered best practice for a lab to also use the three-point bore method as a check before putting a mold into service.

A2. APPARATUS

A2.1. *Three-Point Internal Bore Gauge*—Minimum resolution shall be 0.0025 mm (0.0001 in.). This equipment is applicable only if measuring the inside diameter of molds according to Annex A4.

A2.2. *Calibrated Master Ring*—A calibrated master ring of the same nominal size as the mold diameter shall be used to set the measuring instrument reference for each series of measurements. A 150-mm ANSI/ASME B89.1.6 Class Z (0.00635 mm/0.00025 in.) standard is acceptable for 150-mm sized molds. The master ring shall be calibrated at a frequency no less than every 36 months, measured to a minimum resolution of 0.001 mm (0.00004 in.). This equipment is applicable only if measuring the inside diameter of molds according to Annex A4.

A2.3. *Length Measurement Instrument (Outside Calipers or Micrometer)*—With appropriate range and a minimum resolution of 0.025 mm (0.001 in.). The length measurement instrument shall be standardized annually.

A2.4. *Coordinate Measuring Machine (CMM)*—Capable of performing the three-point diametral measurement at the vertical locations specified in Figure A4.2 with a minimum resolution of 0.0025 mm (0.0001 in.). The CMM shall be calibrated annually per ASME B89.4.19 (or equivalent for CMM type). This equipment is applicable only if measuring the inside diameter of molds according to Annex A5 or measuring the outside diameter of the mold end plates according to Annex A6.

A2.5. *Infrared Thermometer*—For measuring the temperature of molds, end plates, and equipment, shall meet the requirements of M 339M/M 339 with a D:s ratio of 6:1.

A3. PROCEDURE FOR VISUALLY INSPECTING THE CONDITION OF THE MOLD

A3.1. *Perform a visual inspection of the mold*:

A3.1.1. Confirm that the molds are thoroughly cleaned and identified with a unique serial number or other unique identifier. Allow the molds to achieve a temperature of 18 to 28°C (64 to 82°F).

Note A2—This temperature range can be confirmed with an infrared thermometer.

A3.1.2. The mold bore shall be free of residue and deep gouges. Mold bores without gouges typically have an acceptable surface finish. Identify any wear area that may be visible in the mold.

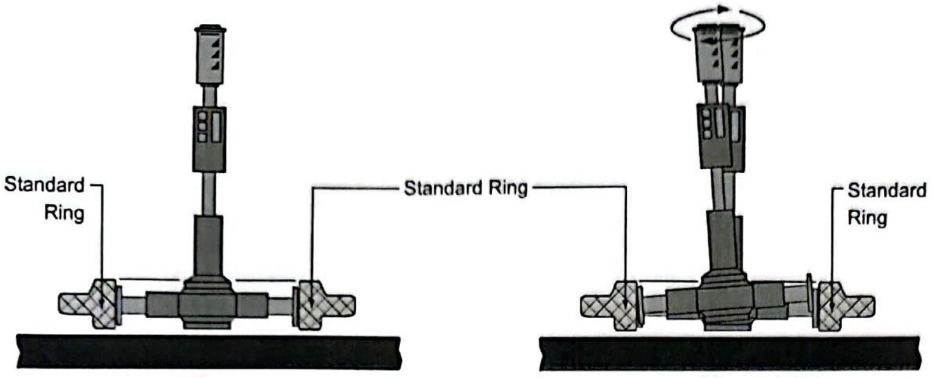
Note A3—Do not attempt to clean an SGC mold in an ignition oven. Extreme heat may cause the mold to soften or become "out of round" and unrepairable.

A4. PROCEDURE FOR MEASURING THE INSIDE DIAMETER OF SUPERPAVE GYRATORY MOLDS WITH A THREE-POINT BORE GAUGE

A4.1. *Standardize the Bore Gauge*—The three-point bore gauge shall be standardized with the master ring prior to each use.

A4.1.1. Allow the gauge and calibrated master ring to achieve a temperature of 18 to 28°C (64 to 82°F) (Note A2).

A4.1.2. Place the master ring on a flat surface. Position the gauge inside the ring without contacting the surface. Engage the contact points with the ring internal diameter. On some gauges, this operation requires turning an adjuster knob to extend the contact points; other gauge types may have alternate engagement operation. (See Figure A4.1.) While extending the gauge contacts, use a small circular motion at the top of the gauge to align the contact tips with the master ring bore. As the bore gauge contacts engage the master ring, the circular movement will reduce until the contacts seat against the ring bore. This engagement should be firm but not overly tight.



Hold the micrometer inside the ring and off the table surface and centered vertically in the ring while tightening.

Move the top of the micrometer in a circular motion while extending the contact points.

Figure A4.1—Techniques for Using the Three-Point Bore Gauge with the Calibrated Master Ring

Note A4—The circular motion depicted in Figure A4.1, applied to the top of the gauge while tightening the contact tips against the bore surface, is necessary to eliminate errors from misalignment.

A4.1.3. Reset (zero) the bore gauge. On mechanical gauges without an electronic reset, confirm the gauge reads within 0.0025 mm (0.0001 in.) of the master ring. Release the gauge from the ring by retracting the contact points.

If the mechanical bore gauge does not read correctly, measurements taken with the gauge require the addition of an offset to compensate for the bias (amount of error from the standard), or the gauge can be recalibrated.

A4.2. Identify the rotational orientation of the measurements. Position the mold on a flat surface with the bore vertical. Place a mark on the top of the mold to identify the rotational orientation of the measurements to be taken.

A4.3. *Measurements*—The inside diameter of the mold shall be measured at three locations (elevations) along its axis. Designate these elevations as 1, 2, and 3. The first measurement location (elevation) shall be approximately 50 mm from the top of the mold. The second measurement shall be in the visible wear area approximately 100 mm from an end of the mold (top or bottom) as determined by the wear area. The third elevation shall be approximately 50 mm from the end opposite the first measurement.

The diameter shall be measured three times at each elevation, resulting in a total of nine individual diameter measurements. Each measurement is identified by a number (1, 2, or 3) corresponding to the elevation and a letter (A, B, or C) corresponding to the angular orientation of the gauge. At each elevation, measurements designated as "A" shall have one of the three contacts aligned with the mark made in Section A4.2, measurements designated as "B" shall have the contact rotated 90 degrees from the mark, and measurements designated as "C" shall have the contact oriented 180 degrees from the mark.

For best accuracy and consistency, each bore measurement should use the same firmness and technique applied in Section A4.1.2 for gauge standardization.

Record each measurement to at least the nearest 0.0025 mm (0.0001 in.). Record the value to the nearest 0.001 mm (0.00004 in.) if the gauge resolution permits.

A4.3.1. Position the bore gauge at the first measurement elevation with one of the contact points aligned with the mark made in Section A4.2. Obtain the measurement, and record this reading as "1A."

A4.3.2. Release the gauge; rotate it 90 degrees and obtain the measurement in this orientation. Record this measurement as "1B."

A4.3.3. Rotate the bore gauge an additional 90 degrees (180 degrees from "1A") to obtain a third reading at the same elevation. Record this reading as "1C."

Note A5—Figure A4.2 shows the gauge in the mold positioned for each measurement. The wear zone is represented in this figure at the top of the mold. Take care not to position the bore gauge probe at the sloped edge of the wear zone.

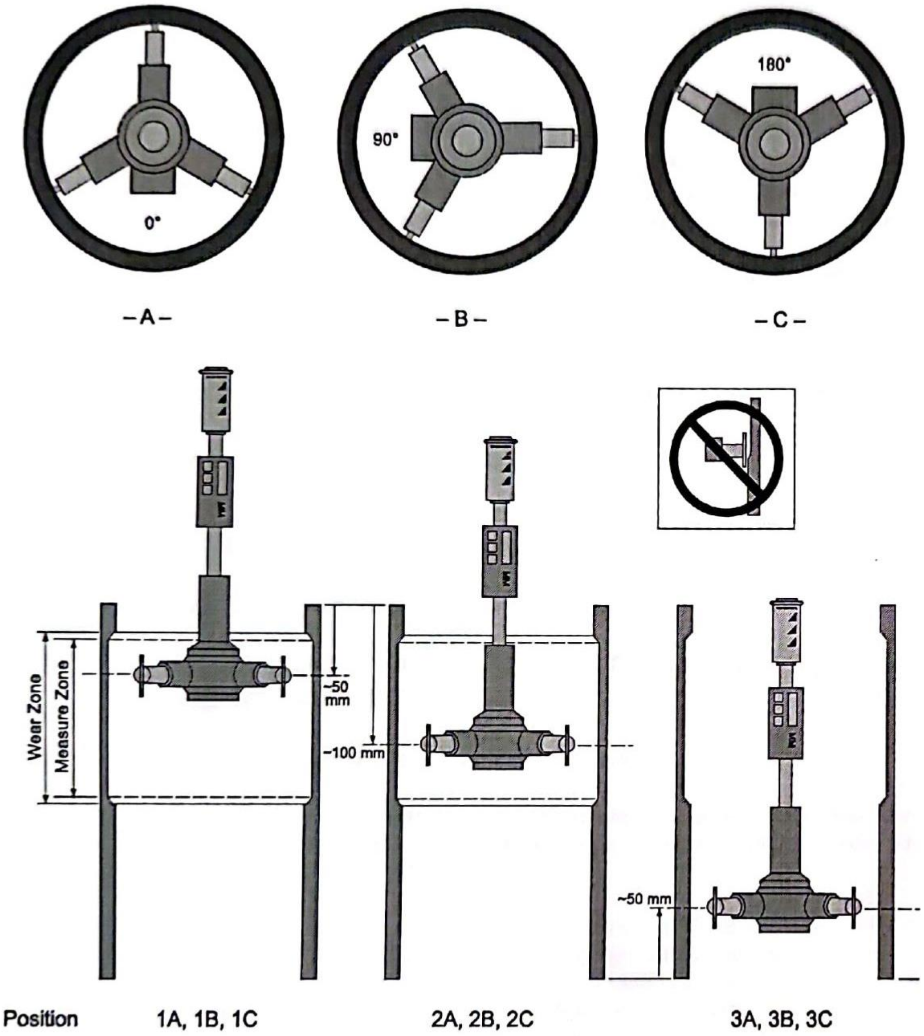


Figure A4.2—Bore Gauge Measurement Positions within the Mold Bore

A4.3.4. Release the bore gauge, and position it for the measurements at the second elevation. Repeat Sections A4.3 through A4.3.3 for elevations 2 and 3. Record the readings, and designate them as "2A," "2B," and "2C" and "3A," "3B," and "3C," respectively.

A4.3.5. Each individual bore measurement shall be compared to the specified range and given a pass/fail rating. If any of the individual bore measurements are assigned a "fail" rating, the mold is considered to be out of conformance and shall not be used.

A4.4. *Calculations*:

A4.4.1. For instruments that indicate the measured value directly, no calculation is required.

A4.4.2. For instruments for which the diameter measurement is an increment from the master ring size, calculate the mold diameter for each measurement by the following equation:

$$\text{measurement} = M + D \qquad (A4.1)$$

where:

M = master ring diameter, mm; and
D = instrument reading, mm (retain the positive or negative sign).

Note A6—A negative reading for "D" indicates that the mold diameter is smaller than the master ring, and a positive reading indicates that the mold diameter is larger than the master ring.

A4.4.3. Measurements taken with instruments measuring in inches shall be converted and reported as millimeters (mm) using the following equation:

$$\text{mm} = \text{in.} \times 25.40 \qquad (A4.2)$$

A5. PROCEDURE FOR MEASURING THE INSIDE DIAMETER OF SUPERPAVE GYRATORY MOLDS WITH A COORDINATE MEASUREMENT MACHINE (CMM)

A5.1. Take measurements in accordance with the operating instructions provided by the equipment manufacturer. Measurements shall be obtained at the vertical locations specified in Figure A4.2.

A5.1.1. Report information in accordance with the requirements in Section A7 of this Annex.

A6. PROCEDURE FOR MEASURING THE OUTSIDE DIAMETER OF SUPERPAVE GYRATORY COMPACTOR MOLD END PLATES

A6.1. *Perform a visual inspection of the mold end plates*:

A6.1.1. Confirm that the end plates are thoroughly cleaned and properly identified. Allow the end plates and outside measuring instrument (caliper, micrometer, or CMM) to achieve a temperature of 18 to 28°C (64 to 82°F) (Note A2).

A6.1.2. The plates shall be free of residue and deep gouges. Surfaces in contact with the asphalt mixture shall be flat. Minor abrasion marks from aggregates are acceptable. Surfaces in contact with the SGC frame or compaction ram shall be free of raised burrs that may cause the plate to wobble during gyration. Small recesses on the side of the plate interfacing the SGC (opposite the asphalt mixture) can reduce rocking and are acceptable.

A6.2. Determine the maximum diameter of the end plate by measuring it at several locations. Place a removable mark at this position. Record the maximum plate diameter to the nearest 0.025 mm (0.001 in.). Designate this measurement as "A."

A6.2.1. Measure the diameter at a 90-degree orientation to the maximum diameter. Record this diameter as "B."

A6.2.2. Each individual diameter measurement shall be compared to the specified range and given a pass/fail rating. If any of the individual bore measurements are assigned a "fail" rating, the mold is considered to be out of conformance and shall not be used.

A7. INSPECTION REPORT

A7.1. *Record and report the following information*:

A7.1.1. Name of evaluator;

A7.1.2. Date;

A7.1.3. Mold owner;

A7.1.4. Location of evaluation;

A7.1.5. Superpave gyratory compactor model;

A7.1.6. Measurement system for the inside diameter measurements;

A7.1.6.1. Bore gauge information, if used (manufacturer and model);

A7.1.6.2. Master ring information, if using three-point bore gauge (diameter to the nearest 0.001 mm (0.00004 in.), calibration certificate number, and calibration date);

A7.1.6.3. CMM information, if used (manufacturer, model, last calibration date);

A7.1.7. Length-measuring instrument information (model, serial number, range, and calibration date);

A7.1.8. *Mold and End Plate Identification*—Mold identification (serial number or other identifying mark) and end plate identification(s) (serial number or other identifying mark);

A7.1.9. Individual inside diameter measurements of the mold to the nearest 0.0025 mm (0.0001 in.) and the corresponding pass/fail rating;

A7.1.10. Individual outside diameter measurements of the end plate to the nearest 0.025 mm (0.001 in.) and the corresponding pass/fail rating; and

A7.1.11. Length measurement of the mold to the nearest 0.1 mm (0.004 in.).

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Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised: December 1, 2022

Standard Method of Test
for

Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens

Reference AASHTO T 166-22, Methods A and C

AASHTO Section	***Illinois Modification***
2.1	Replace with the following: *Referenced Illinois modified AASHTO Standards:* ■ M231, Weighing Devices Used in the Testing of Materials
2.2 New Section	*Referenced Illinois modified ASTM Standards:* ■ D1188, Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Coated Samples
3.1.2	Replace with the following: Constant mass shall be defined as the mass at which further drying at 52 ± 3 °C (125 ± 5 °F) for 2 hours, at 110 ± 5 °C (230 ± 9 °F) for 1 hour, or when weighed after at least two drying cycles of the vacuum-drying apparatus required in ASTM D7227/D7227M does not alter the mass more than 0.5 grams. Samples being saved for Quality Assurance testing shall not be dried at 110 ± 5 °C (230 ± 9 °F).
4.2	Revise as follows: *Size of Specimens*—It is required that the (1) minimum diameter of the gyratory compacted specimens be 149.90 mm (5.90 in.), (2) minimum diameter of the cored specimens be 92.1 mm (3 5/8 in.), and (3) thickness of specimens be a minimum of 19.0 mm (¾ in.).
4.6	Replace with the following: When cores from HMA pavement are used and two or more layers are attached together, a saw or other suitable means shall be used to separate the pavement layers. Care should be exercised to ensure that the specimens are not damaged during the separation process.
5.3	Replace with the following: *Water Bath*
5.3.1 New Section	For immersing the specimen in water while suspended under the weighing device, equipped with an overflow outlet for maintaining a constant water level.

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised: December 1, 2022

Standard Method of Test
for
Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens

Reference AASHTO T 166-22, Methods A and C

AASHTO Section	***Illinois Modification***
5.3.2 New Section	Constant Temperature Water Bath – Shall meet the requirements listed in the Illinois Department of Transportation document, "Hot-Mix Asphalt QC/QA Laboratory Equipment". The thermometer for measuring temperature of the water bath shall have a suitable range to determine 25 ± 1 °C (77 ± 1.8 °F). The thermometers may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.25 °C (± 0.45 °F) (see Note 2). **Note 2** - Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E879 thermistor thermometer; ASTM E1137/E1137M Pt-100 RTD platinum resistance thermometer, Class A; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, Class AA.
5.4	Delete
5.5	Renumber as 5.4
5.5 (Re-numbered as 5.4)	Replace the fourth sentence with the following: The thermometer for measuring temperature of the oven shall have a suitable range to determine 52 ± 3 °C (126 ± 5 °F). The thermometers may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.75 °C (± 1.35 °F) (see Note 3).
Note 4	Renumber as Note 3
6.2	Replace the first sentence with the following: Cool the specimen to room temperature at 25 ± 5 °C (77 ± 9 °F) and brush it to remove any loose particles. Weigh the specimen and record the result as the original dry mass, "A". Measure the thickness of the specimen in. three places to the nearest 1.0 mm (1/16 inch) to obtain an average.
Note 5	Renumber as Note 4
Note 6	Renumber as Note 5

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised: December 1, 2022

Standard Method of Test
for

Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens

Reference AASHTO T 166-22, Methods A and C

AASHTO Section	***Illinois Modification***
8	Delete
9	Delete
10	Delete
11.1	Add the following: Method C (Rapid Test) shall not be used if cores are being saved for Quality Assurance testing.
11.2.1	Replace the last sentence with the following: The thermometer for measuring temperature of the oven shall have a suitable range to determine 110 ± 5 °C (230 ± 9 °F). The thermometers may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.75 °C (± 1.35 °F) (see Note 6).
Note 9	Renumber as Note 6 and replace with the following: **Note 6** - Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; IEC 60584 thermocouple thermometer, Type T, Class 1; or E2877 digital metal stem thermometer.
13.1.1	Replace with the following: The method used (A or C).
Footnote[1]	Delete

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Standard Method of Test for

Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens

AASHTO Designation: T 166-22

AASHTO

Technically Revised: 2022

Editorially Revised: 2022

Technical Subcommittee: 2c, Asphalt–Aggregate Mixtures

1. SCOPE

1.1. This method of test covers the determination of bulk specific gravity (G_{mb}) of specimens of compacted asphalt mixtures.

1.2. This method should not be used with specimens that contain open or interconnecting voids or absorb more than 2.0 percent of water by volume, as determined in Sections 7.2 or 10.2 herein. If the specimen contains open or interconnecting voids or absorbs more than 2.0 percent of water by volume, then T 275 or T 331 should be used.

1.3. The bulk specific gravity (G_{mb}) of the compacted asphalt mixture may be used in calculating the unit mass of the mixture.

Note 1—The values for bulk specific gravity (G_{mb}) obtained from T 275 or T 331 may differ. Care should be exercised when comparing test results from T 275 and T 331.

1.4. The values stated in SI units are to be regarded as the standard.

1.5. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.6. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 231, Weighing Devices Used in the Testing of Materials
- M 339M/M 339, Thermometers Used in the Testing of Construction Materials

- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- R 79, Vacuum Drying Compacted Asphalt Specimens
- T 275, Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Paraffin-Coated Specimens
- T 331, Bulk Specific Gravity (G_{mb}) and Density of Compacted Asphalt Mixtures Using Automatic Vacuum Sealing Method

2.2. *ASTM Standards:*

- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E879, Standard Specification for Thermistor Sensors for General Purpose and Laboratory Temperature Measurements
- E1137/E1137M, Standard Specification for Industrial Platinum Resistance Thermometers
- E2877, Standard Guide for Digital Contact Thermometers

2.3. *International Electrotechnical Commission Standards*:

- IEC 60584-1: 2013 Thermocouples - Part 1: EMF Specifications and Tolerances
- IEC 60751: 2008 Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors

3. TERMINOLOGY

3.1. *Definitions*:

3.1.1. *bulk specific gravity (of solids)* (G_{mb})—the ratio of the mass in air of a unit volume of a permeable material (including both permeable and impermeable voids normal to the material) at a stated temperature to the mass in air of equal density of an equal volume of gas-free distilled water at a stated temperature. The form of the expression shall be:

bulk specific gravity (G_{mb}) at x/y °C *(1)*

where:

x = temperature of the material; and

y = temperature of the water.

3.1.2. *constant mass*—shall be defined as the mass at which further drying does not alter the mass by more than 0.05 percent when weighed at 2-h intervals when using oven drying, or by more than 0.05 percent when weighed after at least two drying cycles of the vacuum-drying apparatus required in R 79.

4. TEST SPECIMENS

4.1. Test specimens may be either laboratory-compacted asphalt mixtures or sampled from asphalt pavements.

4.2. *Size of Specimens*—It is recommended that: (1) the diameter of cylindrically compacted or cored specimens, or the length of the sides of sawed specimens, be at least equal to four times the maximum size of the aggregate; and (2) the thickness of specimens be at least one and one-half times the maximum size of the aggregate.

4.3. Specimens shall be taken from pavements with a core drill, diamond or carborundum saw, or by other suitable means.

4.4. Care shall be taken to avoid distortion, bending, or cracking of specimens during and after the removal from the pavement or mold. Specimens shall be stored in a safe, cool place.

4.5. Specimens shall be free from foreign materials such as seal coat, tack coat, foundation material, soil, paper, or foil.

4.6. If desired, specimens may be separated from other pavement layers by sawing or other suitable means. Care should be exercised to ensure sawing does not damage the specimens.

METHOD A

5. APPARATUS

5.1. *Weighing Device*—The weighing device shall have sufficient capacity, be readable to 0.1 percent of the specimen mass or better, and conform to the requirements of M 231. The weighing device 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 weighing device.

5.2. *Suspension Apparatus*—The wire suspending the container shall be the smallest practical size to minimize any possible effects of a variable immersed length. The suspension apparatus shall be constructed to enable the container to be immersed to a depth sufficient to cover it and the test specimen during weighing. Care should be exercised to ensure no trapped air bubbles exist under the specimen.

5.3. *Water Bath*—For immersing the specimen in water while suspended under the weighing device, equipped with an overflow outlet for maintaining a constant water level, capable of maintaining a uniform temperature at 25 ± 1°C (77 ± 2°F). The thermometer for measuring the temperature of the water bath shall meet the requirements of M 339M/M 339 with a temperature range of at least 20 to 45°C (68 to 113°F) and an accuracy of ±0.25°C (±0.45°F) (see Note 2).

Note 2—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E879 thermistor thermometer; ASTM E1137/E1137M Pt-100 RTD platinum resistance thermometer, Class A; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, Class AA.

5.4. *Thermometer*—For measuring room temperature, meeting the requirements of M 339M/M 339 with a temperature range of at least 15 to 45°C (59 to 113°F) and an accuracy of ±0.5°C (±0.9°F) (Note 3).

Note 3—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E2877 digital metal stem thermometer; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; or IEC 60584 thermocouple thermometer, Type T, Class 1.

5.5. *Oven*—Of sufficient size, capable of maintaining a uniform temperature of 52 ± 3°C (126 ± 5°F). The oven(s) shall be capable of operation at the temperatures required as corrected, if necessary, by standardization. More than one oven may be used, provided each is used within its proper operating temperature range. The thermometer for measuring the oven temperature shall meet the requirements of M 339M/M 339 with a temperature range of at least 40 to 60°C (104 to 140°F) and an accuracy of ±0.75°C (±1.35°F) (Note 4).

Note 4—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E2877 digital metal stem thermometer; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; or IEC 60584 thermocouple thermometer, Type T, Class 1.

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6. PROCEDURE

6.1. Dry the specimen to a constant mass at a temperature of 52 ± 3°C (125 ± 5°F). Specimens saturated with water shall initially be dried overnight and then weighed at 2-h drying intervals. Recently compacted laboratory specimens, which have not been exposed to moisture, do not require drying. As an alternative to oven drying to constant mass, drying the specimen according to R 79 may be used. When using R 79 to achieve constant mass, perform the drying procedure at least twice, with a mass determination after each drying cycle.

6.2. Cool the specimen to room temperature at 25 ± 5°C (77 ± 9°F), and record the dry mass as A (Note 5). Immerse each specimen in the water bath at 25 ± 1°C (77 ± 2°F) for 4 ± 1 min, and record the immersed mass as C. Remove the specimen from the water bath; damp-dry the specimen by blotting it with a damp towel, and determine the surface-dry mass as B as quickly as possible *(the entire operation is not to exceed 15 s)*. Any water that seeps from the specimen during the weighing operation is considered part of the saturated specimen. Each specimen shall be immersed and weighed individually.

Note 5—If desired, the sequence of testing operations may be changed to expedite the test results. For example, first the immersed mass C can be taken, then the surface-dry mass B, and finally the dry mass A.

Note 6—Terry cloth has been found to work well for an absorbent cloth. Damp is considered to be when no water can be wrung from the towel.

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7. CALCULATION

7.1. Calculate the bulk specific gravity (G_{mb}) of the specimen as follows:

$$\text{bulk specific gravity} = \frac{A}{B-C} \qquad (2)$$

where:

A = mass of the specimen in air, g;

B = mass of the surface-dry specimen in air, g; and

C = mass of the specimen in water, g.

7.2. Calculate the percent of water absorbed by the specimen (on a volume basis) as follows:

$$\text{percent of water absorbed by volume} = \frac{B-A}{B-C} \times 100 \qquad (3)$$

7.3. If the percent of water absorbed by the specimen as calculated in Section 7.2 exceeds 2.0 percent, use either T 275 or T 331 to determine the bulk specific gravity (G_{mb}).

METHOD B

8. APPARATUS

8.1. *Weighing Device*—The weighing device shall have sufficient capacity, be readable to 0.1 percent of the specimen mass or better, and conform to the requirements of M 231.

8.2. *Water Bath*—For immersing the specimen in water, meeting the requirements of Section 5.3.

8.3. *Thermometer*—For measuring room temperature, meeting the requirements of Section 5.4.

8.4. *Volumeter*[1]—Calibrated to 1200 mL, or an appropriate capacity depending on the size of the test specimen. The volumeter shall have a tapered lid with a capillary bore.

8.5. *Oven*—For drying samples, meeting the requirements of Section 5.5.

9. PROCEDURE

9.1. Dry the specimen to a constant mass at a temperature of 52 ± 3°C (125 ± 5°F). Specimens saturated with water shall initially be dried overnight and then weighed at 2-h drying intervals. Recently compacted laboratory specimens, which have not been exposed to moisture, do not require drying. As an alternative to oven drying to constant mass, drying using R 79 may be used. When using R 79 to achieve constant mass, perform the drying procedure at least twice, with a mass determination after each drying cycle.

9.2. Cool the specimen to room temperature at 25 ± 5°C (77 ± 9°F), and record the dry mass as *A* (Note 5). Immerse the specimen in the water bath at 25 ± 1°C (77 ± 2°F), and let it saturate for at least 10 min. At the end of the 10-min period, fill a calibrated volumeter with distilled water at 25 ± 1°C (77 ± 2°F), and weigh the volumeter. Designate this mass as *D*. Remove the saturated specimen from the water bath and damp-dry the specimen by blotting with a damp towel (Note 6) as quickly as possible (not to exceed 5 s). Weigh the specimen, and record the surface-dry mass as *B*. Any water that seeps from the specimen during the weighing operation is considered part of the saturated specimen.

9.3. Place the specimen into the volumeter, and let it stand for at least 60 s. Bring the temperature of the water to 25 ± 1°C (77 ± 2°F), and cover the volumeter, making certain that some water escapes through the capillary bore of the tapered lid. Wipe the outside of the volumeter dry with a dry, absorbent cloth, and weigh the volumeter and its contents (Note 7). Record this weight as *E*.

Note 7—If desired, the sequence of testing operations can be changed to expedite the test results. For example, first the mass of the saturated, damp-dry specimen *B* can be taken. Then the volumeter containing the saturated specimen and water *E* can be weighed. The dry mass of the specimen *A* can be determined last.

Note 8—Method B is not acceptable for specimens that have more than 6 percent air voids.

10. CALCULATIONS

10.1. Calculate the bulk specific gravity (G_{mb}) of the specimen as follows:

$$\text{bulk specific gravity} = \frac{A}{B + D - E} \qquad (4)$$

where:

A = mass of the dry specimen, g;

B = mass of the surface-dry specimen, g;
D = mass of the volumeter filled with water at 25 ± 1°C (77 ± 2°F), g; and
E = mass of the volumeter filled with the specimen and water at 25 ± 1°C (77 ± 2°F), g.

10.2. Calculate the percent of water absorbed by the specimen (on a volume basis) as follows:

$$\text{percent of water absorbed by volume} = \frac{B - A}{B + D - E} \times 100 \qquad (5)$$

10.3. If the percent of water absorbed by the specimen as calculated in Section 10.2 exceeds 2.0 percent, use either T 275 or T 331 to determine the bulk specific gravity (G_{mb}).

METHOD C (RAPID TEST)

11. PROCEDURE

11.1. This procedure can be used for testing specimens that are not required to be saved and that contain a substantial amount of moisture. Specimens obtained by coring or sawing can be tested the same day by this method.

11.2. The apparatus shall be the same as given in Section 5 except as defined below. *The testing procedure shall be the same as given in Section 6 or 9 except for the sequence of operations. The dry mass A of the specimen is determined last as follows*:

11.2.1. Place the specimen in a large, flat-bottom drying pan of known mass. Place the pan and specimen in an oven at 110 ± 5°C (230 ± 9°F). Leave the specimen in the oven until it can be easily separated to the point where the particles of the fine aggregate-asphalt portion are not larger than 6.3 mm ($^1/_4$ in.). Place the separated specimen in an oven at 110 ± 5°C (230 ± 9°F), and dry to a constant mass. The oven shall be capable of operation at the temperatures required as corrected, if necessary, by standardization. More than one oven may be used, provided each is used within its proper operating temperature range. The thermometer for measuring the oven temperature shall meet the requirements of M 339M/M 339 with a temperature range of at least 90 to 130°C (194 to 266°F) and an accuracy of ±1.25°C (±2.25°F) (Note 9).

Note 9—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E2877 digital metal stem thermometer; ASTM E230/E230M thermocouple thermometer, any Type, any Class; IEC 60584 thermocouple thermometer, any Type, any Class; or ASTM E879 thermistor thermometer.

11.2.2. Cool the pan and specimen to room temperature at 25 ± 5°C (77 ± 9°F). Determine the mass of the pan and specimen, subtract the mass of the pan, and record as the dry mass, A.

12. CALCULATIONS

12.1. Calculate the bulk specific gravity (G_{mb}) as given in Section 7.1 or 10.1.

13. REPORT

13.1. *The report shall include the following*:

13.1.1. The method used (A, B, or C).

13.1.2. Bulk specific gravity (G_{mb}) reported to the nearest thousandth.

13.1.3. Absorption reported to the nearest hundredth.

14. PRECISION

Table 1—Precision Estimates for T 166

Condition of Test	Standard Deviation (1s)[a]	Acceptable Range of Two Results (d2s)[a]
Single-operator precision	0.002	0.006
Multilaboratory precision	0.006	0.017

[a] These values represent the 1s and 2ds limits described in ASTM C670.

Note: Based on interlaboratory study described in NCHRP Research Report 9-26 Phase 2 involving 150-mm-diameter specimens, 20 laboratories, three materialss (9.5-mm, 12.5-mm, and 19.0-mm mixtures), and two replicates.

15. KEYWORDS

15.1. Asphalt mixture; bulk specific gravity; saturated surface-dry; volumeter.

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[1] Suitable aluminum volumeters of different sizes are available from Pine Instrument Co., 101 Industrial Drive, Grove City, PA 16127; and Rainhart Co., 604 Williams St., Austin, TX 78765.

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Illinois Modified Test Procedure
Effective Date: May 1, 2007
Revised Date: December 1, 2022

Standard Practice
For
Superpave Volumetric Design for Asphalt Mixtures

Reference AASHTO R 35-22

AASHTO Section	***Illinois Modification***
ALL Sections	• All references to calculations involving N_{ini} and N_{max} do not apply at this time. • Replace all references to AASHTO or ASTM standards with the appropriate Illinois-modified specification.
3.6	Replace with the following: Dust-to-Binder Ratio ($P_{0.075}/P_b$)—By mass, the ratio between percent of aggregate passing the 75-µm (No. 200) sieve ($P_{0.075}$) and total asphalt content (P_b).
4.1 Note 3	Delete
6.1	Delete
6.2	Delete
6.6 New Note	Note 5a: Oven dry the mix design aggregates according to T 30.
6.6 New Note	Note 5b: The aggregate sample from each stockpile shall be sieved and separated into the specific size passing each appropriate sieve according to the Department's Hot-Mix Asphalt Level III Technicians Manual.
6.7	Replace with the following: All aggregate specific gravity and absorption values used in mix design shall be obtained from the Department's Central Bureau of Materials aggregate specific gravity/absorption listing.
6.7 New Note	Note 5c: The trial aggregate blends may be prepared from unwashed aggregates. If the trial aggregate blends are prepared from unwashed aggregates, then a dust correction factor shall be determined and applied to the blend chosen for the mix design according to the Department's "Hot-Mix Asphalt Mix Design Procedure for Dust Correction Factor Determination."

Illinois Modified Test Procedure
Effective Date: May 1, 2007
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Standard Practice
For
Superpave Volumetric Design for Asphalt Mixtures

Reference AASHTO R 35-22

AASHTO Section	***Illinois Modification***
6.9	Replace with the following: Prepare a minimum of three trial aggregate blend gradations and confirm that each trial blend meets M 323 gradation controls. An example of three acceptable trial blends in the form of a gradation plot is given in Figure 1.
6.10	Delete
6.10 Note 6	Delete
8.1 New Note	Note 7a The design number of gyrations will be determined by the Department and specified in the plans.
Table 1 and all footnotes	Replace with new Table 1 (below)

Table 1 – N_{design} Table

Design ESALs (millions) Based on 20-year design	**N_{des}**	**Typical Roadway Application**
< 0.3	30	Roadway with very light traffic volume such as local roads, county roads, and city streets where truck traffic is prohibited or at a very minimal level (considered local in nature; not regional, intrastate, or interstate). Special purpose roadways serving recreational sites or areas may also be applicable.
0.3 to 3	50	Includes many collector roads or access streets. Medium-trafficked city streets and the majority of county roadways.
3 to 10	70	Includes many two-lane, multi-lane, divided, and partially or completely controlled access roadways. Among these are medium-to-highly trafficked streets, many state routes, U.S. highways, and some rural interstates.
≥ 10	90	May include the previous class of roadways which have a high amount of truck traffic. Includes U.S. Interstates, both urban and rural in nature. Special applications such as truck-weighing stations or truck-climbing lanes on two-lane roadways may also be applicable to this level.

Illinois Modified Test Procedure
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Superpave Volumetric Design for Asphalt Mixtures

Reference AASHTO R 35-22

AASHTO Section	***Illinois Modification***
8.2 Note 8	Delete
8.4 Note 10	Delete
9.3.6	Replace with the following: Calculate the dust-to-binder ratio for each trial blend where: $\textit{Dust to binder ratio} = \frac{P_{0.075}}{P_b}$ where: P_b = total asphalt content and $P_{0.075}$ = percent passing 75-µm sieve.
10.5.2	Replace with the following: Calculate the dust-to-binder ratio where: $\textit{Dust to binder ratio} = \frac{P_{0.075}}{P_b}$ where: P_b = total asphalt content and $P_{0.075}$ = percent passing 75-µm sieve.
11.3	Replace with the following: If the tensile strength ratio is less than 85 percent, as required in M 323, remedial action, such as the use of anti-strip agents, is required to improve the moisture susceptibility of the mix. When remedial agents are used to modify the asphalt binder, the mixture shall be retested to assure compliance with the minimum requirement of 85 percent.
X2.3.1.1 Note X4	Replace the last sentence with the following: Appropriate mixing times for bucket mixers should be established by evaluating the coating of asphalt mixtures prepared at the mixing temperatures specified in T 312.

Illinois Modified Test Procedure
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Superpave Volumetric Design for Asphalt Mixtures

Reference AASHTO R 35-22

AASHTO Section	***Illinois Modification***
X2.4.2	Replace with the following: Estimate the planned production and field compaction temperatures.
X2.5.1	Delete the last sentence
X2.6.3	Delete
Note X7	Delete
Table X2.1	Delete
X2.6.4	Delete
X2.6.4.1	Delete
X2.6.4.2	Delete
X2.6.4.3	Delete
X2.7.1.1.1 New Section	Dry the aggregates according to T 30.
X2.7.2.1	Replace the fifth sentence with the following: The thermometers may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.75°C (ł 1.5°F) (See Note X10).
Note X10	Delete the first sentence.

Illinois Modified Test Procedure
Effective Date: May 1, 2007
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Standard Practice
For
Superpave Volumetric Design for Asphalt Mixtures

Reference AASHTO R 35-22

AASHTO Section	***Illinois Modification***
X2.7.3.2.5	Replace description of w_i with: w_i = oven-dry weight from X2.7.1.1.1, g; and
X2.7.4.6	Replace description of w_i with: w_i = oven-dry weight from X2.7.1.1.1, g; and
X2.7.5.2.5	Replace description of w_i with: w_i = oven-dry weight from X2.7.1.1.1, g; and
X2.7.6.8	Replace description of w_i with: w_i = oven-dry weight from X2.7.1.1.1, g; and
X2.10.1.10 New Section	Hamburg Wheel rut depth and number of wheel passes.
X2.10.1.11 New Section	I-FIT Flexibility Index (Also Slope, Fracture Energy, and Strength)

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Standard Practice for

Superpave Volumetric Design for Asphalt Mixtures

AASHTO Designation: R 35-22[1]

Technically Revised: 2022 **Editorially Revised: 2022**

Technical Subcommittee: 2d, Proportioning of Asphalt–Aggregate Mixtures

1. SCOPE

1.1. This standard practice for mix design evaluation uses aggregate and mixture properties to produce an asphalt mixture job mix formula. The mix design is based on the volumetric properties of the asphalt mixture in terms of the air voids, voids in the mineral aggregate (VMA), and voids filled with asphalt (VFA). This standard practice may be used to evaluate Superpave mixtures based on 4.0 percent air void content or Superpave5 mixtures based on 5.0 percent air void content. It is important to note that Superpave and Superpave5 methodologies are similar but not the same. The designer must choose Superpave or Superpave5 and follow the practice as appropriate. Requirements for Superpave5 that are significantly different from Superpave are included in Annex A.

1.2. This standard practice may also be used to provide a preliminary selection of mix parameters as a starting point for mix analysis and performance prediction analyses.

1.3. Special mixture design considerations and practices to be used in conjunction with this standard practice for the volumetric design of Warm Mix Asphalt (WMA) are given in Appendix X2.

1.4. *This standard practice may involve hazardous materials, operations, and equipment. This standard practice does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 320, Performance-Graded Asphalt Binder
- M 323, Superpave Volumetric Mix Design
- M 339M/M 339, Thermometers Used in the Testing of Construction Materials
- R 30, Laboratory Conditioning of Asphalt Mixtures
- R 76, Reducing Samples of Aggregate to Testing Size
- R 83, Preparation of Cylindrical Performance Test Specimens Using the Superpave Gyratory Compactor (SGC)
- R 90, Sampling Aggregate Products
- T 11, Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
- T 27, Sieve Analysis of Fine and Coarse Aggregates

- T 84, Specific Gravity and Absorption of Fine Aggregate
- T 85, Specific Gravity and Absorption of Coarse Aggregate
- T 100, Specific Gravity of Soils
- T 166, Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
- T 195, Determining Degree of Particle Coating of Asphalt Mixtures
- T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures
- T 228, Specific Gravity of Semi-Solid Asphalt Materials
- T 275, Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Paraffin-Coated Specimens
- T 283, Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage
- T 312, Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor
- T 324, Hamburg Wheel-Track Testing of Compacted Asphalt Mixtures
- T 378, Determining the Dynamic Modulus and Flow Number for Asphalt Mixtures Using the Asphalt Mixture Performance Tester (AMPT)
- *A Policy on Geometric Design of Highways and Streets*

2.2. *ASTM Standards:*

- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples

2.3. *International Electrotechnical Commission Standard*:

- IEC 60584-1:2013, Thermocouples - Part 1: EMF Specifications and Tolerances

2.4. *Other References*:

- LTPP Seasonal Asphalt Concrete Pavement Temperature Models, LTPPBind, Available online at https://infopave.fhwa.dot.gov/Tools/LTPPBindOnline.

Note 1—The different generations of the LTPPBind program use different algorithms and weather databases for determining the PG high temperature for a location. The choice of which LTPPBind version to use is up to the specifier.

- NCHRP. *National Cooperative Highway Research Report 567: Volumetric Requirements for Superpave Mix Design*. National Cooperative Highway Research Program, Transportation Research Board, Washington, DC, 2006.

3. TERMINOLOGY

3.1. *absorbed binder volume* (V_{ba})—the volume of binder absorbed into the aggregate (equal to the difference in aggregate volume when calculated with the bulk specific gravity and effective specific gravity).

3.2. *air voids* (V_a)—the total volume of the small pockets of air between the coated aggregate particles throughout a compacted paving mixture, expressed as a percent of the bulk volume of the compacted paving mixture.

3.3. *binder content* (P_b)—the percent by mass of binder in the total mixture, including binder and aggregate.

3.4. *design air void content*—the required percent air voids (V_a) at N_{design} gyrations, or 100 percent minus the required percent G_{mm} (relative density) at N_{design} gyrations, from M 323. The design air void content is 4.0 percent for Superpave mixtures and 5.0 percent for Superpave5 mixtures.

3.5. *design ESALs*—design equivalent (80 kN) single-axle loads.

3.5.1. *discussion*—design ESALs are the anticipated project traffic level expected on the design lane over a 20-year period. For pavements designed for more or less than 20 years, determine the design ESALs for 20 years when using this standard practice.

3.6. *dust-to-binder ratio* ($P_{0.075}/P_{be}$)—by mass, the ratio between the percent passing the 75-μm (No. 200) sieve ($P_{0.075}$) and the effective binder content (P_{be}).

3.7. *effective binder volume* (V_{be})—the volume of binder that is not absorbed into the aggregate.

3.8. *HMA*—hot mix asphalt.

3.9. *maximum aggregate size*—one size larger than the nominal maximum aggregate size (Note 2).

Note 2—The definitions given in Sections 3.9 and 3.10 apply to Superpave mixes only and differ from the definitions published in other AASHTO standards.

3.10. *nominal maximum aggregate size*—one size larger than the first sieve that retains more than 10 percent aggregate (Note 2).

3.11. *primary control sieve (PCS)*—the sieve defining the break point between fine and coarse-graded mixtures for each nominal maximum aggregate size.

3.12. *reclaimed asphalt pavement (RAP)*—removed and/or processed pavement materials containing asphalt binder and aggregate.

3.13. *reclaimed asphalt pavement binder ratio (RAPBR)*—The ratio of the RAP binder in the mixture divided by the mixture's total binder content.

3.14. *voids filled with asphalt (VFA)*—the percentage of the VMA filled with binder (the effective binder volume divided by the VMA).

3.15. *voids in the mineral aggregate (VMA)*—the volume of the intergranular void space between the aggregate particles of a compacted paving mixture that includes the air voids and the effective binder content, expressed as a percent of the total volume of the specimen.

3.16. *WMA*—warm mix asphalt.

4. SUMMARY OF THE PRACTICE

4.1. *Materials Selection*—Binder, aggregate, and RAP stockpiles are selected that meet the environmental and traffic requirements applicable to the paving project. The bulk specific gravity of all aggregates proposed for blending and the specific gravity of the binder are determined.

Note 3—If RAP is used, the bulk specific gravity of the RAP aggregate may be estimated by determining the theoretical maximum specific gravity (G_{mm}) of the RAP mixture and using an assumed asphalt absorption for the RAP aggregate to back-calculate the RAP aggregate bulk specific gravity, if the absorption can be estimated with confidence. The RAP aggregate effective specific gravity may be used in lieu of the bulk specific gravity at the discretion of the agency. The use of the effective specific gravity may introduce an error into the combined aggregate bulk specific gravity and subsequent VMA calculations. The agency may choose to specify adjustments to the VMA requirements to account for this error based on experience with local aggregates.

4.2. *Design Aggregate Structure*—It is recommended that at least three trial aggregate blend gradations from selected aggregate stockpiles are blended. For each trial gradation, an initial trial binder content is determined, and at least two specimens are compacted in accordance with T 312. A design aggregate structure and an estimated design binder content are selected on the basis of satisfactory conformance of a trial gradation meeting the requirements given in M 323 for V_a, VMA, VFA, dust-to-binder ratio at N_{design}, and relative density at N_{initial}.

Note 4—Previous Superpave mix design experience with specific aggregate blends may eliminate the need for three trial blends.

4.3. *Design Binder Content Selection*—Replicate specimens are compacted in accordance with T 312 at the estimated design binder content and at the estimated design binder content ±0.5 percent and +1.0 percent. The design binder content is selected on the basis of satisfactory conformance with the requirements of M 323 for V_a, VMA, VFA, and dust-to-binder ratio at N_{design}, and the relative density at N_{initial} and N_{max}.

4.4. *Evaluating Moisture Susceptibility*—Evaluate the moisture susceptibility of the design aggregate structure at the design binder content. Oven-condition the mixture according to T 283 Section 6. Compact specimens to 7.0 ± 0.5 percent air voids according to T 312. Group, moisture-condition, test, and evaluate specimens according to T 283. The design shall meet the tensile strength ratio requirement of M 323.

5. SIGNIFICANCE AND USE

5.1. The procedure described in this standard practice is used to produce asphalt mixtures that satisfy Superpave asphalt volumetric mix design requirements. At an agency's discretion, this standard practice may be used to produce asphalt mixtures that satisfy Superpave5 asphalt volumetric mix design requirements. Unless noted, all sections apply to Superpave and Superpave5. Requirements specific to Superpave5 are contained in Annex A.

6. PREPARING AGGREGATE TRIAL BLEND GRADATIONS

6.1. Select a binder in accordance with the requirements of M 323 and M 320.

6.2. Determine the specific gravity of the binder according to T 228.

6.3. Obtain samples of aggregates and RAP proposed to be used for the project from the aggregate and RAP stockpiles in accordance with R 90.

Note 5—Each stockpile usually contains a given size of an aggregate fraction. Most projects employ three to five stockpiles to generate a combined gradation conforming to the job-mix formula and M 323.

6.4. Reduce the samples of aggregate fractions according to R 76 to samples of the size specified in T 27.

6.5. When RAP is used, dry the RAP samples in an oven at 110°C until constant mass. Avoid exposing RAP to oven conditioning for extended periods of time to minimize further aging of the RAP binder. Determine the binder content of the RAP using T 308 or T 164. Retain the RAP aggregate following ignition or extraction testing for gradation analyses, specific gravity determinations, and aggregate consensus property tests.

6.6. Wash and grade each aggregate sample according to T 11 and T 27 for the purpose of materials characterization of the aggregates.

6.7. Determine the bulk and apparent specific gravity for each coarse and fine aggregate fraction in accordance with T 85 and T 84, respectively, and determine the specific gravity of the mineral filler in accordance with T 100.

6.8. Calculate the combined aggregate gradation using Equation 1:

$$P = Aa + Bb + Cc, \text{ etc.} \qquad (1)$$

where:

P = percentage of material passing a given sieve for the combined aggregates A, B, C, etc.;
A, B, C, etc. = percentage of material passing a given sieve for aggregates A, B, C, etc.; and
a, b, c, etc. = proportions of aggregates A, B, C, etc., used in the combination, and where the total = 1.00.

6.9. Prepare a minimum of three trial aggregate blend gradations; plot the gradation of each trial blend on a 0.45-power gradation analysis chart and confirm that each trial blend meets M 323 gradation controls (see Table 4 of M 323). Gradation control is based on four control sieve sizes: the sieve for the maximum aggregate size, the sieve for the nominal maximum aggregate size, the primary control sieve (PCS) from M 323, and the 0.075-mm sieve. An example of three acceptable trial blends in the form of a gradation plot is given in Figure 1. If RAP is used, adjust the mass of the RAP to account for the RAP binder.

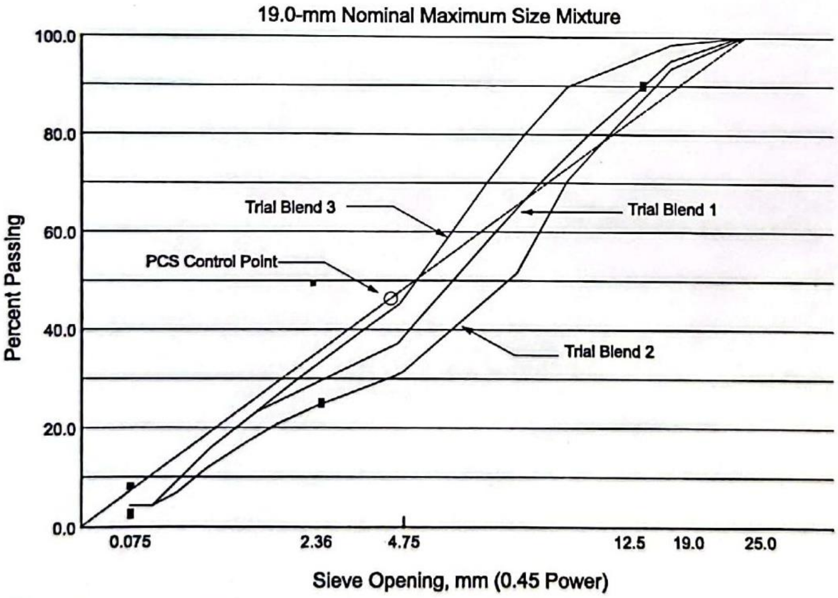


Figure 1—Evaluation of the Gradations of Three Trial Blends (Example)

6.10. Obtain a test specimen from each of the trial blends according to R 76, including RAP aggregate if used, and conduct the quality tests specified in Section 6 of M 323 to confirm that the aggregate in the trial blends meets the minimum quality requirements specified in M 323.

Note 6—The designer has an option of performing the quality tests on each stockpile instead of the trial aggregate blend. The test results from each stockpile can be used to estimate the results for a given combination of materials.

7. DETERMINING AN INITIAL TRIAL BINDER CONTENT FOR EACH TRIAL AGGREGATE GRADATION

7.1. Designers can either use their experience with the materials or the procedure given in Appendix X1 to determine an initial trial binder content for each trial aggregate blend gradation.

Note 7—When using RAP, the initial trial binder content should be reduced by an amount equal to that provided by the RAP.

8. COMPACTING SPECIMENS OF EACH TRIAL GRADATION

8.1. For Superpave mix designs, prepare replicate mixtures (Note 8) at the initial trial binder content for each of the chosen trial aggregate trial blend gradations. From Table 1, determine the number of gyrations based on the design ESALs for the project.

8.2. For Superpave5 mix designs, prepare replicate mixtures according to Annex A.

Note 8—At least two replicate specimens are required, but three or more may be prepared if desired. Generally, 4500 to 4700 g of aggregate is sufficient for each compacted specimen with a height of 110 to 120 mm for aggregates with combined bulk specific gravities of 2.55 to 2.70, respectively.

8.3. Condition the mixtures according to R 30 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.

8.4. Determine the bulk specific gravity (G_{mb}) of each of the compacted specimens in accordance with T 166 or T 275 as appropriate.

Table 1—Superpave Gyratory Compaction Effort

Design ESALs [a] (Million)	Compaction Parameters			Typical Roadway Application [b]
	$N_{initial}$	N_{design}	N_{max}	
<0.3	6	50	75	Applications include roadways with very light traffic volumes, such as local roads, county roads, and city streets where truck traffic is prohibited or at a very minimal level. Traffic on these roadways would be considered local in nature, not regional, intrastate, or interstate. Special purpose roadways serving recreational sites or areas may also be applicable to this level.
0.3 to <3	7	75	115	Applications include many collector roads or access streets. Medium-trafficked city streets and the majority of county roadways may be applicable to this level.
3 to <30	8	100	160	Applications include many two-lane, multilane, divided, and partially or completely controlled access roadways. Among these are medium to highly trafficked city streets, many state routes, U.S. highways, and some rural Interstates.
≥30	9	125	205	Applications include the vast majority of the U.S. Interstate system, both rural and urban in nature. Special applications such as truck-weighing stations or truck-climbing lanes on two-lane roadways may also be applicable to this level.

[a] The anticipated project traffic level expected on the design lane over a 20-year period. Regardless of the actual design life of the roadway, determine the design ESALs for 20 years.

[b] As defined by *A Policy on Geometric Design of Highways and Streets*, AASHTO.

Note 9—When specified by the agency and the top of the design layer is ≥100 mm from the pavement surface and the estimated design traffic level is ≥0.3 million ESALs, decrease the estimated design traffic level by one, unless the mixture will be exposed to significant mainline construction traffic prior to being overlaid. If less than 25 percent of a construction lift is within 100 mm of the surface, the lift may be considered to be below 100 mm for mixture design purposes.

Note 10—When the estimated design traffic level is between 3 and <10 million ESALs, the Agency may, at its discretion, specify N_{initial} at 7, N_{design} at 75, and N_{max} at 115.

8.5. Determine the theoretical maximum specific gravity (G_{mm}) according to T 209 of separate samples representing each of these combinations that have been mixed and conditioned to the same extent as the compacted specimens.

Note 11—The maximum specific gravity for each trial mixture shall be based on the average of at least two tests.

9. EVALUATING COMPACTED TRIAL MIXTURES

9.1. Determine the volumetric requirements for the trial mixtures in accordance with M 323.

9.2. Calculate V_a and VMA at N_{design} for each trial mixture using Equations 2 and 3:

$$V_a = 100\left[1-\left(\frac{G_{mb}}{G_{mm}}\right)\right] \tag{2}$$

$$\text{VMA} = 100 - \frac{G_{mb}P_s}{G_{sb}} \tag{3}$$

where:

G_{mb} = bulk specific gravity of the extruded specimen;.

G_{mm} = theoretical maximum specific gravity of the mixture;

P_s = aggregate content, percent by mass of total mixture; and

G_{sb} = bulk specific gravity of the combined aggregate.

Note 12—Although the initial trial binder content was estimated for the design air void content, the actual air void content of the compacted specimen is unlikely to be exactly the same as the design air void content. Therefore, the change in binder content needed to obtain the design air void content, and the change in VMA caused by this change in binder content, is estimated. These calculations permit the evaluation of VMA and VFA of each trial aggregate gradation at the same design air void content.

9.3. Estimate the volumetric properties at the design percent air voids for each compacted specimen.

9.3.1. Determine the difference in average air void content at N_{design} (ΔV_a) of each aggregate trial blend from the design percent air voids using Equation 4:

$$\Delta V_a = \text{design \% air void} \tag{4}$$

where:

V_a = air void content of the aggregate trial blend at N_{design} gyrations.

9.3.2. Estimate the change in binder content (ΔP_b) needed to change the air void content to the design percent using Equation 5:

$$\Delta P_b = -0.4\left(\Delta V_a\right) \tag{5}$$

9.3.3. Estimate the change in VMA (ΔVMA) caused by the change in the air void content (ΔV_a) determined in Section 9.3.1 for each trial aggregate blend gradation, using Equation 6 or 7.

$$\Delta VMA = 0.2\left(\Delta V_a\right) \quad \text{if} \quad V_a > \text{design \% air void} \tag{6}$$

$$\Delta VMA = -0.1\left(\Delta V_a\right) \quad \text{if} \quad V_a < \text{design \% air void} \tag{7}$$

Note 13—A change in binder content affects the VMA through a change in the bulk specific gravity of the compacted specimen (G_{mb}).

9.3.4. Calculate the VMA for each aggregate trial blend at N_{design} gyrations and the design percent air voids using Equation 8:

$$VMA_{\text{design}} = VMA_{\text{trial}} + \Delta VMA \tag{8}$$

where:

VMA_{design} = VMA estimated at the design air void content; and
VMA_{trial} = VMA determined at the initial trial binder content.

9.3.5. Using the values of ΔV_a determined in Section 9.3.1 and Equation 9, estimate the relative density of each specimen at N_{initial} when the design air void content is adjusted to the design percent at N_{design}:

$$\%G_{mm_{\text{initial}}} = 100\left(\frac{G_{mb}h_d}{G_{mm}h_i}\right) - \Delta V_a \tag{9}$$

where:

$\%G_{mm_{\text{initial}}}$ = relative density at N_{initial} gyrations at the adjusted design binder content;
h_d = height of the specimen after N_{design} gyrations, from the Superpave gyratory compactor, mm; and
h_i = height of the specimen after N_{initial} gyrations, from the Superpave gyratory compactor, mm.

9.3.6. Calculate the effective specific gravity of the aggregate (G_{se}), the estimated percent of effective binder ($P_{be_{est}}$), and the estimated dust-to-binder ratio ($P_{0.075}/P_{be}$) for each trial blend using Equations 10, 11, and 12:

$$G_{se} = \frac{100 - P_b}{\dfrac{100}{G_{mm}} - \dfrac{P_b}{G_b}} \tag{10}$$

$$P_{be_{est}} = -\left(P_s \times G_b\right)\left[\frac{\left(G_{se} - G_{sb}\right)}{\left(G_{se} \times G_{sb}\right)}\right] + P_{b_{est}} \tag{11}$$

where:

$P_{be_{est}}$ = estimated effective binder content,
P_s = aggregate content, percent by mass of total mixture,
G_b = specific gravity of the binder,
G_{se} = effective specific gravity of the combined aggregate,
G_{sb} = bulk specific gravity of the combined aggregate, and
$P_{be_{est}}$ = estimated binder content at 4 percent air voids.

$$P_{0.075} / P_{be} = \frac{P_{0.075}}{P_{be_{est}}} \tag{12}$$

where:

$P_{0.075}$ = percent passing the 0.075-mm sieve.

9.3.7. Compare the estimated volumetric properties from each trial aggregate blend gradation at the adjusted design binder content with the criteria specified in M 323. Choose the trial aggregate blend gradation that best satisfies the volumetric criteria.

Note 14—Table 2 presents an example of the selection of a design aggregate structure from three trial aggregate blend gradations for a Superpave (4.0 percent air voids) mix design.

Note 15—Many trial aggregate blend gradations will fail the VMA criterion. Generally, the $\%G_{mm_{\text{initial}}}$ criterion will be met if the VMA criterion is satisfied. Section 12.1 gives a procedure for the adjustment of VMA.

Note 16—If the trial aggregate gradations have been chosen to cover the entire range of the gradation controls, then the only remaining solution is to make adjustments to the aggregate production or to introduce aggregates from a new source. The aggregates that fail to meet the required criteria will not produce a quality mix and should not be used. One or more of the aggregate stockpiles should be replaced with another material that produces a stronger structure. For example, a quarry stone can replace a crushed gravel, or crushed fines can replace natural fines.

Table 2—Selection of a Design Aggregate Structure for a Superpave Mix Design (Example)

Volumetric Property	Trial Mixture (19.0-mm Nominal Maximum Aggregate) 20-Year Project Design ESALs = 5 million			Criteria
	1	2	3	
	At the Initial Trial Binder Content			
P_b (trial)	4.4	4.4	4.4	
$\%G_{mm_{\text{initial}}}$ (trial)	88.3	88.0	87.3	
$\%G_{mm_{\text{design}}}$ (trial)	95.6	94.9	94.5	
V_a at N_{design}	4.4	5.1	5.5	4.0
VMA_{trial}	13.0	13.6	14.1	
	Adjustments to Reach Design Binder Content (V_a = 4.0% at N_{design})			
ΔV_a	−0.4	−1.1	−1.5	
ΔP_b	0.2	0.4	0.6	
ΔVMA	−0.1	−0.2	−0.3	
	At the Estimated Design Binder Content (V_a = 4.0 % at N_{design})			
Estimated P_b (design)	4.6	4.8	5.0	
VMA (design)	12.9	13.4	13.8	≥13.0
$\%G_{mm_{\text{initial}}}$ (design)	88.7	89.1	88.5	≤89.0

Notes:
1. The top portion of this table presents measured densities and volumetric properties for specimens prepared for each aggregate trial blend at the initial trial binder content.
2. None of the specimens had an air void content of exactly 4.0 percent. Therefore, the procedures described in Section 9 must be applied to (1) estimate the design binder content at which V_a = 4.0 percent, and (2) obtain adjusted VMA and relative density values at this estimated binder content.
3. The middle portion of this table presents the change in binder content (ΔP_b) and VMA (ΔVMA) that occurs when the air void content (V_a) is adjusted to 4.0 percent for each trial aggregate blend gradation.
4. A comparison of the VMA and densities at the estimated design binder content to the criteria in the last column shows that trial aggregate blend gradation No. 1 does not have sufficient VMA (12.9 percent versus a requirement of ≥13.0 percent). Trial blend No. 2 exceeds the criterion for relative density at N_{initial} gyrations (89.1 percent versus a requirement of ≤89.0 percent). Trial blend No. 3 meets the requirement for relative density and VMA and, in this example, is selected as the design aggregate structure.

10. SELECTING THE DESIGN BINDER CONTENT

10.1. Prepare replicate mixtures (Note 8) containing the selected design aggregate structure at each of the following four binder contents: (1) the estimated design binder content, P_b (design); (2) 0.5 percent below P_b (design); (3) 0.5 percent above P_b (design); and (4) 1.0 percent above P_b (design).

10.1.1. Use the number of gyrations previously determined in Section 8.1.

10.2. Condition the mixtures according to R 30 and compact the specimens to N_{design} gyrations according to T 312. Record the specimen height to the nearest 0.1 mm after each revolution.

10.3. Determine the bulk specific gravity (G_{mb}) of each of the compacted specimens in accordance with T 166 or T 275 as appropriate.

10.4. Determine the theoretical maximum specific gravity (G_{mm}) according to T 209 of each of the four mixtures using companion samples that have been conditioned to the same extent as the compacted specimens (Note 11).

10.5. Determine the design binder content that produces a target (design) air void content (V_a) at N_{design} gyrations using the following steps:

10.5.1. Calculate V_a, VMA, and VFA at N_{design} using Equations 2, 3, and 13:

$$VFA = 100\left(\frac{VMA - V_a}{VMA}\right) \tag{13}$$

10.5.2. Calculate the dust-to-binder ratio using Equation 14:

$$P_{0.075} / P_{be} = \frac{P_{0.075}}{P_{be}} \tag{14}$$

where:

P_{be} = effective binder content.

10.5.3. For each of the four mixtures, determine the average corrected specimen relative densities at N_{initial} $\left(\%G_{mm_{\text{initial}}}\right)$, using Equation 15:

$$\%G_{mm_{\text{initial}}} = 100\left(\frac{G_{mb}h_d}{G_{mm}h_i}\right) \tag{15}$$

10.5.4. Plot the average V_a, VMA, VFA, and relative density at N_{design} for replicate specimens versus binder content.

Note 17—All plots are generated automatically by the Superpave software. Figure 2 presents a sample data set and the associated plots.

10.5.5. By graphical or mathematical interpolation (Figure 2), determine the binder content to the nearest 0.1 percent at which the target V_a is equal to the design requirement. This is the design binder content (P_b) at N_{design}.

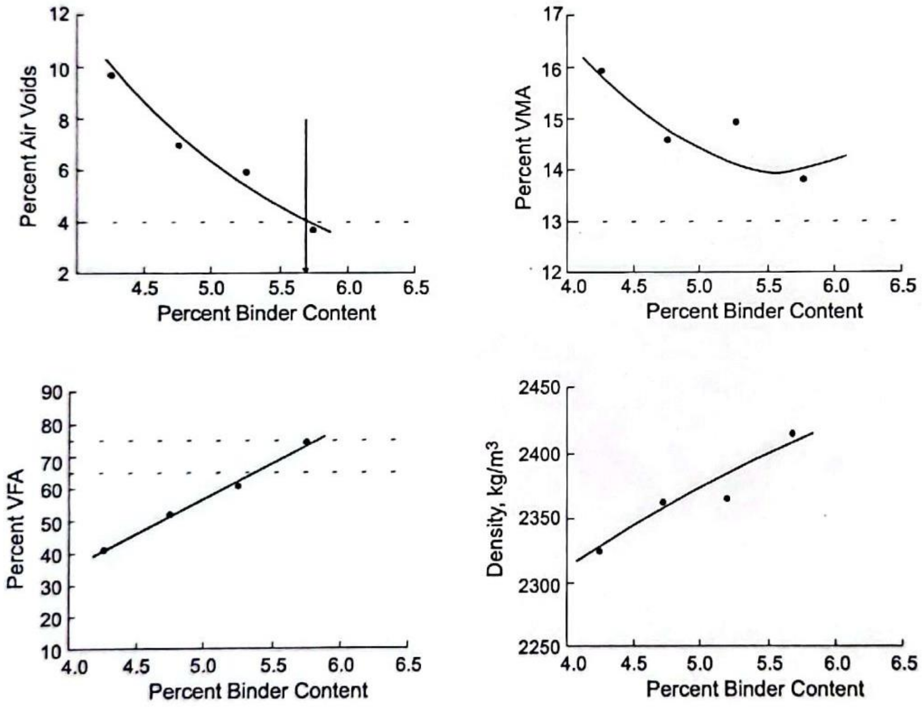
10.5.6. By interpolation (Figure 2), verify that the volumetric requirements specified in M 323 are met at the design binder content.

10.6. Compare the calculated percent of maximum relative density with the design criteria at N_{initial} by interpolation, if necessary. This interpolation can be accomplished by the following procedure.

10.6.1. Prepare a densification curve for each mixture by plotting the measured relative density at X gyrations, $\%G_{mm_X}$, versus the logarithm of the number of gyrations (see Figure 3).

10.6.2. Examine a plot of air void content versus binder content. Determine the difference in air voids between the design air void content and the air void content at the nearest, lower binder content. Determine the air void content at the nearest, lower binder content at its data point, not on the line of best fit. Designate the difference in air void content as ΔV_a.

10.6.3. Using Equation 15, determine the average corrected specimen relative densities at $N_{initial}$ $\left(\%G_{mm_{initial}}\right)$. Confirm that $\%G_{mm_{initial}}$ satisfies the design requirements in M 323 at the design binder content.



Average V_a, VMA, VFA, and Relative Density at N_{design}

P_b (%)	V_a (%)	VMA (%)	VFA (%)	Density at N_{design} (kg/m^3)
4.3	9.5	15.9	40.3	2320
4.8	7.0	14.7	52.4	2366
5.3	6.0	14.9	59.5	2372
5.8	3.7	13.9	73.5	2412

Notes:
1. In this example, the estimated design binder content is 4.8 percent; the minimum VMA requirement for the design aggregate structure (19.0-mm nominal maximum size) is 13.0 percent, and the VFA requirement is 65 to 75 percent.
2. Entering the plot of percent air voids versus percent binder content at 4.0 percent air voids, the design binder content is determined as 5.7 percent.
3. Entering the plots of percent VMA versus percent binder content and percent VFA versus percent binder content at 5.7 percent binder content, the mix meets the VMA and VFA requirements.

Figure 2—Sample Volumetric Design Data for a Superpave Mix Design at N_{design}

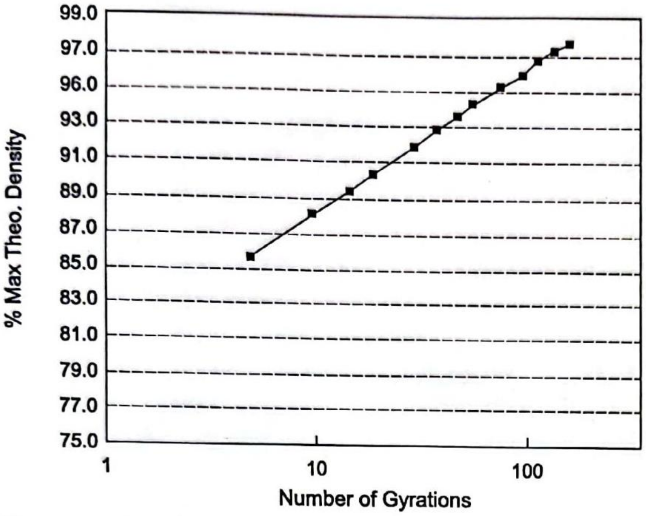


Figure 3—Sample Densification Curve

10.7. Prepare replicate (Note 8) specimens composed of the design aggregate structure at the design binder content to confirm that $\%G_{mm_{\max}}$ satisfies the design requirements in M 323.

10.7.1. Condition the mixtures according to R 30 and compact the specimens according to T 312 to the maximum number of gyrations, $N_{\max}$, from Table 1 for Superpave. See Annex A for maximum number of gyrations, N_{max}, for Superpave5.

10.7.2. Determine the average specimen relative density at $N_{\max}$, $\%G_{mm_{\max}}$, by using Equation 16, and confirm that $\%G_{mm_{\max}}$ satisfies the volumetric requirement in M 323.

$$\%G\left(\frac{G_{mb}}{G_{mm}}\right)_{mm_{\max}} \qquad (16)$$

where:

$\%G_{mm_{\max}}$ = relative density at $N_{\max}$ gyrations at the design binder content.

11. EVALUATING MOISTURE SUSCEPTIBILITY

11.1. Prepare six mixture specimens (nine are needed if freeze–thaw testing is required) composed of the design aggregate structure at the design binder content. Oven-condition the mixture according to T 283 Section 6 and compact the specimens to 7.0 ± 0.5 percent air voids for Superpave mixtures or 5.0 ± 0.5 percent air voids for Superpave5 mixtures according to T 312.

11.2. Group, moisture-condition, test, and evaluate specimens according to T 283. Ensure the asphalt mixture used to determine theoretical maximum specific gravity (G_{mm}) is cured, heated or dried according to T 283, Section 9.1 during the evaluation and grouping of specimens. After curing, heating, or drying according to T 283, Section 9.1, do not further condition the asphalt mixture according to T 209, Section 9.2 before placing the asphalt mixture in a flask, bowl, or pycnometer to determine the theoretical maximum specific gravity (G_{mm}). The design shall meet the tensile strength ratio requirement of M 323.

11.3. If the tensile strength ratio is less than 0.80, as required in M 323, remedial action such as the use of antistrip agents is required to improve the moisture susceptibility of the mix. When remedial agents are used to modify the binder, retest the mix to assure compliance with the 0.80 minimum requirement.

Note 18—The specifying agency may require Hamburg wheel-track testing according to T 324 for evaluating moisture susceptibility.

12. ADJUSTING THE MIXTURE TO MEET VOLUMETRIC PROPERTIES

12.1. *Adjusting VMA*—If a change in the design aggregate skeleton is required to meet the specified VMA, there are three likely options: (1) change the gradation (Note 18); (2) reduce the minus 0.075-mm fraction (Note 19); or (3) change the surface texture and/or shape of one or more of the aggregate fractions (Note 20).

Note 18—Changing gradation may not be an option if the trial aggregate blend gradation analysis includes the full spectrum of the gradation control area.

Note 19—Reducing the percent passing the 0.075-mm sieve of the mix will typically increase the VMA. If the percent passing the 0.075-mm sieve is already low, this is not a viable option.

Note 20—This option will require further processing of existing materials or a change in aggregate sources.

12.2. *Adjusting VFA*—The lower limit of the VFA range should always be met at the design air void content if the VMA meets the requirements. If the upper limit of the VFA is exceeded, then the VMA is substantially above the minimum required. If so, redesign the mixture to reduce the VMA. Actions to consider for redesign include: (1) changing to a gradation that is closer to the maximum density line; (2) increasing the minus 0.075-mm fraction, if room is available within the specification control points; or (3) changing the surface texture and shape of the aggregates by incorporating material with better packing characteristics, e.g., less thin, elongated aggregate particles.

12.3. *Adjusting the Tensile Strength Ratio*—The tensile strength ratio can be increased by (1) adding chemical antistrip agents to the binder to promote adhesion in the presence of water; or (2) adding hydrated lime to the mix.

13. REPORT

13.1. The report shall include the identification of the project number, traffic level, and mix design number.

13.2. The report shall indicate the design air void content, 4.0 percent for Superpave mixtures or 5.0 percent for Superpave5 mixtures.

13.3. The report shall include information on the design aggregate structure including the source of aggregate, kind of aggregate, any RAP materials, required quality characteristics, and gradation.

13.4. The report shall contain information about the design virgin binder including the source, content (%) binder, and the performance grade. Include reclaimed asphalt binder content and binder ratio when used.

13.5. The report shall contain information about the asphalt mixture including the total percent of binder in the mix; the relative density; the number of initial, design, and maximum gyrations; and the VMA, VFA, V_{be}, V_{ba}, V_a, and dust-to-binder ratio.

14. KEYWORDS

14.1. Asphalt mix design; Superpave; Superpave5, volumetric mix design.

ANNEX A

(Mandatory Information)

A1. PREPARING SUPERPAVE5 REPLICATE AGGREGATE SPECIMENS

A1.1. Prepare replicate mixtures (Note A1) at the initial trial binder content for each of the chosen trial aggregate trial blend gradations. From Table A1, determine the number of gyrations based on the design ESALs for the project.

Note A1—At least two replicate specimens are required, but three or more may be prepared if desired. Generally, 4500 to 4700 g of aggregate is sufficient for each compacted specimen with a height of 110 to 120 mm for aggregates with combined bulk specific gravities of 2.55 to 2.70, respectively.

A1.2. Condition the mixtures according to R 30 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.

A1.3. Determine the bulk specific gravity (G_{mb}) of each of the compacted specimens in accordance with T 166 or T 275 as appropriate.

Table A1—Superpave5 Gyratory Compaction Effort

Design ESALs [a] (Million)	Compaction Parameters			Typical Roadway Application [b]
	$N_{initial}$	N_{design}	N_{max}	
<0.3	5	30	40	Applications include roadways with very light traffic volumes, such as local roads, county roads, and city streets where truck traffic is prohibited or at a very minimal level. Traffic on these roadways would be considered local in nature, not regional, intrastate, or interstate. Special purpose roadways serving recreational sites or areas may also be applicable to this level.
0.3 to <3	5	30	40	Applications include many collector roads or access streets. Medium-trafficked city streets and the majority of county roadways may be applicable to this level.
3 to <30	6	50	75	Applications include many two-lane, multilane, divided, and partially or completely controlled access roadways. Among these are medium to highly trafficked city streets, many state routes, U.S. highways, and some rural Interstates.
≥30	6	50	75	Applications include the vast majority of the U.S. Interstate system, both rural and urban in nature. Special applications such as truck-weighing stations or truck-climbing lanes on two-lane roadways may also be applicable to this level.

[a] The anticipated project traffic level expected on the design lane over a 20-year period. Regardless of the actual design life of the roadway, determine the design ESALs for 20 years.

[b] As defined by *A Policy on Geometric Design of Highways and Streets*, AASHTO.

A1.4. Determine the theoretical maximum specific gravity (G_{mm}) according to T 209 of separate samples representing each of these combinations that have been mixed and conditioned to the same extent as the compacted specimens.

Note A2—The maximum specific gravity for each trial mixture shall be based on the average of at least two tests.

APPENDIXES

(Nonmandatory Information)

X1. CALCULATING AN INITIAL TRIAL BINDER CONTENT FOR EACH AGGREGATE TRIAL BLEND

X1.1. Calculate the bulk and apparent specific gravities of the combined aggregate in each trial blend using the specific gravity data for the aggregate fractions obtained in Section 6.6 and Equations X1.1 and X1.2:

$$G_{sb} = \frac{P_1 + P_2 + \ldots + P_n}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \ldots + \frac{P_n}{G_n}} \qquad (X1.1)$$

$$G_{sa} = \frac{P_1 + P_2 + \ldots + P_n}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \ldots + \frac{P_n}{G_n}} \qquad (X1.2)$$

where:

G_{sb} = bulk specific gravity for the combined aggregate;
$P_1, P_2, \ldots P_n$ = percentages by mass of aggregates 1, 2, . . .*n*;
$G_1, G_2, \ldots G_n$ = bulk specific gravities (Equation X1.1) or apparent specific gravities (Equation X1.2) of aggregates 1, 2, *n*; and
G_{sa} = apparent specific gravity for the combined aggregate.

X1.2. Estimate the effective specific gravity of the combined aggregate in the aggregate trial blend using Equation X1.3:

$$G_{se} = G_{sb} + 0.8(G_{sa} - G_{sb}) \qquad (X1.3)$$

where:

G_{se} = effective specific gravity of the combined aggregate,
G_{sb} = bulk specific gravity of the combined aggregate; and
G_{sa} = apparent specific gravity of the combined aggregate.

Note X1—The multiplier, 0.8, can be changed at the discretion of the designer. Absorptive aggregates may require values closer to 0.6 or 0.5.

Note X2—The Superpave mix design system includes a mixture-conditioning step before the compaction of all specimens; this conditioning generally permits binder absorption to proceed to completion. Therefore, the effective specific gravity of Superpave mixtures will tend to be close to the apparent specific gravity in contrast to other design methods where the effective specific gravity generally will lie near the midpoint between the bulk and apparent specific gravities.

X1.3. Estimate the volume of binder absorbed into the aggregate, V_{ba}, using Equations X1.4 and X1.5:

$$V_{ba} = W_s \left(\frac{1}{G_{sb}} - \frac{1}{G_{se}} \right) \qquad (X1.4)$$

where:

W_s, the mass of aggregate in 1 cm³ of mix, g, is calculated as:

$$W_s = \frac{P_s(1-V_a)}{\frac{P_b}{G_b}+\frac{P_s}{G_{se}}} \qquad (X1.5)$$

and where:

P_s = mass percent of aggregate, in decimal equivalent, assumed to be 0.95;

V_a = volume of air voids, assumed to be 0.04 cm^3 in 1 cm^3 of mix for Superpave and 0.05 cm^3 for Superpave5;

P_b = mass percent of binder, in decimal equivalent, assumed to be 0.05; and

G_b = specific gravity of the binder.

X1.4. Estimate the volume of effective binder using Equation X1.6:

$$V_{be} = 0.176 - \left[0.0675\log\left(S_n\right)\right] \qquad (X1.6)$$

where:

V_{be} = volume of effective binder, cm^3; and

S_n = nominal maximum sieve size of the largest aggregate in the aggregate trial blend, mm.

Note X3—This regression equation is derived from an empirical relationship between (1) VMA and V_{be} when the air void content, V_a, is equal to:

- 4.0 percent: V_{be} = VMA – V_a = VMA – 4.0, or
- 5.0 percent: V_{be} = VMA – V_a = VMA – 5.0

and

(2) the relationship between VMA and the nominal maximum sieve size of the aggregate in M 323. This equation applies for both Superpave and Superpave5 of the same nominal maximum size because the minimum V_{be} is the same for either mixture.

X1.5. Calculate the estimated initial trial binder (P_{bi}) content for the aggregate trial blend gradation using Equation X1.7:

$$P_{bi} = 100\left(\frac{G_b\left(V_{be}+V_{ba}\right)}{\left(G_b\left(V_{be}+V_{ba}\right)\right)+W_s}\right) \qquad (X1.7)$$

where:

P_{bi} = estimated initial trial binder content, percent by weight of total mix.

X2. SPECIAL MIXTURE DESIGN CONSIDERATIONS AND PRACTICES FOR WARM MIX ASPHALT (WMA)

X2.1. *Purpose*:

X2.1.1. This appendix presents special mixture design considerations and methods for designing warm mix asphalt (WMA) using R 35. WMA refers to asphalt mixtures that are produced at temperatures approximately 50°F (28°C) or more lower than typically used in the production of HMA (hot mix asphalt). The goal of WMA is to produce mixtures with equivalent strength, durability, and performance characteristics as HMA using substantially reduced production temperatures.

These special mixture design considerations and practices are applicable anytime a WMA technology is being used. The WMA technologies may be used as coating and compaction aids without lowering the production temperature by 50°F (28°C).

X2.1.2. The practices in this appendix are applicable to a wide range of WMA technologies including:

- WMA additives that are added to the asphalt binder,
- WMA additives that are added to the mixture during production,
- Wet aggregate mixtures, and
- Plant foaming processes.

X2.1.3. The information in this appendix supplements the procedures in R 35. This appendix assumes the user is proficient with the standard procedures in R 35.

X2.2. *Summary*:

X2.2.1. This appendix includes separate sections addressing the following aspects of WMA mixture design:

- Additional Laboratory Equipment;
- WMA Technology Selection;
- Binder Grade Selection;
- RAP in WMA;
- Technology-Specific Specimen Fabrication Procedures;
- WMA Mixture Evaluations:
  - Coating,
  - Compactability,
  - Evaluating of Moisture Sensitivity,
  - Evaluation of Rutting Resistance; and
- Adjusting the Mixture to Meet Specification Requirements.

X2.2.2. In each section, reference is made to the applicable section of R 35.

X2.3. *Additional Laboratory Equipment*:

X2.3.1. All WMA Processes:

X2.3.1.1. *Mechanical Mixer*—A planetary mixer with a wire whip having a capacity of 20-qt or a 5-gal bucket mixer.

Note X4—The mixing times in this appendix were developed using a planetary mixer with a wire whip, Blakeslee Model B-20 or equivalent. Appropriate mixing times for bucket mixers should be established by evaluating the coating of asphalt mixtures prepared at the viscosity-based mixing temperatures specified in T 312.

X2.3.2. Binder Additive WMA Processes:

X2.3.2.1. *Low-Shear Mechanical Stirrer*—A low-shear mechanical stirrer with appropriate impeller to homogeneously blend the additive in the binder.

X2.3.3. Plant Foaming Processes:

X2.3.3.1. *Laboratory Foamed Asphalt Plant*—A laboratory-scale foamed asphalt plant capable of producing consistent foamed asphalt at the water content used in field production. The device should be capable of producing foamed asphalt for laboratory batches ranging from approximately 10 to 20 kg.

X2.4. *WMA Technology Selection*:

X2.4.1. There are more than 20 WMA technologies being marketed in the United States. Select the WMA technology that will be used in consultation with the specifying agency and technical representatives from the WMA technology providers. Consideration should be given to a number of factors including (1) available performance data, (2) the cost of the WMA additives, (3) planned production and compaction temperatures, (4) planned production rates, (5) plant capabilities, and (6) modifications required to successfully use the WMA technology with available field and laboratory equipment.

X2.4.2. Determine the planned production and field compaction temperatures.

X2.5. *Binder Grade Selection*:

X2.5.1. Use the same grade of binder normally used with HMA. Select the performance grade of the binder in accordance with M 323, considering the environment and traffic at the project site.

Note X5—For WMA technologies having production temperatures that are 100°F (56°C) or more lower than HMA production temperatures, it may be necessary to increase the high-temperature performance grade of the binder one grade level to meet the rutting resistance requirements included in this appendix.

X2.6. *RAP in WMA*:

X2.6.1. For WMA mixtures incorporating RAP, the planned field compaction temperature shall be greater than the as-recovered high-temperature grade of the RAP binder.

Note X6—This requirement is included to ensure mixing of the new and reclaimed binders. Laboratory studies showed that new and reclaimed binders do mix at WMA process temperatures provided this requirement is satisfied and the mixture remains at or above the planned compaction temperature for at least 2 h. Plant mixing should be verified through an evaluation of volumetric or stiffness properties of plant-produced mixtures.

X2.6.2. Select RAP materials in accordance with M 323.

X2.6.3. For blending chart analyses, the intermediate and low-temperature properties of the virgin binder may be improved using Table X2.1.

Note X7—The intermediate and low-temperature grade improvements given in Table X2.1 will allow additional RAP to be used in WMA mixtures when blending chart analyses are used. An approximate 0.6°C improvement in the low-temperature properties will allow approximately 10 percent additional RAP binder to be added to the mixture based on blended binder grade requirements.

Table X2.1—Recommended Improvement in Virgin Binder Low-Temperature Continuous Grade for RAP Blending Chart Analysis for WMA Production Temperatures

Virgin binder PG grade	58-28	58-22	64-22	64-16	67-22
Average HMA production temperature, °F	285	285	292	292	300
Rate of improvement of virgin binder low-temperature grade per 1°C reduction in plant temperature	0.035	0.025	0.025	0.012	0.025
WMA Production Temperature, °F	Recommended Improvement in Virgin Binder Low-Temperature Continuous Grade for RAP Blending Chart Analysis, °C				
300	NA	NA	NA	NA	0.0
295	NA	NA	NA	NA	0.1
290	NA	NA	0.0	0.0	0.1
285	0.0	0.0	0.1	0.0	0.2
280	0.1	0.1	0.2	0.1	0.3
275	0.2	0.1	0.2	0.1	0.3
270	0.3	0.2	0.3	0.1	0.4
265	0.4	0.3	0.4	0.2	0.5
260	0.5	0.3	0.4	0.2	0.6
255	0.6	0.4	0.5	0.2	0.6
250	0.7	0.5	0.6	0.3	0.7
245	0.8	0.6	0.7	0.3	0.8
240	0.9	0.6	0.7	0.3	0.8
235	1.0	0.7	0.8	0.4	0.9
230	1.1	0.8	0.9	0.4	1.0
225	1.2	0.8	0.9	0.4	1.0
220	1.3	0.9	1.0	0.5	1.1
215	1.4	1.0	1.1	0.5	1.2
210	1.5	1.0	1.1	0.5	1.3

X2.6.4. Blending Chart Example:

X2.6.4.1. *Problem Statement*—A producer will be producing WMA using a virgin PG 64-22 binder at a temperature of 250°F. In the mixture, 35 percent of the total binder will be replaced with RAP binder, so according to M 323 a blending chart analysis is needed. The continuous grade of the recovered RAP binder is PG 93.0 (29.4) – 18.1. The continuous grade of the virgin PG 64-22 binder is PG 66.2 (21.1) – 23.9. The specified grade for the blended binder in the mixture is PG 64-22. Use the M 323 blending chart analysis to determine if the proposed RAP and virgin binder provide an acceptable blended binder.

X2.6.4.2. *Solution as WMA*—Because the mixture will be produced as WMA at 250°F, determine the virgin binder grade improvement for the blending chart analysis by entering Table X2.1 in the PG 64-22 column and reading the intermediate- and low-temperature improvement from the row for 250°F. The intermediate- and low-temperature grade improvement is 0.6°C. For WMA at 250°F, perform the M 323 blending chart analysis using PG 66.2 (20.5) –24.5 for the virgin binder and PG 93.0 (29.4) –18.1 for the RAP Binder. Because a PG 64-XX virgin binder is being used and a PG 64-XX is specified, it is not necessary to check the high-temperature grade. Use Equation X1.12 from M 323 to determine the maximum allowable RAP content based on the intermediate and low temperatures. For PG 64-22, 25°C is the maximum allowable blended binder intermediate-temperature grade and –22°C the maximum allowable blended binder low-temperature grade.

$$\text{RAP} = \frac{\left(T_{\text{blend}} - T_{\text{virgin}}\right)}{\left(T_{\text{RAP}} - T_{\text{virgin}}\right)} \quad \text{(Eq. X1.12 from M 323)}$$

where:

RAP = percentage of RAP, by weight, expressed as a decimal to the nearest 0.001;

T_{blend} = continuous grade temperature of the blended binder (high, intermediate, low);

T_{virgin} = continuous grade temperature of the virgin binder (high, intermediate, low); and

T_{RAP} = continuous grade temperature of the RAP binder (high, intermediate, low).

Maximum RAP Binder Based on Intermediate-Temperature Grade:

$$\%RAP = \frac{(25 - 20.5)}{(29.4 - 20.5)} \times 100 = \frac{4.5}{8.9} \times 100 = 50.5\%$$

Maximum RAP Binder Based on Low-Temperature Grade:

$$\%RAP = \frac{(-22 - (-24.5))}{(-18.1 - (24.5))} \times 100 = \frac{2.5}{6.4} \times 100 = 39.0\%$$

The critical property is the low-temperature grade, which allows 39.0 percent of the binder to be RAP binder. The proposed mixture contains only 35 percent RAP binder; therefore, it is acceptable.

X2.6.4.3. *Solution as HMA*—If the mixture were produced as HMA, the blending chart analysis would be completed using PG 66.2 (21.1) –23.9 for the virgin binder and PG 93.0 (29.4) –18.1 for the RAP binder.

Maximum RAP Binder Based on Intermediate-Temperature Grade:

$$\%RAP = \frac{(25 - 21.1)}{(29.4 - 21.1)} \times 100 = \frac{3.9}{8.3} \times 100 = 47.0\%$$

Maximum RAP Binder Based on Low-Temperature Grade:

$$\%RAP = \frac{(-22 - (-23.9))}{(-18.1 - (23.9))} \times 100 = \frac{1.9}{5.8} \times 100 = 32.7\%$$

Again, the critical property is the low-temperature grade, but this time the proposed RAP binder content of 35 percent exceeds the maximum allowable of 32.7 percent; therefore, the HMA mixture is not acceptable.

X2.7. *Technology-Specific Specimen Fabrication Procedures*:

X2.7.1. Batching:

X2.7.1.1. Determine the number and size of specimens that are required. Table X2.2 summarizes approximate specimen sizes for WMA mixture design.

Note X8—The mass of mixture required for the various specimens depends on the specific gravity of the aggregate and the air void content of the specimen. Trial specimens may be required to determine appropriate batch weights for T 283 and flow number testing.

Table X2.2—Specimen Requirements

Specimen Type	Gyratory Specimen Size	Approximate Specimen Mass	Number Required
Maximum specific gravity	NA	500 to 6000 g depending on maximum aggregate size	2 per trial blend, plus 8 to determine design binder content, plus 1 at the design binder content for compactability evaluation
Volumetric design	150-mm diameter by 115 mm high	4700 g	2 per trial blend, plus 8 to determine design binder content
Coating	NA	500 to 6,000 g depending on maximum aggregate size	1 at the design binder content
Compactability	150-mm diameter by 115 mm high	4700 g	4 at the design binder content
T 283	150-mm diameter by 95 mm high	3800 g	6 at the design binder content
Flow number	150-mm diameter by 175 mm high	7000 g	4 at the design binder content

X2.7.1.2. Prepare a batch sheet showing the batch weight of each aggregate fraction, RAP, and the asphalt binder.

X2.7.1.3. Weigh into a pan the weight of each aggregate fraction.

Note X9—For WMA processes that use wet aggregate, weigh the portion of the aggregate that will be heated into one pan and weigh the portion of the aggregate that will be wetted into a second pan.

X2.7.1.4. Weigh into a separate pan, the weight of RAP.

X2.7.2. *Heating*:

X2.7.2.1. Place the aggregate in an oven set at approximately 15°C higher than the planned production temperature. The oven shall be thermostatically controlled, capable of maintaining any desired temperature setting from room temperature to 176°C within ±3°C. Oven(s) shall be capable of operation at the temperatures required, as corrected, if necessary, by calibration. More than one oven may be used, provided each is used within its proper operating temperature range. The thermometer(s) for measuring the temperature of the oven(s) shall meet the requirements of M 339M/M 339 with a temperature range of at least 20 to 185°C, and an accuracy of ±0.75°C (see Note X10).

Note X10—The aggregate will require 2 to 4 h to reach the temperature of the oven. Aggregates may be placed in the oven overnight. Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; or IEC 60584 thermocouple thermometer, Type T, Class 1.

X2.7.2.2. Heat the RAP in the oven with the aggregates but limit the heating time for the RAP to 2 h.

X2.7.2.3. Heat the binder to the planned production temperature.

X2.7.2.4. Heat mixing bowls and other tools to the planned production temperature.

X2.7.2.5. Preheat a forced draft oven and pans to the planned field compaction temperature for use in short-term conditioning the mixture.

X2.7.3. *Preparation of WMA Mixtures with WMA Additive Added to the Binder*:

Note X11—If specific mixing and storage instructions are provided by the WMA additive supplier, follow the supplier's instructions.

X2.7.3.1. Adding WMA Additive to Binder:

X2.7.3.1.1. Weigh the required amount of the additive into a small container.

Note X12—The additive is typically specified as a percent by weight of binder. For mixtures containing RAP, determine the weight of additive based on the total binder content of the mixture.

X2.7.3.1.2. Heat the asphalt binder in a covered container in an oven set at 135°C until the binder is sufficiently fluid to pour. During heating occasionally stir the binder manually to ensure homogeneity.

X2.7.3.1.3. Add the required amount of additive to the binder, and stir it with a mechanical stirrer until the additive is totally dispersed in the binder.

X2.7.3.1.4. Store the binder with WMA additive at room temperature in a covered container until needed for use in the mixture design.

X2.7.3.2. Preparing WMA Specimens:

X2.7.3.2.1. Heat the mixing tools, aggregate, RAP, and binder in accordance with Section X2.7.2.

X2.7.3.2.2. If a liquid antistripping additive is required, add it to the binder per the manufacturer's instructions.

X2.7.3.2.3. Place the hot mixing bowl on a scale, and tare the scale.

X2.7.3.2.4. Charge the mixing bowl with the heated aggregates and RAP, and dry-mix thoroughly.

X2.7.3.2.5. Form a crater in the blended aggregate, and weigh the required amount of asphalt binder into the mixture to achieve the desired batch weight.

Note X13—If the aggregates and RAP have been stored for an extended period of time in a humid environment, then it may be necessary to adjust the weight of binder based on the oven-dry weight of the aggregates and RAP as follows:

1. Record the oven-dry weight of the aggregates and RAP, w_i.
2. Determine the target total weight of the mixture as follows:

$$w_t = \frac{w_i}{\left(1 - \frac{P_{b_{new}}}{100}\right)} \qquad (X2.1)$$

where:

w_t = target total weight, g;
w_i = oven-dry weight from Step 1, g; and
$P_{b_{new}}$ = percent by weight of total mix of new binder in the mixture.

3. Add new binder to the bowl to reach w_t.

X2.7.3.2.6. Remove the mixing bowl from the scale, and mix the material with a mechanical mixer for 90 s.

X2.7.3.2.7. Oven-condition the mixture by placing it in a flat, shallow pan at an even thickness of 25 to 50 mm, and place the pan in the forced-draft oven for 2 h ± 5 min at the planned field compaction temperature ±3°C. Stir the mixture once after 1 h ± 5 min to maintain uniform conditioning.

X2.7.4. *Preparation of WMA Mixtures with WMA Additive Added to the Mixture:*

Note X14—If specific mixing and storage instructions are provided by the WMA additive supplier, follow the supplier's instructions.

X2.7.4.1. Weigh the required amount of the additive into a small container.

Note X15—The quantity of additive may be specified as a percent by weight of binder or a percent by weight of total mixture.

X2.7.4.2. If a liquid antistripping additive is required, add it to the binder per the manufacturer's instructions.

X2.7.4.3. Heat the mixing tools, aggregate, RAP, and binder in accordance with Section X2.7.2.

X2.7.4.4. Place the hot mixing bowl on a scale, and tare the scale.

X2.7.4.5. Charge the mixing bowl with the heated aggregates and RAP, and dry-mix thoroughly.

X2.7.4.6. Form a crater in the blended aggregate, and weigh the required amount of asphalt binder into the mixture to achieve the desired batch weight.

Note X16—If the aggregates and RAP have been stored for an extended period of time in a humid environment, then it may be necessary to adjust the weight of binder based on the oven-dry weight of the aggregates and RAP as follows:

1. Record the oven-dry weight of the aggregates, and RAP, w_i.
2. Determine the target total weight of the mixture as follows:

$$w_t = \frac{w_i}{\left(1 - \frac{P_{b_{new}}}{100}\right)} \qquad (X2.2)$$

where:

w_t = target total weight, g;

w_i = oven-dry weight from Step 1, g; and

$P_{b_{new}}$ = percent by weight of total mix of new binder in the mixture.

3. Add new binder to the bowl to reach w_t.

X2.7.4.7. Pour the WMA additive into the pool of new asphalt binder.

X2.7.4.8. Remove the mixing bowl from the scale, and mix material with a mechanical mixer for 90 s.

X2.7.4.9. Oven-condition the mixture by placing it in a flat, shallow pan at an even thickness of 25 to 50 mm, and place the pan in the forced-draft oven for 2 h ± 5 min at the planned field compaction temperature ± 3°C. Stir the mixture once after 1 h ± 5 min to maintain uniform conditioning.

X2.7.5. *Preparation of WMA Mixtures with a Wet Fraction of Aggregate*:

Note X17—Consult the WMA process supplier for appropriate additive dosage rates, mixing temperatures, percentage of wet aggregate, and wet aggregate moisture content.

X2.7.5.1. Adding WMA Additive to Binder:

X2.7.5.1.1. Weigh the required amount of the additive into a small container.

Note X18—The additive is typically specified as a percent by weight of binder. For mixtures containing RAP, determine the weight of additive based on the total binder content of the mixture.

X2.7.5.1.2. Heat the asphalt binder in a covered container in an oven set at 135°C until the binder is sufficiently fluid to pour. During heating occasionally stir the binder manually to ensure homogeneity.

X2.7.5.1.3. Add the required amount of additive to the binder, and stir it with a mechanical stirrer until the additive is totally dispersed in the binder.

X2.7.5.2. Preparing WMA Specimens:

X2.7.5.2.1. Add the required amount of moisture to the wet fraction of the aggregate. Mix it thoroughly, then cover and let stand for at least 2 h before mixing it with the heated fraction.

X2.7.5.2.2. Heat the mixing tools, dry aggregate portion, and dry RAP portion to the initial mixing temperature in accordance with Section X2.7.2.

X2.7.5.2.3. Place the hot mixing bowl on a scale, and tare the scale.

X2.7.5.2.4. Charge the mixing bowl with the heated aggregates and RAP, and dry-mix thoroughly.

X2.7.5.2.5. Form a crater in the blended aggregate, and weigh the required amount of asphalt binder into the mixture to achieve the desired batch weight.

Note X19—If the aggregates and RAP have been stored for an extended period of time in a humid environment, it may be necessary to adjust the weight of binder based on the oven-dry weight of the aggregates and RAP as follows:

1. Record the oven-dry weight of the aggregates and RAP, w_i.
2. Determine the target total weight of the mixture as follows:

$$w_t = \frac{\left(w_i + w_{dwf}\right)}{\left(1 - \frac{P_{b_{new}}}{100}\right)} \quad (X2.3)$$

where:

w_t = target total weight, g;
w_i = oven-dry weight from Step 1, g;
w_{dwf} = oven-dry weight of the wet fraction from the batch sheet, g; and
$P_{b_{new}}$ = percent by weight of total mix of new binder in the mixture.

3. Determine the target weight of the heated mixture:

$$w_{thm} = w_t - w_{dwf} \quad (X2.4)$$

where:

w_{thm} = target weight of the heated mixture, g;
w_t = target total weight, g; and
w_{dwf} = oven-dry weight of the wet fraction from the batch sheet.

4. Add new binder to the bowl to reach w_{thm}.

X2.7.5.2.6. Add the additive to the binder immediately before mixing it with the heated fraction of the aggregate according to Section X2.7.5.1.

X2.7.5.2.7. Remove the mixing bowl from the scale, and mix the material with a mechanical mixer for 30 s.

X2.7.5.2.8. Stop the mixer, and immediately add the wet fraction aggregate.

X2.7.5.2.9. Restart the mixer, and continue to mix for 60 s.

X2.7.5.2.10. Place the mixture in a flat, shallow pan at an even thickness of 25 to 50 mm.

X2.7.5.2.11. Check the temperature of the mixture in the pan to ensure it is between 90 and 100°C.

X2.7.5.2.12. Oven-condition the mixture by placing the pan in the forced-draft oven for 2 h ± 5 min at the planned field compaction temperature ± 3°C. Stir the mixture once after 1 h ± 5 min to maintain uniform conditioning.

X2.7.6. *Preparation of Foamed Asphalt Mixtures:*

X2.7.6.1. The preparation of foamed asphalt mixtures requires special asphalt binder foaming equipment that can produce foamed asphalt using the amount of moisture that will be used in field production.

X2.7.6.2. Prepare the asphalt binder foaming equipment, and load it with binder per the manufacturer's instructions.

X2.7.6.3. If a liquid antistripping additive is required, add it to the binder in the foaming equipment according to the manufacturer's instructions.

X2.7.6.4. Heat the mixing tools, aggregate, and RAP in accordance with Section X2.7.2.

X2.7.6.5. Prepare the foamed asphalt binder according to the instructions for the foaming equipment.

X2.7.6.6. Place the hot mixing bowl on a scale, and tare the scale.

X2.7.6.7. Charge the mixing bowl with the heated aggregates and RAP, and dry-mix thoroughly.

X2.7.6.8. Form a crater in the blended aggregate, and add the required amount of foamed asphalt into the mixture to achieve the desired batch weight.

Note X20—The laboratory foaming equipment uses a timer to control the amount of foamed asphalt produced. Ensure the batch size is large enough that the required amount of foamed asphalt is within the calibrated range of the foaming device. This operation may require producing one batch for the two gyratory specimens and the two maximum specific gravity specimens at each asphalt content, then splitting the larger batch into individual samples.

Note X21—If the aggregates and RAP have been stored for an extended period of time in a humid environment, then it may be necessary to adjust the weight of binder based on the oven-dry weight of the aggregates and RAP as follows:

1. Record the oven-dry weight of the aggregates and RAP, w_i.
2. Determine the target total weight of the mixture as follows:

$$w_t = \frac{w_i}{\left(1 - \frac{P_{b_{new}}}{100}\right)} \tag{X2.5}$$

where:

w_t = target total weight, g;

w_i = oven-dry weight from Step 1, g; and

$P_{b_{new}}$ = percent by weight of total mix of new binder in the mixture.

3. Add foamed binder to the bowl to reach w_t.

X2.7.6.9. Remove the mixing bowl from the scale, and mix the materials with a mechanical mixer for 90 s.

X2.7.6.10. Oven-condition the mixture by placing it in a flat, shallow pan at an even thickness of 25 to 50 mm, and place the pan in the forced-draft oven for 2 h ± 5 min at the planned field compaction temperature ± 3°C. Stir the mixture once after 1 h ± 5 min to maintain uniform conditioning.

X2.8. *WMA Mixture Evaluations*:

X2.8.1. At the optimum binder content determined in accordance with R 35, prepare WMA mixtures in accordance with the appropriate procedure from Section X2.7 for the following evaluations:

- Coating
- Compactability
- Moisture sensitivity
- Rutting resistance

X2.8.2. *Coating*:

X2.8.2.1. Prepare a sufficient amount of mixture at the design binder content to perform the coating evaluation procedure in T 195 using the appropriate WMA fabrication procedure from Section X2.7. Do not oven-condition the mixture.

X2.8.2.2. Evaluate the coating in accordance with T 195.

X2.8.2.3. The recommended coating criterion is at least 95 percent of the coarse aggregate particles being fully coated.

X2.8.3. *Compactability*:

X2.8.3.1. Prepare a sufficient amount of mixture at the design binder content for four gyratory specimens and one maximum specific gravity measurement using the appropriate WMA fabrication procedure from Section X2.7 including oven-conditioning for 2 h ± 5 min at the planned field compaction temperature.

X2.8.3.2. Determine the theoretical maximum specific gravity (G_{mm}) according to T 209.

X2.8.3.3. Compact duplicate specimens at the planned field compaction temperature to N_{design} gyrations according to T 312. Record the specimen height for each gyration.

X2.8.3.4. Determine the bulk specific gravity (G_{mb}) of each specimen according to T 166.

X2.8.3.5. Allow the mixture to cool to 30°C below the planned field compaction temperature. Compact duplicate specimens to N_{design} gyrations determined from Table 1 for Superpave or from Annex A1 for Superpave5 according to T 312. Record the specimen height for each gyration.

X2.8.3.6. Determine the bulk specific gravity (G_{mb}) of each specimen according to T 166.

X2.8.3.7. For each specimen, determine the corrected specimen relative densities for each gyration using Equation X2.6:

$$\%G_{mm_N} = 100\left(\frac{G_{mb}h_d}{G_{mm}h_N}\right) \qquad (X2.6)$$

where:

$\%G_{mm_N}$ = relative density at N gyrations;

G_{mb} = bulk specific gravity of the specimen compacted to N_{design} gyrations;

h_d = height of the specimen after N_{design} gyrations, from the Superpave gyratory compactor, mm; and

h_N = height of the specimen after N gyrations, from the Superpave gyratory compactor, mm.

X2.8.3.8. For each Superpave specimen, determine the number of gyrations needed to reach 92 percent relative density. For Superpave5 specimens, determine the number of gyrations needed to reach 95 percent relative density.

X2.8.3.9. For Superpave mixtures, determine the average number of gyrations needed to reach 92 percent relative density at the planned field compaction temperature. For Superpave5 mixtures, determine the average number of gyrations needed to reach 95 percent relative density at the planned field compaction temperature.

X2.8.3.10. For Superpave mixtures, determine the average number of gyrations needed to reach 92 percent relative density at 30°C below the planned field compaction temperature. For Superpave5 mixtures, determine the average number of gyrations needed to reach 95 percent relative density at 30°C below the planned field compaction temperature.

X2.8.3.11. Determine the gyration ratio using Equation X2.7 for Superpave mixtures:

$$\text{ratio} = \frac{(N_{92})_{T-30}}{(N_{92})_T} \tag{X2.7}$$

where:

ratio = gyration ratio;

$(N_{92})_{T-30}$ = gyrations needed to reach 92 percent relative density at 30°C below the planned field compaction temperature; and

$(N_{92})_T$ = gyrations needed to reach 92 percent relative density at the planned field compaction temperature.

X2.8.3.12. Determine the gyration ratio using Equation X2.8 for Superpave5 mixtures:

$$\text{ratio} = \frac{(N_{95})_{T-30}}{(N_{95})_T} \tag{X2.8}$$

where:

ratio = gyration ratio;

$(N_{95})_{T-30}$ = gyrations needed to reach 95 percent relative density at 30°C below the planned field compaction temperature; and

$(N_{95})_T$ = gyrations needed to reach 95 percent relative density at the planned field compaction temperature.

X2.8.3.13. The recommended compactability criterion is a gyration ratio less than or equal to 1.25.

Note X22—The compactability criterion limits the temperature sensitivity of WMA to that for a typical HMA mixture. The criterion is based on limited research conducted in NCHRP 9-43. The criterion should be considered tentative and subject to change as additional data on WMA mixtures are collected.

X2.8.4. *Evaluating Moisture Sensitivity*:

X2.8.4.1. Prepare a sufficient amount of mixture at the design binder content for six gyratory specimens using the appropriate WMA fabrication procedure from Section X2.7 without oven-conditioning required by Section X2.7.3.2.7, Section X2.7.4.9, Section X2.7.5.2.12, or Section X2.7.6.10. Oven-condition the mixture according to T 283, Section 6.

X2.8.4.2. For Superpave mixtures, compact test specimens to 7.0 ± 0.5 percent air voids according to T 312. For Superpave5 compact test specimens, to 5.0 ± 0.5 percent air voids according to T 312.

X2.8.4.3. Group, moisture-condition, test, and evaluate the specimens according to T 283.

X2.8.4.4. The recommended moisture sensitivity criteria are a tensile strength ratio greater than 0.80 and no visual evidence of stripping.

X2.8.5. *Evaluating Rutting Resistance*:

X2.8.5.1. Evaluate rutting using the flow number test in T 378.

Note X23—WMA additives and processes may affect the rutting resistance of the mixture and rutting resistance should be evaluated. Agencies with established criteria for other test methods, such as T 320 (SST), T 324 (Hamburg), and T 340 (APA), may specify those methods in lieu of T 378.

X2.8.5.2. Prepare a sufficient amount of mixture at the design binder content for four flow number test specimens using the appropriate WMA fabrication procedure from Section X2.7 including oven-conditioning for 2 h ± 5 min at the planned field compaction temperature.

X2.8.5.3. The test is conducted on 100-mm diameter by 150-mm-high test specimens that are sawed and cored from larger gyratory specimens that are 150-mm diameter by at least 160 mm high. Refer to R 83 for detailed test specimen fabrication procedures. Do not oven-condition the mixture according to R 83, Section 9.2.3. Oven-condition WMA mixtures according to Section X2.7.

X2.8.5.4. For Superpave mixtures, prepare the flow number test specimens to 7.0 ± 1.0 percent air voids. For Superpave5 mixtures, prepare the flow number test specimens to 5.0 ± 1.0 percent air voids.

X2.8.5.5. Perform the flow number test at the design temperature at 50 percent reliability as determined using LTPPBind (Note 1). The temperature is computed at 20 mm for surface courses, and the top of the pavement layer for intermediate and base courses.

X2.8.5.6. Perform the flow number test unconfined using a repeated deviatoric stress of 600 kPa with a contact deviatoric stress of 30 kPa.

X2.8.5.7. Determine the flow number for each specimen; then average the results. Compare the average flow number with the criteria given in Table X2.3.

Table X2.3—Minimum Flow Number Requirements

Traffic Level, Million ESALs	Minimum Flow Number
<3	NA
3 to <10	30
10 to <30	105
≥30	415

X2.9. *Adjusting the Mixture to Meet Specification Properties*:

X2.9.1. This section provides guidance for adjusting the mixture to meet the evaluation criteria contained in Section X2.8. For WMA mixtures, this section augments Section 12 in R 35.

X2.9.2. *Improving Coating*—Most WMA processes involve complex chemical reactions, thermodynamic processes, or both. Consult the WMA additive supplier for methods to improve coating.

X2.9.3. *Improving Compactability*—Most WMA processes involve complex chemical reactions, thermodynamic processes, or both. Consult the WMA additive supplier for methods to improve compactability.

X2.9.4. *Improving the Tensile Strength Ratio*—Some WMA processes include adhesion promoters to improve resistance to moisture damage. Consult the WMA additive supplier for methods to improve the tensile strength ratio.

X2.9.5. *Improving Rutting Resistance*—The rutting resistance of WMA can be improved through changes in binder grade and volumetric properties. The following rules of thumb can be used to identify mixture adjustments that improve rutting resistance.

- Increasing the high-temperature performance grade by one grade level improves rutting resistance by a factor of 2.
- Adding 25 to 30 percent RAP will increase the high-temperature performance grade by approximately one grade level.
- Increasing the fineness modulus (sum of the percent passing the 0.075-, 0.150-, and 0.300-mm sieves) by 50 improves rutting resistance by a factor of 2.
- Decreasing the design VMA by 1 percent will improve rutting resistance by a factor of 1.2.
- Increasing N_{design} by one level will improve rutting resistance by a factor of 1.2.

Note X24—These rules for mixture adjustment are documented in *NCHRP Report 567: Volumetric Requirements for Superpave Mix Design.*

X2.10. *Additional Reporting Requirements for WMA*:

X2.10.1. For WMA mixtures, report the following information in addition to that required in R 35:

X2.10.1.1. WMA process description;

X2.10.1.2. Planned production temperature;

X2.10.1.3. Planned field compaction temperature;

X2.10.1.4. High-temperature grade of the recovered binder in the RAP for mixtures incorporating RAP;

X2.10.1.5. Coating at the design binder content;

X2.10.1.6. For Superpave mixtures, the gyrations needed to reach 92 percent relative density for the design binder content at the planned field compaction temperature and 30°C below the planned field compaction temperature. For Superpave5 mixtures, the gyrations needed to reach 95 percent relative density for the design binder content at the planned field compaction temperature and 30°C below the planned field compaction temperature;

X2.10.1.7. Gyration ratio;

X2.10.1.8. Dry tensile strength, tensile strength ratio, and observed stripping at the design binder content; and

X2.10.1.9. Flow number test temperature and the flow number at the design binder content.

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[1] Formerly AASHTO Provisional Standard PP 28. First published as a full standard in 2004.

Illinois Modified Test Procedure
Effective Date: January 1, 1998
Revised Date: December 1, 2022

Standard Method of Test
for
Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus

Reference AASHTO T 245-22

AASHTO Section	***Illinois Modification***
3.3	Replace the first sentence with the following: *Ring Dynamometer Assembly* – One-ring dynamometer (Figure 2) of 44.4 kN (10,000 lb) capacity and sensitivity of 44.5 N (10 lb) up to 4.45 kN (1,000 lb) and 111.2 N (25 lb) between 4.45 and 44.4 kN (1,000 and 10,000 lb) shall be equipped with a micrometer dial.
3.4	Replace with the following: Flow testing is optional. However, if it is tested then one X-Y stress-strain recorder graduated to 0.25 mm (0.01 inch) is required.
3.5	Replace the third through fifth sentences and Note 2 with the following: Ovens or hot plates shall meet the temperature requirements listed in the document “Hot-Mix Asphalt Laboratory Equipment”. Thermometers for measuring temperature of materials shall have a suitable range to determine 50 – 450 °F (10 – 232 °C). The thermometers may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 1.35 °F (± 0.75 °C) (see Note 2). **Note 2** - Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; IEC 60584 thermocouple thermometer, Type T, Class 1; or E2877 digital metal stem thermometer.
3.8	Replace with the following: *Thermometers* – thermometers for measuring the temperature of the water bath shall have a suitable range to determine 50 ± 1 °C (122 ± 1.8 °F). The thermometer may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.25 °C (± 0.45 °F) (see Note 3).
5.2	Revise the first and second sentences as follows: Bring the specimens prepared with asphalt cement to the specified temperature by immersing in the water bath for 1 hour. Maintain the bath temperature at 60 ± 1 °C (140 ± 1.8 °F).

Illinois Modified Test Procedure
Effective Date: January 1, 1998
Revised Date: December 1, 2022

Standard Method of Test
for
Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus

Reference AASHTO T 245-22

AASHTO Section	***Illinois Modification***
5.2	Revise the fifth sentence as follows: Thoroughly clean the guide rods and the inside surfaces of the test heads prior to conducting the test and lubricate the guide rods and breaking head with a kerosene cloth.
5.2	Delete references to the flowmeter; it is not required.
5.3	Delete reference to manually recording the maximum load and flowmeter reading; it is not required.

Standard Method of Test for

Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus

AASHTO Designation: T 245-22

Technically Revised: 2022

Technical Subcommittee: 2d, Proportioning of Asphalt–Aggregate Mixtures

1. SCOPE

1.1. This method covers the measurement of the resistance to plastic flow of cylindrical specimens of asphalt mixture loaded on the lateral surface by means of the Marshall apparatus. This method is for use with mixtures containing asphalt binder or asphalt cutback and aggregate up to 25.4-mm (1-in.) maximum size.

1.2. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 339M/M 339, Thermometers Used in the Testing of Construction Materials
- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- R 68, Preparation of Asphalt Mixtures by Means of the Marshall Apparatus

2.2. *ASTM Standards*:

- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- D3549/D3549M, Standard Test Method for Thickness or Height of Compacted Asphalt Mixture Specimens
- D5361/D5361M, Standard Practice for Sampling Compacted Asphalt Mixtures for Laboratory Testing
- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E879, Standard Specification for Thermistor Sensors for General Purpose and Laboratory Temperature Measurements

2.3. *International Electrotechnical Commission Standard*:

- IEC 60751: 2008 Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors

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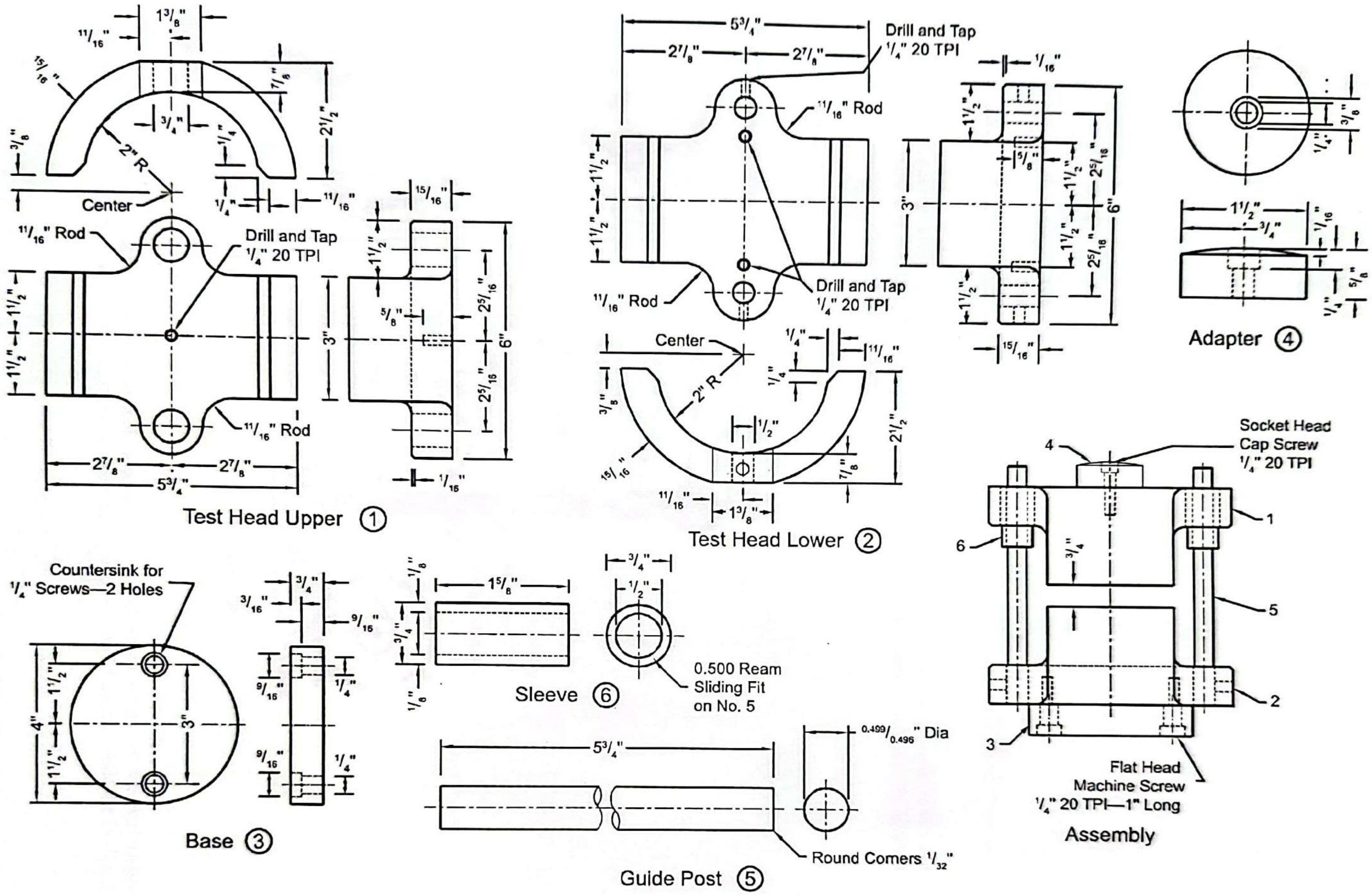
3. APPARATUS

3.1. *Breaking Head (Figure 1)*—Shall consist of upper and lower cylindrical segments or test heads having an inside radius of curvature of 50.8 mm (2 in.) accurately machined. The lower segment shall be mounted on a base having two perpendicular guide rods or posts extending upward. Guide sleeves in the upper segment shall be in such a position as to direct the two segments together without appreciable binding or loose motion on the guide rods.



Note: See Table 1 for equivalents.

Figure 1—Breaking Head

Table 1—Table of Equivalents for Figure 1

Metric Equiva-lents, mm	U.S. Customary Units, in.	Metric Equiva-lents, mm	U.S. Customary Units, in.	Metric Equiva-lents, mm	U.S. Customary Units, in.	Metric Equiva-lents, mm	U.S. Customary Units, in.
0.11	0.005	17.5	$^{11}/_{16}$	58.7	$2^{5}/_{16}$	104.8	$4^{1}/_{8}$
0.8	$^{1}/_{32}$	19.0	$^{3}/_{4}$	63.5	$2^{1}/_{2}$	108.7	$4^{9}/_{32}$
1.6	$^{1}/_{16}$	22.2	$^{7}/_{8}$	69.8	$2^{3}/_{4}$	109.1	$4^{19}/_{64}$
3.2	$^{1}/_{8}$	23.8	$^{15}/_{16}$	73.0	$2^{7}/_{8}$	114.3	$4^{1}/_{2}$
4.8	$^{3}/_{16}$	25.4	1	76.2	3	117.5	$4^{5}/_{8}$
6.4	$^{1}/_{4}$	28.6	$1^{1}/_{8}$	82.6	$3^{1}/_{4}$	120.6	$4^{3}/_{4}$
7.1	$^{9}/_{32}$	31.8	$1^{1}/_{4}$	87.3	$3^{7}/_{16}$	128.6	$5^{1}/_{16}$
9.5	$^{3}/_{8}$	34.9	$1^{3}/_{8}$	98.4	$3^{7}/_{8}$	130.2	$5^{1}/_{8}$
12.6	0.496	38.1	$1^{1}/_{2}$	101.2	$3^{63}/_{64}$	146.0	$5^{3}/_{4}$
12.67	0.499	41.3	$1^{5}/_{8}$	101.35	3.990	152.4	6
12.7	$^{1}/_{2}$	44.4	$1^{3}/_{4}$	101.47	3.995	158.8	$6^{1}/_{4}$
14.3	$^{9}/_{16}$	50.8	2	101.6	4	193.7	$7^{5}/_{8}$
15.9	$^{5}/_{8}$	57.2	$2^{1}/_{4}$	101.73	4.005	685.8	27

3.2. *Loading Jack*—The loading jack (Figure 2) shall consist of a screw jack mounted in a testing frame and shall produce a uniform vertical movement of 50.8 mm (2 in.)/min. An electric motor may be attached to the jacking mechanism.

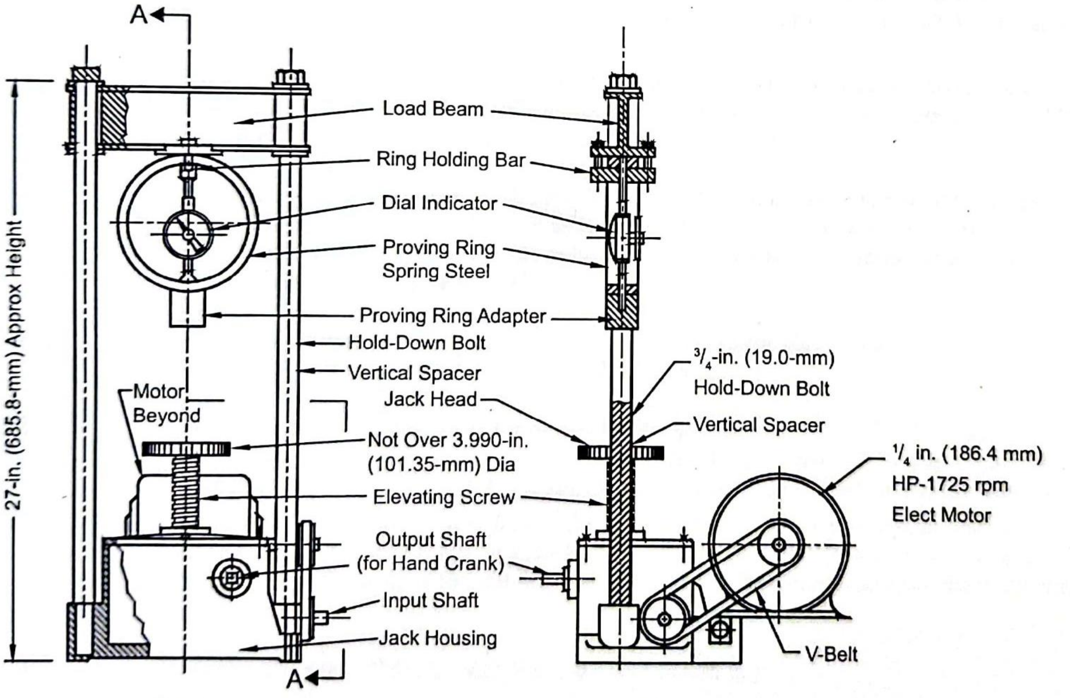


Figure 2—Loading Jack

Note 1—Instead of the loading jack, a mechanical or hydraulic testing machine may be used, provided the rate of movement can be maintained at 50.8 mm (2 in.)/min while the load is applied.

3.3. *Ring Dynamometer Assembly*—One-ring dynamometer (Figure 2) of 22.2-kN (5000-lb) capacity and sensitivity of 44.5 N (10 lb) up to 4.45 kN (1000 lb) and 111.2 N (25 lb) between 4.45 and 22.2 kN (1000 and 5000 lb) shall be equipped with a micrometer dial. The micrometer dial shall be graduated in 0.0025 mm (0.0001 in.) increments. Upper and lower ring dynamometer attachments are required for fastening the ring dynamometer to the testing frame and transmitting the load to the breaking head. Instead of the ring dynamometer assembly, any suitable load-measuring device may be used, provided the capacity and sensitivity satisfy the above requirements.

3.4. *Flowmeter*—The flowmeter shall consist of a guide sleeve and a gauge. The activating pin of the gauge shall slide inside the guide sleeve with a slight amount of frictional resistance. The guide sleeve shall slide freely over the guide rod of the breaking head. The flowmeter gauge shall be adjusted to zero when placed in position on the breaking head when each individual test specimen is inserted between the breaking head segments. Graduations of the flowmeter gauge shall be in 0.25-mm (0.01-in.) divisions. Instead of the flowmeter, a micrometer dial or stress–strain recorder graduated in 0.25 mm (0.01 in.) increments may be used to measure flow.

3.5. *Ovens or Hot Plates*—Properly standardized ovens or hot plates shall be provided for heating aggregates, asphalt material, specimen molds, compaction hammers, and other equipment to the required mixing and molding temperatures. Suitable shields, baffle plates, or sand baths shall be used on the surfaces of the hot plates to minimize localized overheating. Ovens or hot plates shall be capable of reaching and maintaining a temperature of 200 ± 3°C (392 ± 5.4°F). More than one heating unit may be used, provided each is used within its proper operating temperature range. Thermometer for measuring the temperature of materials shall meet the requirements of M 339M/M 339 with a temperature range of at least 50 to 200°C (122 to 392°F), and an accuracy of ±0.75°C (±1.35°F) (see Note 2).

Note 2—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E1137/E1137M Pt-100 RTD platinum resistance thermometer, Special order; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, Special order.

3.6. *Water Bath*—The water bath shall be at least 152.4 mm (6 in.) deep and shall be thermostatically controlled so as to maintain the bath at 60 ± 1°C (140 ± 2°F) or 37.8 ± 1°C (100 ± 2°F). The tank shall have a perforated false bottom or be equipped with a shelf for supporting specimens 50.8 mm (2 in.) above the bottom of the bath.

3.7. *Air Bath*—The air bath for asphalt cutback mixtures shall be thermostatically controlled and shall maintain the air temperature at 25 ± 1°C (77° ± 2°F).

3.8. *Thermometers*—Thermometer for measuring the temperature of water and air baths as well as testing head temperature shall meet the requirements of M 339M/M 339 with a temperature range of at least 15 to 65°C (59 to 149°F), and an accuracy of ±0.25°C (±0.45°F) (see Note 3).

Note 3—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E879 thermistor thermometer; ASTM E1137/E1137M Pt-100 RTD platinum resistance thermometer, Class A; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, Class AA.

3.9. *Vernier Calipers*—Calipers readable to 0.1 mm (0.004 in.)

3.10. *Gloves*—For handling hot equipment and other gloves for removing specimens from water bath.

4. TEST SPECIMENS

4.1. *Number and Dimension of Specimens*—Three cylindrical specimens, 101.6 ± 0.1 mm (4.0 ± 0.05 in.) in diameter and ranging from 25.4 mm (1.0 in.) to 76.2 mm (3.0 in.) tall, are recommended. Prepare specimens in accordance with AASHTO R 68.

4.2. *Roadway Core Specimens*—Core specimens meeting the dimensional requirements of Section 4.1 may be collected in accordance with D5361/D5361M.

5. PROCEDURE

5.1. Measure specimen height in accordance with ASTM D3549/D3549M.

5.2. Bring the specimens prepared with asphalt cement to the specified temperature by immersing in the water bath 30 to 40 min or placing in the oven for 2 h. Maintain the bath or oven temperature at 60 ± 1°C (140 ± 1.8°F) for the asphalt binder specimens. Bring the specimens prepared with asphalt cutback to the specified temperature by placing them in the air bath for a minimum of 2 h. Maintain the air bath temperature at 25 ± 1°C (77 ± 1.8°F). Thoroughly clean the guide rods and the inside surfaces of the test heads prior to performing the test, and lubricate the guide rods so that the upper test head slides freely over them. The testing-head temperature shall be maintained between 21.1 to 37.8°C (70 to 100°F) using a water bath when required. Remove the specimen from the water bath, oven, or air bath, and place in the lower segment of the breaking head. Place the upper segment of the breaking head on the specimen, and place the complete assembly in position on the testing machine. Place the flowmeter, where used, in position over one of the guide rods and adjust the flowmeter to zero while holding the sleeve firmly against the upper segment of the breaking head. Hold the flowmeter sleeve firmly against the upper segment of the breaking head while the test load is being applied.

5.3. Apply the load to the specimen by means of the constant rate of movement of the loading jack or testing-machine head of 50.8 mm (2 in.) per minute until the maximum load is reached and the load decreases as indicated by the dial. Record the maximum load noted on the testing machine or converted from the maximum micrometer dial reading. Release the flowmeter sleeve or note the micrometer dial reading, where used, the instant the maximum load begins to decrease. Note and record the indicated flow value or equivalent units in twenty-five hundredths of a millimeter (hundredths of an inch) if a micrometer dial is used to measure the flow. The elapsed time for the test from removal of the test specimen from the water bath to the maximum load determination shall not exceed 30 s.

Note 4—For core specimens, correct the load when thickness is other than 63.5 mm ($2^1/_2$ in.) by using the proper multiplying factor from Table 2.

Table 2—Stability Correlation Ratios[a,b]

Volume of Specimen, cm^3	Approximate Thickness of Specimen, in.	mm	Correlation Ratio
200 to 213	1	25.4	5.56
214 to 225	$1^{1}/_{16}$	27.0	5.00
226 to 237	$1^{1}/_{8}$	28.6	4.55
238 to 250	$1^{3}/_{16}$	30.2	4.17
251 to 264	$1^{1}/_{4}$	31.8	3.85
265 to 276	$1^{5}/_{16}$	33.3	3.57
277 to 289	$1^{3}/_{8}$	34.9	3.33
290 to 301	$1^{7}/_{16}$	36.5	3.03
302 to 316	$1^{1}/_{2}$	38.1	2.78
317 to 328	$1^{9}/_{16}$	39.7	2.50
329 to 340	$1^{5}/_{8}$	41.3	2.27
341 to 353	$1^{11}/_{16}$	42.9	2.08
354 to 367	$1^{3}/_{4}$	44.4	1.92
368 to 379	$1^{13}/_{16}$	46.0	1.79
380 to 392	$1^{7}/_{8}$	47.6	1.67
393 to 405	$1^{15}/_{16}$	49.2	1.56
406 to 420	2	50.8	1.47
421 to 431	$2^{1}/_{16}$	52.4	1.39
432 to 443	$2^{1}/_{8}$	54.0	1.32
444 to 456	$2^{3}/_{16}$	55.6	1.25
457 to 470	$2^{1}/_{4}$	57.2	1.19
471 to 482	$2^{5}/_{16}$	58.7	1.14
483 to 495	$2^{3}/_{8}$	60.3	1.09
496 to 508	$2^{7}/_{16}$	61.9	1.04
509 to 522	$2^{1}/_{2}$	63.5	1.00
523 to 535	$2^{9}/_{16}$	65.1	0.96
536 to 546	$2^{5}/_{8}$	66.7	0.93
547 to 559	$2^{11}/_{16}$	68.3	0.89
560 to 573	$2^{3}/_{4}$	69.9	0.86
574 to 585	$2^{13}/_{16}$	71.4	0.83
586 to 598	$2^{7}/_{8}$	73.0	0.81
599 to 610	$2^{15}/_{16}$	74.6	0.78
611 to 625	3	76.2	0.76

[a] The measured stability of a specimen multiplied by the ratio for the thickness of the specimen equals the corrected stability for a 63.5-mm ($2^{1}/_{2}$-in.) specimen.

[b] Volume–thickness relationship is based on a specimen diameter of 101.6 mm (4 in.).

6. REPORT

6.1. *The report shall include the following information:*

6.1.1. Type of sample tested (laboratory sample or pavement core specimen);

Note 5—For core specimens, the height of each test specimen in millimeters (or inches) shall be reported.

6.1.2. Average maximum load in pounds-force (or newtons) of at least three specimens, corrected when required;

6.1.3. Average flow value, in twenty-five hundredths of a millimeter (hundredths of an inch), of three specimens; and

6.1.4. Test temperature.

7. PRECISION AND BIAS

7.1. Criteria for judging the acceptability of Marshall stability and flow test results obtained by this method are shown in Table 3.

Table 3—Precision Estimates

Test and Type of Index		Coefficient of Variation, % of mean[a]	Acceptable Range of Two Test Results, % of mean[a]
Marshall stability	Within laboratory precision	6	16
	Between laboratory precision	16	43
Marshall flow	Within laboratory precision	9	26
	Between laboratory precision	20	58

[a] These values represent the 1s percent and d2s percent limits as described in ASTM C670.

7.2. The precision estimates noted in Table 3 are based on specimens compacted with mechanical and manual hammers and include dense graded mixtures with limestone and gravel aggregates, and different asphalt binders.

8. KEYWORDS

8.1. Asphalt; binder; cutback; cylindrical specimens; Marshall apparatus; mixtures; plastic flow; stability.

9. REFERENCES

9.1. AASHTO. T 166, Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens.

9.2. AASHTO. T 275, Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Paraffin-Coated Specimens.

9.3. AASHTO. T 331, Bulk Specific Gravity (G_{mb}) and Density of Compacted Asphalt Mixtures Using Automatic Vacuum Sealing Method.

9.4. ASTM. E11, Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves.

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: December 1, 2023

Standard Method of Test
for
Hamburg Wheel-Track Testing of Compacted Asphalt Mixtures

Reference AASHTO T 324-23

AASHTO Section	***Illinois Modification***
1.2	Revise the last sentence as follows: Alternatively, field cores with a diameter of 150 mm (5.91 in.), 255 mm (10 in.), 300 mm (12 in.), or saw-cut slab specimens may be tested.
2.1	Revise the individual AASHTO Standards with the appropriate Illinois modified AASHTO Standards: ▪ R 30, Mixture Conditioning of Hot Mix Asphalt (HMA) ▪ T 166, Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens ▪ T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures ▪ T 312, Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
2.1	Delete: R 97
2.1	Illinois Manual of Test Procedures: ▪ Appendix B6, Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples ▪ Appendix B7, Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations ▪ Appendix E3, PFP and QCP Random Density Procedure ▪ Appendix E4, PFP and QCP Hot Mix Asphalt Random Jobsite Sampling
4.1	Revise the second sentence as follows: The specimen is submerged in a temperature-controlled water bath at 50 ± 1.0°C (122 ± 1.8°F).
5.1	Delete the first sentence of the last paragraph:
Note 1	Revise as follows: Reference the NCHRP Report of available devices in the market meeting the relevant requirements as proposed in the NCHRP Report to verify the sinusoidal wave requirement of the Hamburg wheel tracking device.
5.2	Replace the second sentence with the following: The thermometer for measuring the temperature of the water bath shall have a suitable range to determine 50 ± 1 °C (122 ± 1.8 °F). The thermometer may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.25 °C (± 0.45 °F) (see Note 2).

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Effective Date: June 1, 2012
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for
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(continued)
Reference AASHTO T 324-23

AASHTO Section	***Illinois Modification***
5.3.2	Delete
5.3.4	Delete
5.3.5	Delete
Note 3	Delete
5.8	Replace with the following: Ovens – shall meet the temperature requirements listed in the document “Hot-Mix Asphalt Laboratory Equipment”. Thermometers for measuring temperature of aggregate, binder, and asphalt mixtures shall have a suitable range to determine 50 – 450 °F (10 – 232 °C). The thermometers may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 1.35 °F (0.75 °C) (see Note 3). **Note 3** - Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; IEC 60584 thermocouple thermometer, Type T, Class 1; or E2877 digital metal stem thermometer.
6.1	Replace Section 6.1 with the following: *Number of Test Specimens* – A single slab specimen, two 150 mm (5.91 in.) diameter gyratory compacted specimens, or field cores according to Section 6.4 will be tested under each wheel in the Hamburg Wheel Tester. A test is currently defined as HMA specimens being tested using two wheels. However, if the District has sufficient experience with how their mixtures perform in the Hamburg Wheel Tester, a test may be conducted using a single wheel, at the discretion of the District.
6.2.2	Replace with the following: The mixing temperature shall be according to IL Modified AASHTO T 312.
6.2.4	Replace with the following: Laboratory mixed test samples shall be conditioned at the appropriate compaction temperature according to the short-term conditioning procedure in IL Modified AASHTO R 30.
6.2.5	Replace with the following: The compaction temperature shall be according to IL Modified AASHTO T 312.

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(continued)
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AASHTO Section	***Illinois Modification***
6.2.6.2	Replace with the following: *Compacting SGC Cylindrical Specimens*--Material shall be compacted into specimens using an SGC according to IL Modified AASHTO T 312. Compact three 160 mm tall gyratory cylinders to an air void level of 7.5 ± 0.5 %. If I-FIT long-term aging is conducted compact four 160 mm tall gyratory cylinders. Cut a 62 ± 2 mm disc from both the top and bottom of two of the 160 mm tall gyratory cylinders (for a total of four individual Hamburg Wheel test specimens). Position each of the test specimens so that the wheel is run on the as-compacted face. The I-FIT specimens are cut from the middle of the third and fourth gyratory cylinders. If the lab is not capable of compacting 160 mm tall gyratory cylinders, then compact two 115 mm tall gyratory cylinders instead of each 160 mm tall cylinder.
6.3.1	Replace with: Obtain field-mixed asphalt mixture sample in accordance with Appendix B.6 or E.4 of sufficient size to determine G_{mm} and make the 160 mm tall gyratory cylinders required in Section 6.2.6.2. Appendix B.6 shall be used in QC/QA applications and Appendix E.4 shall be used in QCP or PFP applications.
6.4.1	Replace sentence one with the following: *Cutting Field Cores or Field Slab Specimens*--Field cores or field slab specimens may be taken from compacted HMA pavements according to Appendix B7 and Appendix E3. Appendix B.7 shall be used in QC/QA applications and Appendix E.3 shall be used in QCP or PFP applications. Replace sentence five with the following: The height of a field core specimen may need to be adjusted to fit the specimen mounting system.
Note 5	Renumber Note 5 to be Note 4, and Replace the second sentence with the following: In order for the total sample height to be 62±2 mm (2.4±0.1 in.), the sample must be trimmed with a wet saw if it is too tall. If the sample is too short then it must be shimmed up with Plaster of Paris (or equivalent).
Note 6	Renumber Note 6 to be Note 5.

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AASHTO Section	***Illinois Modification***
7.3	Replace the second sentence with the following: Refer to Sections 6.2.6.2 and 6.3.1 for air void requirements for SCG compacted cylinders and prepared test specimens.
Note 7	Renumber Note 7 to be Note 6.
8.6.1	Replace with the following: *Test Temperature*-The test temperature shall be 50±1°C (122±1.8°F).
8.6.2	Replace with the following: *Maximum Rut Depth*-The maximum allowable rut depth shall be less than or equal to 12.5 mm (0.5 in.). When setting the machine up for testing, the maximum rut depth should be set at a value greater than 12.5 mm (16.0 mm suggested) to avoid a premature end of the test caused by temporary rut depth spikes.
8.6.3	Add the following: *Selecting the Number of Wheel Passes*-The minimum number of wheel passes shall be according to Article 1030.05(d)(3) in the Illinois Department of Transportation Standard Specifications for Road and Bridge Construction. It may be useful to run every test for 20,000 wheel passes to collect additional data on moisture sensitivity.
8.6.4	Replace the first sentence with the following: Enter a start delay of 30 min to precondition the test specimens.
Note 8	Renumber Note 8 to be Note 7.
Note 9	Renumber Note 9 to be Note 8.
Note 10	Renumber Note 10 to be Note 9.

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AASHTO Section	***Illinois Modification***
8.8.4	Replace with the following: Each wheel on the wheel-tracking device shall shut off independent of the other wheel. The end of a test for each wheel can occur when the specified number of wheel passes listed in Section 8.6.3 or the number of passes otherwise specified has occurred on that wheel. Further, each wheel on the device shall be set to lift independently when the LDT displacement is 16.0 mm (0.63 in.) for that wheel. The HWTD measures the rut depth at multiple points per pass across the specimen. The maximum rut depth is defined as the average rut depth of the point with the deepest rut depth and the rut depth of the two points physically closest to it. The testing device software automatically saves the test data file for each wheel.
8.8.4.1 New Section	Add the following: If the test was conducted using two wheels, the two wheels should have an average rut depth less than or equal to 12.5 mm at the prescribed number of passes in section 8.6.3. The test result is reported as the average of the two rut depths. A test is considered as failing if the **average** rut depth exceeds 12.5 mm at, or less than, the prescribed number of passes. If one wheel exceeds the 12.5 mm rut depth at, or less than, the prescribed number of passes, the maximum rut depth difference between the two wheels at failure shall be 6.25 mm. An additional test will be completed to replace the original if the maximum rut depth difference is exceeded. If the test was conducted using a single wheel, a passing test from that wheel shall have a rut depth less than or equal to 12.5 mm at the prescribed number of passes in section 8.6.3.
Note 11	Renumber Note 11 to be Note 10.
8.9.2	Replace the first sentence with the following: Precondition the test specimens in the water bath for 30 min after the water has reached the selected test temperature.
8.9.3	Replace the first sentence with the following: Lower the wheels onto the specimens after the test specimens have preconditioned at the selected test temperature for 30 min.
9.1	Delete

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Effective Date: June 1, 2012
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Standard Method of Test
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(continued)
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AASHTO Section	***Illinois Modification***
9.1.1	Delete
9.1.2	Delete
9.3	Delete the first sentence.
9.4	Revise the second sentence to read: From this plot, the following values may be obtained:
9.5	Revise the first sentence to read: The following test parameters may be calculated, all expressed in “Passes.”
Note 12	Delete
Appendix A2.2	The thermometer for measuring the temperature of the water bath shall have a suitable range to determine 50 ± 1 °C (122 ± 1.8 °F). The thermometer may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.25 °C (± 0.45 °F) (see Note 2).
A6.4	Delete
A6.5	Delete
Table A1.1	Delete
Figure A1.1	Delete
A7.13	Delete
A7.14	Delete
A7.15	Delete
X1.1	Replace with the following: Follow the manufacturer’s recommendations for lubrication and cleaning.

Standard Method of Test for

Hamburg Wheel-Track Testing of Compacted Asphalt Mixtures

AASHTO Designation: T 324-23

Technically Revised: 2023 **Editorially Revised: 2023**

Technical Subcommittee: 2d, Proportioning of Asphalt–Aggregate Mixtures

1. SCOPE

1.1. This test method describes a procedure for testing the rutting and moisture-susceptibility of asphalt mixture pavement samples in the Hamburg wheel-tracking device.

1.2. The method describes the testing of a submerged, compacted asphalt mixture in a reciprocating rolling-wheel device. This test provides information about the rate of permanent deformation from a moving, concentrated load. A laboratory compactor has been designed to prepare slab specimens. Also, the Superpave Gyratory Compactor (SGC) has been designed to compact specimens in the laboratory. Alternatively, field cores having a diameter of 150 mm (6 in.), 250 mm (10 in.), or 300 mm (12 in.), or saw-cut slab specimens may be tested.

1.3. The test method is used to determine the premature failure susceptibility of asphalt mixture due to weakness in the aggregate structure, inadequate binder stiffness, or moisture damage. This test method measures the rut depth and number of passes to failure.

1.4. This test method measures the potential for moisture damage effects because the specimens are submerged in temperature-controlled water during loading.

1.5. This test method is intended to be the standard; however, agencies may require deviations for various reasons, including test temperature, maximum rut depth calculation, equipment, or others. Deviations must be documented and made available to any accreditation or certifying entities or stakeholders, such as contractors and material producers, upon request.

1.6. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.7. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 339M/M 339, Thermometers Used in the Testing of Construction Materials
- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- R 30, Mixture Conditioning of Asphalt Mixtures
- R 97, Sampling Asphalt Mixtures
- T 166, Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
- T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures
- T 269, Percent Air Voids in Compacted Dense and Open Asphalt Mixtures
- T 312, Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor

2.2. *ASTM Standards*:

- D6027/D6027M, Standard Practice for Calibrating Linear Displacement Transducers for Geotechnical Purposes
- D8079, Standard Practice for Preparation of Compacted Slab Asphalt Mix Samples Using a Segmented Rolling Compactor
- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E879, Standard Specification for Thermistor Sensors for General Purpose and Laboratory Temperature Measurements
- E1137/E1137M, Standard Specification for Industrial Platinum Resistance Thermometers
- E2877, Standard Guide for Digital Contact Thermometers

2.3. *International Electrotechnical Commission Standards*:

- IEC 60584-1: 2013 Thermocouples - Part 1: EMF Specifications and Tolerances
- IEC 60751: 2008 Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors

2.4. *National Cooperative Highway Research Program*:

- NCHRP Web-Only Document 219, *Hamburg Wheel-Track Test Equipment Requirements and Improvements to AASHTO T 324*. NCHRP Project 20-07/Task 361. National Cooperative Highway Research Program, Transportation Research Board, Washington, DC, 2016. Available from https://www.trb.org/Publications/Blurbs/173895.aspx; login required.

3. SIGNIFICANCE AND USE

3.1. This test measures the rutting and moisture susceptibility of an asphalt mixture specimen.

4. SUMMARY OF METHOD

4.1. A laboratory-compacted specimen of asphalt mixture, a saw-cut slab specimen, or a core taken from a compacted pavement is repetitively loaded using a reciprocating steel wheel. The specimen is submerged in a temperature-controlled water bath at a temperature specified by the agency. The deformation of the specimen, caused by the wheel loading, is measured.

4.2. The impression is plotted as a function of the number of wheel passes. An abrupt increase in the rate of deformation may coincide with stripping of the asphalt binder from the aggregate in the asphalt mixture specimen.

5. APPARATUS

5.1. *Hamburg Wheel-Tracking Device*—An electrically powered machine capable of moving a 203.2 ± 2.0-mm (8 ± 0.08-in.) diameter, 47 ± 0.5-mm (1.85 ± 0.02-in.) wide steel wheel over the center (x and y axes) of the test specimen. The load on the wheel is 703 ± 4.5 N (158.0 ± 1.0 lb). The wheel reciprocates over the specimen, with the position varying sinusoidally over time. A maximum level of deviation from a perfectly sinusoidal wave is defined through the root mean square error (RMSE), which is calculated as follows:

$$\mathrm{RMSE} = \sqrt{\frac{\sum e_i^2}{n}} \tag{1}$$

where:

e_i = deviation from a pure sinusoidal curve, and

n = number of data points.

The maximum allowable deviation from a sinusoidal wave through the entire track length is set at an RMSE of 2.54 mm (0.1 in.) unless otherwise specified by the agency. The wheel makes 52 ± 2 passes across the specimen per minute. The maximum speed of the wheel, reached at the midpoint of the specimen, is 0.305 ± 0.02 m/s (1 ± 0.066 ft/s).

Note 1—Verify the sinusoidal wave requirement of the Hamburg wheel-tracking device using a Hamburg wheel-tracking device verification/calibration kit.

5.2. *Temperature Control System*—A water bath capable of controlling the temperature within ±1.0°C (1.8°F) over a range of 25 to 70°C (77 to 158°F) with a mechanical circulating system stabilizing the temperature within the specimen tank. The thermometer for measuring the temperature of the water bath shall meet the requirements of M 339M/M 339 with a temperature range of at least 20 to 75°C (68 to 167°F), and an accuracy of ±0.25°C (±0.45°F) (see Note 2).

Note 2—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E879 thermistor thermometer; ASTM E1137/E1137M Pt-100 RTD platinum resistance thermometer, Class A; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, Class AA.

5.3. *Impression Measurement System*:

5.3.1. A linear displacement transducer (LDT) device capable of measuring the depth of the impression (rut) of the wheel to within 0.15 mm (0.006 in.), over a minimum range of 0 to 20 mm (0 to 0.8 in.).

5.3.2. The system shall measure the depth of the impression at a minimum at the following locations along the track length: –114 (–4.5), –91 (–3.6), –69 (–2.7), –46 (–1.8), –23 (–0.9), 0 (0), +23 (+0.9), +46 (+1.8), +69 (+2.7), +91 (+3.6), and +114 (+4.5) mm (in.) with zero being the midpoint of the track unless otherwise specified by the agency. The midpoint of the track shall be marked by the manufacturer.

5.3.3. The system measures the rut depth, without stopping the wheel, at least every 20 passes. Rut depth is expressed as a function of the wheel passes. The device will also disengage if the average LDT displacement (read from the micro-control unit, not the screen) is 40.90 mm (1.6 in.) or greater for an individual specimen. Note that the screen readout subtracts the initial LDT reading from the total displacement.

5.3.4. The maximum level of deviation from the 11 preset locations is defined through the RMSE, which is calculated as follows:

$$\text{RMSE} = \sqrt{\frac{\sum e_i^2}{n}} \qquad (2)$$

where:

e_i = deviation from the preset location after considering the effect of curvature of the aluminum apparatus (Table A1.1); and

n = number of data points.

5.3.5. The maximum allowable RMSE at the 11 preset locations after considering the effect of curvature of the aluminum apparatus (Table A1.1), discussed in the NCHRP Web-Only Document 219, is 1.27 mm (0.05 in.).

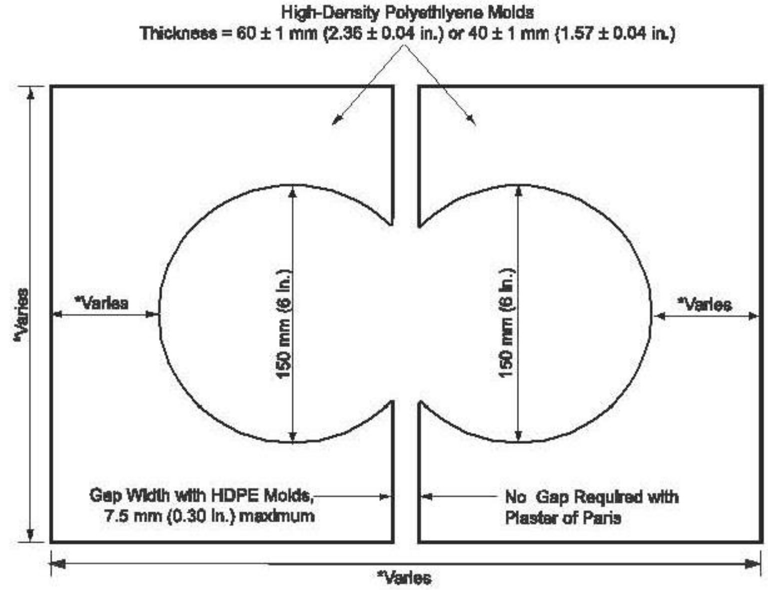
Note 3—The locations of the deformation readings should be verified using the aluminum apparatus presented in Section A6.4.

5.4. *Wheel Pass Counter*—A non-contacting solenoid that counts each wheel pass over the specimen. The signal from this counter is coupled to the wheel impression measurement, allowing for the rut depth to be expressed as a function of the wheel passes.

5.5. *Slab Specimen Mounting System*—A stainless steel tray that is mounted rigidly to the machine. The mounting system must restrict shifting of the specimen to within 0.5 mm (0.02 in.) during testing and must suspend the specimen to provide a minimum of 20 mm (0.8 in.) of free circulating water on all sides of the mounting system.

5.6. *Cylindrical Specimen Mounting System*—An assembly consisting of two high-density polyethylene (HDPE) molds or plaster of Paris, in accordance with Section 8 to secure the specimen (as shown in Figures 1 and 2), placed on a stainless steel tray that is mounted rigidly to the machine. This mounting system must restrict shifting of the specimen to within 0.5 mm (0.02 in.) during testing and must suspend the specimen to provide a minimum of 20 mm (0.8 in.) of free circulating water on all sides of the mounting system.

Figure 1—Cylindrical Specimen Mounting System



* Dimensions may vary depending on the manufacturer.

Figure 2—Schematic of Cylindrical Specimen Mounting System

5.7. *Linear Kneading Compactor*—A hydraulic-powered unit that uses a series of vertically aligned steel plates to compact molded asphalt mixtures into flat, rectangular slabs of predetermined thickness and density.

5.8. *Ovens*—For heating aggregate and asphalt binders to their appropriate mixing temperature. Oven(s) for heating shall be properly standardized and capable of operation at the temperatures required, between 100 to 175°C (212 to 347°F), within ±5°C (±9°F), as corrected, if necessary, by calibration. More than one oven may be used, provided each is used within its proper operating temperature range. The thermometer for measuring the temperature of materials shall meet the requirements of M 339M/M 339 with a temperature range of at least 140 to 175°C (284 to 347°F), and an accuracy of ±1.25°C (±2.25°F) (see Note 4).

Note 4—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; or IEC 60584 thermocouple thermometer, Type T, Class 1.

5.9. *Superpave Gyratory Compactor (SGC)*—And molds conforming to T 312.

5.10. Bowls, spoon, spatula, etc.

6. SPECIMEN PREPARATION

6.1. *Number of Test Specimens*—Prepare two test specimens for each test, either slab specimens or cylinders.

6.2. *Laboratory-Produced Asphalt Mixture*:

6.2.1. Batch mixture proportions in accordance with the desired job mix formula.

6.2.2. Use the mixing temperature at which the asphalt binder achieves a viscosity of 170 ± 20 cSt. For modified asphalt binders, use the mixing temperature recommended by the binder manufacturer.

6.2.3. Dry-mix the aggregates and mineral admixture (if used) first, then add the correct percentage of asphalt binder. Mix the materials to coat all aggregates thoroughly. (Wet-mix the aggregates if using a lime slurry or other wet material.)

6.2.4. Condition test samples at the appropriate compaction temperature in accordance with the short-term conditioning procedure for mechanical properties in R 30.

6.2.5. Use the compaction temperature at which the asphalt binder achieves a viscosity of 280 ± 30 cSt. For modified asphalt binders, use the compaction temperature recommended by the binder manufacturer.

6.2.6. *Laboratory Compaction of Specimens*—Compact either slab specimens or SGC cylindrical specimens.

6.2.6.1. *Compacting Slab Specimens*—Heat molds and tools to compaction temperature. Compact slab specimens 320 mm (12.5 in.) long and 260 mm (10.25 in.) wide using a Linear Kneading Compactor (or equivalent such as a compactor meeting ASTM D8079). Specimen thickness must be at least twice the nominal maximum aggregate size, generally yielding a specimen 38 to 100 mm (1.5 to 4 in.) thick. Allow compacted slab specimens to cool at normal room temperature on a clean, flat surface until cool to the touch.

6.2.6.2. *Compacting SGC Cylindrical Specimens*—Compact two 150-mm (6-in.) diameter specimens in accordance with T 312. Specimen thickness must be at least twice the nominal maximum aggregate size, generally yielding a specimen 38 to 100 mm (1.5 to 4 in.) thick. Allow compacted specimens to cool at normal room temperature on a clean, flat surface until cool to the touch.

6.3. *Field-Produced Asphalt Mixture—Loose Mix*:

6.3.1. Obtain a sample of asphalt mixture in accordance with R 97.

6.3.2. *Laboratory Compaction of Specimens*—Compact either slab specimens or SGC cylindrical specimens in accordance with Section 6.2.6.

6.4. *Field-Produced Asphalt Mixture—Field Compacted (Core/Slab Specimen)*:

6.4.1. *Cutting Field Cores or Field Slab Specimens*—Field cores or field slab specimens consist of wet saw-cut compacted specimens taken from asphalt mixture pavements. Cut field cores 300 mm (12 in.), 250 mm (10 in.), or 150 mm (6 in.) in diameter. Cut field slab specimens approximately 260 mm (10.25 in.) wide by 320 mm (12.5 in.) long. Use a slab specimen thickness of 38 to 100 mm (1.5 to 4 in.). The height of a field core or field slab specimen is typically 38 mm (1.5 in.) but may be adjusted to fit the specimen mounting system by wet saw-cutting. Cut field cores in accordance with Section 6.4.2.

Note 5—Take care to load the sample so it is level to the surface of the mold. Trim the sample if it is too tall or use shims if it is too short (supporting with plaster if needed). Calibrate the down pressure from the wheel to be 703 ± 4.5 N (158.0 ± 1.0 lb.) at the center, level to the top of the mold position. Even a small change in elevation will change the down pressure significantly.

6.4.2. *Cutting SGC Cylindrical Specimens and Field Cores*—Cut specimens after they have cooled to room temperature using a wet or dry saw. Saw the specimens along equal secant lines (or chords) such that when joined together in the molds, there is no space between the cut edges. The amount of material sawed from the SGC cylindrical specimens may vary to achieve a gap width no greater than 7.5 mm (0.3 in.) between the molds.

Note 6—To cut specimens consistently may require the use of a jig.

7. DETERMINING AIR VOID CONTENT

7.1. Determine the bulk specific gravity of the specimens in accordance with T 166.

7.2. Determine the maximum specific gravity of the mixture in accordance with T 209.

7.3. Determine the air void content of the specimens in accordance with T 269. The recommended target air void content is 7.0 ± 0.5 percent for laboratory-compacted SGC cylindrical specimens and 7.0 ± 1.0 percent for laboratory-compacted slab specimens. Field specimens may be tested at the air void content at which they are obtained.

8. PROCEDURE

8.1. *Slab and Large Field Core Specimen Mounting*—Use plaster of Paris to rigidly mount the 300 mm (12 in.), 250 mm (10 in.), or slab specimens in the mounting trays. Mix the plaster at approximately a 1:1 ratio of plaster to water. Pour the plaster to a height equal to that of the specimen to fill the air space between the specimen and the sides of the mounting tray. The slab specimen will be in direct contact with the mounting tray; however, plaster may flow underneath the specimen. If the thickness of the Slab or Large Field Core Specimen is the same as the height of the mounting tray, the plaster underneath the specimen must not exceed 2 mm (0.08 in.). If the thickness of the Slab or Large Field Core Specimen is less than the height of the mounting tray, plaster and/or shims from aluminum, HDPE, or other suitable material shall be used underneath the specimen as necessary to bring the top of the specimen level with the top of the mounting tray and to prevent any movement of the specimen in the mounting tray during testing. Allow the plaster at least 1 h to set. If using other mounting material, it should be able to withstand 890 N (200 lb) of load without cracking.

8.2. *SGC Cylindrical and Field Core Specimen Mounting*—Rigidly mount the 150-mm [5.91-in.] or 152-mm [6-in.] diameter samples in the mounting tray using HDPE molds meeting the dimensions outlined in Figure 2 or use plaster of Paris. For HDPE molds, place the molds in the mounting tray and insert the cut specimens in the molds. Shim the molds in the mounting tray as necessary. Secure the molds into the mounting tray. If plaster of Paris is used, pour the plaster to a height equal to that of the specimen to fill the air space between the specimen and the sides of the mounting tray. The specimen will be in direct contact with the mounting tray; however, plaster may flow underneath the specimen. For SGC Cylindrical Specimens the plaster underneath the specimen must not exceed 2 mm (0.08 in.) in thickness. For Field Core Specimens plaster and/or shims from aluminum, HDPE, or other suitable material shall be used underneath the specimen as necessary to bring the top of the specimen level with the top of the HDPE molds and to prevent any movement of the specimen in the molds during testing. Allow the plaster at least 1 h to set.

Note 7—Cores drilled with a 152-mm [6-in.] drill bit may not fit in the 150-mm [5.91-in.] HDPE mold and may require further trimming and mounting in plaster of Paris.

8.3. Place the mounting tray(s) with the test specimens into the device. Adjust the height of the specimen tray as recommended by the manufacturer, and secure by hand-tightening the bolts.

8.4. Turn the testing device and all components on.

8.5. Start the software used to communicate with the testing device.

8.6. Enter the pertinent project information and testing configuration requirements.

8.6.1. Select the test temperature based on the applicable specifications.

8.6.2. Select the maximum allowable rut depth based on the applicable specifications.

8.6.3. Select the maximum number of passes based on the applicable specifications.

8.6.4. Enter a start delay of 45 min to precondition the test specimens. The temperature of the specimens in the mounting tray will be the test temperature selected in Section 8.6.1 on completion of this preconditioning period.

8.7. Proceed to Section 8.8 to operate the testing device in "Auto" mode. Proceed to Section 8.9 to operate the testing device in "Manual" mode.

Note 8—Perform the test in "Auto" mode for testing devices manufactured in the United States later than 1998, where software will automatically open and close the valves to fill and drain the water bath. Perform the test in "Manual" mode for devices made available to the United States prior to 1998.

8.8. *Performing the Test in Auto Mode*:

8.8.1. Adjust the height of the LDT in accordance with the manufacturer's recommendations.

Note 9—The LDT for each steel wheel is automatically zeroed at the start of the test. The software will display a zero at the start of the test.

8.8.2. If using cylindrical specimens, lower the wheels onto the edge of the test specimens such that a majority of the wheel is in contact with the HDPE molds in the mounting tray. If using slabs, lower the wheels onto the specimen no more than 5 min prior to the beginning of the test. In either case, the sample must not be submerged longer than 60 ± 5 min prior to starting the test. This includes the conditioning time.

8.8.3. Start the test by selecting the "Start" button of the testing device software.

Note 10—The start delay time or preconditioning time will start after the water heats to the test temperature selected in Section 8.6.1.

8.8.4. The wheel-tracking device will stop when 20,000 passes have occurred, when some other predetermined number of passes has occurred, or when the test has achieved the maximum impression depth established in Section 8.6.2. The testing device software automatically saves the test data file.

8.8.5. Raise the wheel(s) and remove the specimen mounting tray(s) and rutted specimens.

8.8.6. Proceed to Section 8.10.

8.9. *Performing the Test in Manual Mode*:

8.9.1. Close the drain valve(s) and fill the water bath of the wheel-tracking device with water until the float device(s) raises to a horizontal position.

Note 11—Adjust the amount of hot and cold water if necessary, as the water temperature may vary.

8.9.2. Precondition the test specimens in the water bath for 45 min after the water has reached the selected test temperature. Do not place the sample in the conditioning bath more than 60 ± 5 min prior to beginning the test. This includes the preconditioning time.

8.9.3. Lower the wheels onto the specimens after the test specimens have preconditioned at the selected test temperature for 45 min. For machines that start automatically after the selected preconditioning time, it is allowable to lower the wheels before the preconditioning cycle. The wheel must not be in contact with the specimen for more than 5 min prior to starting the wheel.

8.9.4. Ensure the micro-control unit's LDT reads between 10 and 18 mm (0.4 and 0.7 in.). Adjust the LDT height to obtain this reading. Loosen the two screws on the LDT mount and slide the LDT up or down to the desired height. Tighten the screws.

8.9.5. Start the test.

8.9.6. The wheel-tracking device will stop when 20,000 passes have occurred, when some other predetermined number of passes has occurred, or when the test has achieved the maximum impression depth established in Section 8.6.2.

8.9.7. Open the valve(s) beneath the tanks and drain the water bath. Raise the wheel(s) and remove the specimen mounting tray(s) and rutted specimens.

8.10. Clean the water bath, heating coils, wheels, and temperature probe with water and scouring pads or per the manufacturer's recommendations. Use a wet-dry vacuum to remove particles that have settled to the bottom of the baths. Clean the filter element and spacers after every test or per the manufacturer's recommendations. Do not use solvents to clean the water bath.

8.11. Turn the wheels after each test, so the same section of the wheel surface is not in contact with the test specimen from test to test. This rotation will provide for even wear over the entire wheel. The test should operate with a smooth movement across the test specimen.

9. CALCULATIONS

9.1. *For the purposes of this method, a "test" is defined as:*

9.1.1. Two 320-mm (12.5-in.) long by 260-mm (10.25-in.) wide slab specimens, two 250-mm (10-in.) diameter core specimens, or two 300-mm (12-in.) diameter core specimens representing similar material run in the Hamburg wheel-tracking device simultaneously; or

9.1.2. Four 150-mm (6-in.) diameter cylindrical or core specimens grouped in pairs (1 and 1a) representing similar material run in the Hamburg wheel-tracking device simultaneously.

9.2. The test results will be reported as the average value of both specimens (a) or both pairs of specimens (b). Alternatively, the specifying agency may choose to define a "test" as a single slab or core specimen or as a pair of 150-mm (6-in.) diameter cylindrical specimens.

9.3. The maximum rut depth shall be calculated based on the average rut depth for the five middle deformation locations (i.e., located at –46 (–1.8), –23 (–0.9), 0, +23 (+0.9), and +46 (+1.8) mm (in.)) or other suitable method as specified by the agency. Plot the rut depth versus number of passes for each test for each deformation location.

9.4. Figure 3 shows a typical plot of the output produced by the Hamburg wheel-tracking device. From this plot, obtain the following values:

9.4.1. Slope and intercept of the first steady-state portion of the curve, and

9.4.2. Slope and intercept of the second steady-state portion of the curve.

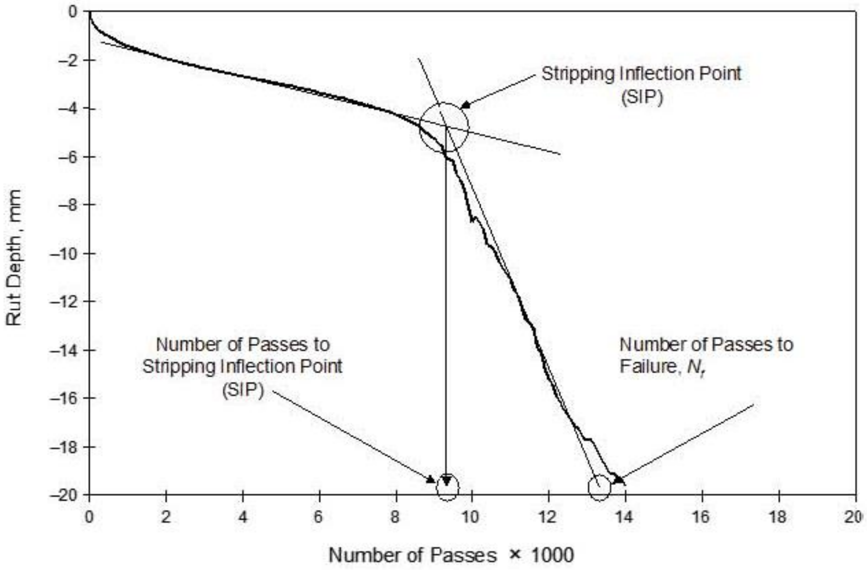


Figure 3—Hamburg Curve with Test Parameters

9.5. Calculate the following test parameters, all expressed in "Passes."

$$\text{stripping inflection point (SIP)} = \frac{\text{intercept (second portion)} - \text{intercept (first portion)}}{\text{slope (first portion)} - \text{slope (second portion)}} \qquad (3)$$

where failure rut depth is the specified maximum allowable rut depth for the test.

Note 12—The specifying agency may choose to define a "test" as an individual slab or core specimen or as a pair of specimens as defined in Section 9.1.

10. REPORT

10.1. *The report may include the following parameters:*

10.1.1. Asphalt mixture production (field or lab);

10.1.2. Compaction method (slab or SGC cylindrical specimen);

10.1.3. Number of passes at maximum impression;

10.1.4. Maximum impression;

10.1.5. Test temperature;

10.1.6. Specimen(s) air voids;

10.1.7. Type and amount of anti-stripping additive used;

10.1.8. Creep slope;

10.1.9. Strip slope; and

10.1.10. Stripping inflection point.

11. PRECISION AND BIAS

11.1. Work is underway to develop precision and bias statements for this standard.

12. KEYWORDS

12.1. Compacted asphalt mixture; moisture-susceptibility; rutting; wheel-track testing.

ANNEX A—EVALUATING HAMBURG WHEEL-TRACKING DEVICE

(Mandatory Information)

A1. SCOPE

A1.1. This Annex covers the evaluation of the Hamburg wheel-tracking device as a check for compliance with the requirements outlined in Sections 5.1 and 5.2. Included are measurements of the wheel s diameter and width, visual inspection of critical surface conditions, verification of the water bath temperature, LDT calibration, wheel loading assembly, wheel travel, and rut measurement.

A1.2. Minimum frequency of this evaluation is 12 months, except for water bath temperature, which is 6 months.

A2. APPARATUS

A2.1. *Measurement Instrument (Calipers or Micrometer)*—With appropriate range and a minimum resolution of 0.1 mm (0.004 in.). The measurement instrument shall be standardized annually.

A2.2. *Reference Thermometer*—With a minimum range of 25 to 70°C (77 to 158°F) with a minimum resolution of 0.1°C (± 0.2°F) and accurate to ± 0.5°C (± 0.9°F).

A2.3. *Hamburg Wheel-Tracking Device Verification/Calibration Kit*—Containing equipment necessary to complete all measurements in Section A6.

Note A1—Calibration kits are available from several equipment manufacturers.

PROCEDURES

A3. MEASURING THE DIAMETER OF THE HAMBURG WHEEL

A3.1. *Perform a visual inspection of the wheel*: The wheel shall be free of residue and deep gouges. Identify any wear that may be visible on the wheel.

A3.2. Determine the maximum diameter of the wheel by measuring it at several locations. Place a removable mark at the maximum diameter position. Record the maximum diameter to the nearest 0.1 mm (0.004 in.).

A3.3. Measure the diameter at a 90-degree orientation to the maximum diameter. Record this diameter to the nearest 0.1 mm (0.004 in.).

A3.4. Each individual diameter measurement shall be compared to the specified range and given a pass/fail rating. If any of the individual measurements are assigned a "fail" rating, the wheel is considered to be out of conformance and shall not be used.

A4. MEASURING THE WIDTH OF THE HAMBURG WHEEL

A4.1. *Perform a visual inspection of the wheel loading surface*: The edge shall be free of residue and deep gouges. Identify any wear that may be visible on the edge of the wheel.

A4.2. Determine the maximum width of the wheel by measuring it at several locations. Place a removable mark at this position. Record the maximum width to the nearest 0.1 mm (0.004 in.).

A4.3. Measure the width at a 90-degree, 180-degree, and 270-degree orientation to the maximum width. Record each width to the nearest 0.1 mm (0.004 in.).

A4.4. Each individual width measurement shall be compared to the specified range and given a pass/fail rating. If any of the individual measurements is assigned a "fail" rating, the wheel is considered to be out of conformance and shall not be used.

A5. VERIFYING THE WATER BATH TEMPERATURE

A5.1. Verify the water bath temperature is within ±1.0°C (±1.8°F) of the temperature readout from the testing device or software every 6 months.

A5.2. Measure the water bath temperature at four locations per the manufacturer's recommendations.

A5.3. Average the four measurements and report this as the water bath verification temperature.

A6. VERIFYING THE LDT CALIBRATION, WHEEL ASSEMBLY, RUT MEASUREMENT, AND WHEEL TRAVEL

A6.1. Verify the LDT calibration in accordance with ASTM D6027/D6027M or per the manufacturer's recommendations.

A6.2. Verify the load from the wheel loading assembly at the level of the initial height of the test per the manufacturer's recommendations to be 703 ± 4.5 N (158.0 ± 1.0 lb). A calibrated load cell, accurate to 0.4 N (0.1 lb), is sufficient for this check. Align the center of the load cell with the middle of the wheel width as well as the center axis of the wheel.

A6.3. Verify that the wheel is reciprocating on the test sample at 52 ± 2 passes per min.

A6.4. Verify that rut measurements are obtained at the 11 preset locations defined in Section 5.2.1 using the aluminum apparatus presented in Figure A1.1. The maximum allowable RMSE at the 11 preset locations after considering the effect of curvature of the aluminum apparatus (Table A1.1) discussed in NCHRP Web-Only Document 219 is 1.27 mm (0.05 in.).

A6.5. The wheel position varying sinusoidally over time shall be verified to have a maximum RMSE of 2.54 mm (0.1 in.) from a perfectly sinusoidal wave unless otherwise specified by the agency.

Table A1.1—Offset Values for Displacement Readings

Position (in.)	Position (mm)	Offset (mm)
−4.5	−114	0.79
−3.6	−91	0.50
−2.7	−69	0.28
−1.8	−46	0.13
−0.9	−23	0.03
0.0	0	0.00
0.9	23	0.03
1.8	46	0.13
2.7	69	0.28
3.6	91	0.50
4.5	114	0.79

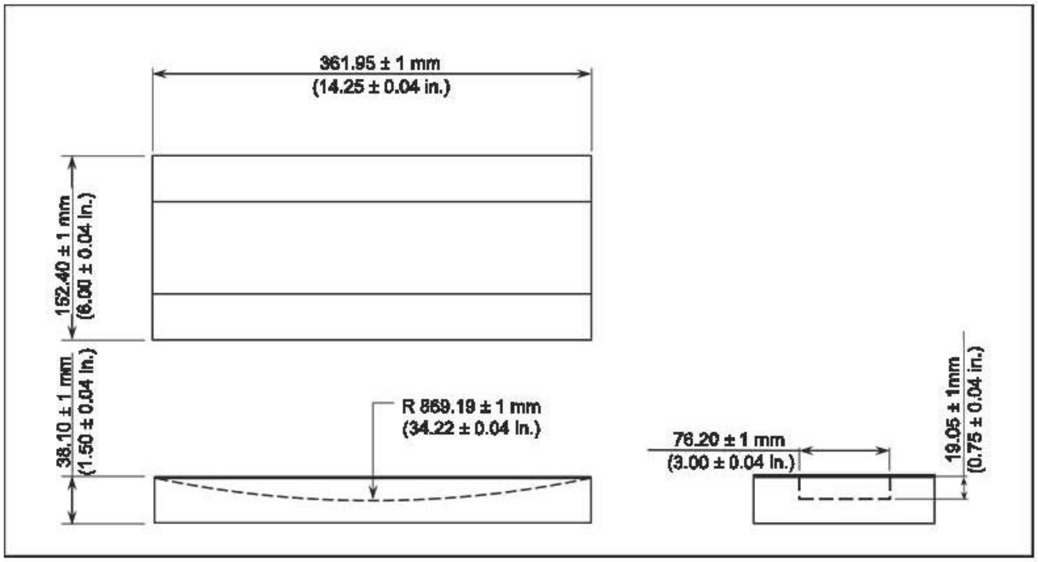


Figure A1.1—Details of the Metal Specimen

A7. INSPECTION REPORT

A7.1. *Record and report the following information:*

A7.2. Name of evaluator.

A7.3. Date.

A7.4. Equipment owner.

A7.5. Location of evaluation.

A7.6. Hamburg wheel-tracking device.

A7.7. Diameter measurements of the wheel to the nearest 0.1 mm (0.004 in.).

A7.8. Width of the loading surface of the wheel to the nearest 0.1 mm (0.004 in.).

A7.9. Water bath temperature to the nearest 0.1°C (0.1°F).

A7.10. LDT.

A7.11. Wheel assembly load reading to the nearest 0.1 N (0.1 lb.).

A7.12. Wheel travel (passes per min.).

A7.13. RMSE at the 11 preset locations after taking into account the effect of curvature of the aluminum apparatus to the nearest 0.01 mm (0.004 in.).

A7.14. Deviation from a perfectly sinusoidal wave as defined through the RMSE to the nearest 0.01 mm (0.004 in.).

A7.15. Allowable maximum deviation from a perfectly sinusoidal wave as defined through the RMSE to the nearest 0.01 mm (0.004 in.) unless equal to 2.54 mm (0.1 in.).

APPENDIX

(Nonmandatory Information)

X1. MAINTENANCE

X1.1. Grease all of the grease fittings with fresh grease every 20 tests (not to exceed 2 months) per the manufacturer's recommendations.

Illinois Modified Test Procedure
Effective Date: December 1, 2018
Revised Date: December 1, 2023

Standard Method of Test

for

Determining the Fracture Potential of Asphalt Mixtures Using the Illinois Flexibility Index Test (I-FIT)

Reference AASHTO T 393-22

Note: Illinois Modified AASHTO T 393 replaces all references to AASHTO TP 124.

AASHTO Section	***Illinois Modification***
2.1	Replace the individual AASHTO Standards with the appropriate Illinois modified AASHTO Standards:
2.1	Delete: R 67
2.1	Add reference to: ▪ Appendix B.7, Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations ▪ Appendix E.3, PFP and QCP Random Density Procedure
6.1.7	Replace the second sentence with the following: The thermometer for measuring the temperature of water baths shall have a suitable range to determine 25 ± 0.5 °C. The thermometer may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.13 °C.
6.1.9	Replace with the first three sentences with the following: *Oven*—A forced-draft oven, properly standardized, thermostatically controlled, and capable of maintaining a uniform temperature of 95 ± 3 °C. More than one oven may be used, provided each is used within its proper operating temperature range. The thermometer for measuring the temperature of materials shall have a suitable range to determine 95 ± 3 °C. The thermometer may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.75 °C.
9.1.1	Replace with the following: *SGC Specimens*—Prepare one laboratory SGC cylinder in the SGC according to T 312 with the compaction height of 160 mm ± 1 mm. Compact two 160 ± 1 mm tall SGC cylinders if long-term aging is to be conducted. Determine the bulk specific gravity (G_{mb}) and air voids of the SGC cylinder according to T 166 and T 269, respectively. The air voids of the 160 ± 1 mm tall SGC cylinders shall be 7.5 ± 0.5%. From the middle of each 160 mm ± 1 mm tall specimen, obtain two cylindrical 50 ± 1 mm thick discs with smooth, parallel faces by saw cutting each face (see Figure 4). Cut each disc into two dimensionally equivalent halves resulting in four individual I-FIT specimens from each 160 ± 1 mm tall SGC cylinder. A minimum of three individual test specimens are required for one I-FIT test.

Illinois Modified Test Procedure
Effective Date: December 1, 2018
Revised Date: December 1, 2023

Standard Method of Test
for

Determining the Fracture Potential of Asphalt Mixtures Using the Illinois Flexibility Index Test (I-FIT)

Reference AASHTO T 393-22

Note: Illinois Modified AASHTO T 393 replaces all references to AASHTO TP 124.

AASHTO Section	***Illinois Modification***
Note 6	Replace with the following: The height of the gyratory compacted cylinders should be 160 ± 1 mm and contain 7.5 ± 0.5 percent air voids. If a lab does not have the capability to compact 160 ± 1 mm tall gyratory cylinders, then two 115 ± 1 mm tall gyratory cylinders with 7.5 ± 0.5 percent air voids may be compacted and used instead to replace each 160 ± 1 mm tall gyratory cylinder. A 50 ± 1 mm thick disc will be cut from the middle of each 115 mm tall gyratory cylinder, which will result in four individual I-FIT specimens (see Figure 4). Although the required air voids are determined from the SGC cylinders, it is also required to continue to determine the air voids on the individual semi-circular I-FIT test specimens to identify if 7.5 ± 0.5% air voids on the SGC cylinders is appropriate to produce individual semi-circular test specimens with 7.0 ± 1.0% air voids.
9.1.2	Replace the first sentence with the following: Obtain pavement cores in accordance with Appendix B.7 or Appendix E.3. Appendix B.7 shall be used in QC/QA applications and Appendix E.3 shall be used in QCP or PFP applications.
10.1	Replace with the following: Perform a long-term aging procedure on I-FIT specimens as defined in Section 7.3 of IL modified AASHTO R 30.
Note 8	Delete
12.1	Re-number Note 9 to be Note 8.
12.2	Re-number Note 10 to be Note 9.
12.7 New Section	When four individual I-FIT specimens that are within specification are tested, the Flexibility Index value that is farthest from the average of the four test specimens shall be discarded as an outlier to lower the variability of the average Flexibility Index value that is reported. The test specimen that is discarded as an outlier shall be removed from the calculations of average and COV for peak load, post-peak slope, fracture energy, and Flexibility Index.
12.8 New Section	When three individual I-FIT specimens are tested, all three specimens will be included in the average and COV for peak load, post-peak slope, fracture energy, and flexibility index.

Illinois Modified Test Procedure
Effective Date: December 1, 2018
Revised Date: December 1, 2023

Standard Method of Test
for

Determining the Fracture Potential of Asphalt Mixtures Using the Illinois Flexibility Index Test (I-FIT)

Reference AASHTO T 393-22

Note: Illinois Modified AASHTO T 393 replaces all references to AASHTO TP 124.

AASHTO Section	***Illinois Modification***
14.1.7	Delete
14.1.8	Delete
14.1.9	Delete
Appendix X1.4.1.4.5	Replace Equation X1.10b with the following: $FI = \frac{G_f}{\lvert m \rvert} \times A$
Appendix X2	Delete

Standard Method of Test for

Determining the Fracture Potential of Asphalt Mixtures Using the Illinois Flexibility Index Test (I-FIT)

AASHTO

AASHTO Designation: T 393-22[1]

Adopted with Revisions: 2021

Editorially Revised: 2022

Technical Subcommittee: 2d, Proportioning of Asphalt–Aggregate Mixtures

1. SCOPE

1.1. This test method covers the determination of Mode I (tensile opening mode during crack propagation) cracking resistance properties of asphalt mixtures at intermediate test temperatures. Specimens are tested in the semicircular bend geometry, which is a half disc with a notch parallel to the direction of load application. The data analysis procedure associated with this test determines the fracture energy (G_f) and post peak slope (m) of the load–load line displacement (LLD) curve. These parameters are used to develop a flexibility index (FI) to predict the fracture resistance of an asphalt mixture at intermediate temperatures. The FI can be used as part of the asphalt mixture approval process.

1.2. These procedures apply to test specimens having a nominal maximum aggregate size (NMAS) of 19 mm or less. Lab compacted and pavement core specimens can be tested according to this test procedure. A thickness correction factor will need to be developed and applied for pavement cores tested at a thickness less than 45 mm.

1.3. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish and follow appropriate health and safety practices and determine the applicability of regulatory limitations prior to use.*

1.4. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 339M/M 339, Thermometers Used in the Testing of Construction Materials
- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- R 67, Sampling Asphalt Mixtures after Compaction (Obtaining Cores)

- T 166, Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
- T 269, Percent Air Voids in Compacted Dense and Open Asphalt Mixtures
- T 283, Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage
- T 312, Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor

2.2. *ASTM Standards*:

- D8, Standard Terminology Relating to Materials for Roads and Pavements
- D3549/D3549M, Standard Test Method for Thickness or Height of Compacted Bituminous Paving Mixture Specimens
- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E879, Standard Specification for Thermistor Sensors for General Purpose and Laboratory Temperature Measurements
- E1137/E1137M, Standard Specification for Industrial Platinum Resistance Thermometers
- E2877, Standard Guide for Digital Contact Thermometers

2.3. *International Electrotechnical Commission Standards*:

- IEC 60584-1: 2013 Thermocouples - Part 1: EMF Specifications and Tolerances
- IEC 60751: 2008 Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors

2.4. *Other Publications:*

- Al-Qadi, I. L., H. Ozer, J. Lambros, A. El Khatib, P. Singhvi, T. Khan, and B. Doll. *Testing Protocols to Ensure Performance of High Asphalt Binder Replacement Mixes Using RAP and RAS*, FHWA ICT-15-07. Illinois Center for Transportation, Rantoul, IL, 2015.
- Doll. B., H. Ozer, J. Rivera-Perez, J. Lambros, and I. L. Al-Qadi. Investigation of Viscoelastic Fracture Fields in Asphalt Mixtures Using Digital Image Correlation. *International Journal of Fracture*, Vol. 205, No. 1. Springer Nature Switzerland AG, January 2017,pp. 37–56.
- Ozer, H., I. L. Al-Qadi, J. Lambros, A. El-Khatib, P. Singhvi, and B. Doll. Development of the Fracture-Based Flexibility Index for Asphalt Concrete Cracking Potential Using Modified Semi-Circle Bending Test Parameters. *Construction and Building Materials*, Vol. 115. Science Direct, Elsevier B.V., Amsterdam, Netherlands, 2016a, pp. 390–401.
- Ozer, H., and P. Singhvi, T. Khan, J. Rivera, I. L. Al-Qadi. Fracture Characterization of Asphalt Mixtures with RAP and RAS Using the Illinois Semi-Circular Bending Test Method and Flexibility Index. *Transportation Research Record*, Vol. 2575. Transportation Research Board, National Research Council, Washington, DC, 2016b, pp. 130–137.
- Ozer, H., I. L. Al-Qadi, P. Singhvi, J. Bausano, R. Carvalho, X. Li, and N. Gibson. Assessment of Asphalt Mixture Performance Tests to Predict Fatigue Cracking in an Accelerated Pavement Testing Trial. *International Journal of Pavement Engineering*, Special Issue for Cracking in Flexible Pavements and Asphalt Mixtures: Theories to Modeling, and Testing to Mitigation, 2017.
- RILEM Technical Committee 50-FMC. Determination of the Fracture Energy of Mortar and Concrete by Means of Three-Point Bend Tests on Notched Beams. *Materials and Structures*, No. 106, July–August 1985. Springer Netherlands for International Union of Laboratories and Experts in Construction Materials, Systems and Structures (RILEM), Dordrecht, The Netherlands, 1985, pp. 285–290.

3. TERMINOLOGY

3.1. *Definitions*:

3.1.1. *critical displacement, u_1*—displacement at the intersection of the post-peak slope with the displacement-axis.

3.1.2. *displacement at peak load, u_0*—recorded displacement at peak load.

3.1.3. *final displacement, u_{final}*—recorded displacement at the 0.1 kN cut-off load.

3.1.4. *flexibility index*, FI—index intended to characterize the cracking resistance of asphalt mixture, calculated by multiplying the ratio of fracture energy to post-peak slope by a constant multiplier.

3.1.5. *fracture energy, G_f*—energy required to create a unit surface area of a crack.

3.1.6. *ligament area*, $Area_{lig}$—cross-sectional area of specimen through which the crack propagates, calculated by multiplying ligament width (test specimen thickness) and ligament length.

3.1.7. *linear variable displacement transducer (LVDT)*—sensor device for measuring linear displacement.

3.1.8. *load line displacement (LLD)*—displacement measured in the direction of the load application.

3.1.9. *post-peak slope, m*—slope at the first inflection point of the load–LLD curve after the peak.

3.1.10. *semicircular bend (SCB) geometry*—a half disc with a notch parallel to the direction of load application.

3.1.11. *work of fracture (W_f)*—calculated as the area under the load–LLD curve.

4. SUMMARY OF METHOD

4.1. A superpave gyratory compactor (SGC) compacted asphalt mixture specimen or an asphalt pavement core is trimmed and cut in half to create a semicircular test specimen. A notch is sawn in the flat side of the semicircular specimen opposite the curved edge. The specimen is conditioned and maintained through testing at 25 ± 0.5°C. The specimen is positioned in the fixture with the notched side down centered on two rollers. A load is applied along the vertical radius of the specimen and the load and load line displacement (LLD) are measured during the entire duration of the test. The load is applied such that a constant LLD rate of 50 mm/min is obtained and maintained for the duration of the test. The I-FIT fixture and I-FIT specimen geometry for an SGC laboratory compacted specimen are shown in Figure 1.

4.2. Fracture energy (G_f), post-peak slope (m), displacement at peak load (u_0), critical displacement (u_1), and a flexibility index (FI) are calculated from the load and LLD results.

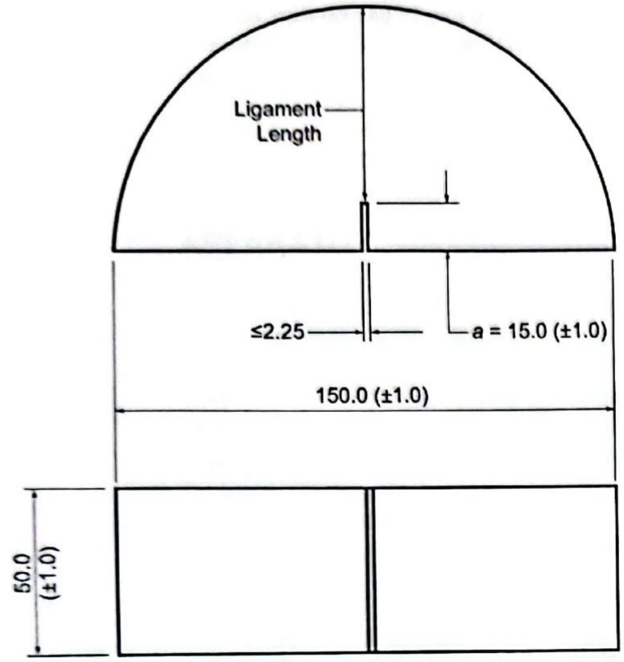


Figure 1—I-FIT SGC Laboratory Compacted Specimen Configuration (dimensions in millimeters)

5. SIGNIFICANCE AND USE

5.1. The I-FIT is used to determine fracture resistance parameters of an asphalt mixture at an intermediate temperature (Al-Qadi et al., 2015; Ozer et al., 2016a; Ozer et al., 2016b). From the fracture parameters of G_f and m obtained, the FI of an asphalt mixture is calculated. The FI provides a means to identify brittle mixtures that may be prone to premature cracking. The range for an acceptable FI will vary according to local environmental conditions, application of mixture, nominal maximum aggregate size (NMAS), asphalt binder content, asphalt binder performance grade (PG), air voids, and expectation of service life, etc. (Al-Qadi et al., 2015; Ozer et al., 2016a; Ozer et al., 2016b; Ozer et al., 2017).

5.2. The calculated FI indicates an asphalt mixture's overall capacity to resist cracking related damage (Al-Qadi et al., 2015). Generally, a mixture with higher FI can resist crack propagation for longer time duration under tensile stress. The FI should not be directly used in structural design and analysis of pavements. FI values, obtained using this procedure, are used in ranking the cracking resistance of alternative mixtures for a given layer in a structural design. The G_f parameter is dependent on specimen size, loading time, and temperature. Fracture mechanisms for viscoelastic materials are influenced by crack front viscoelasticity and bulk material (far from the crack front) viscoelasticity. Total calculated G_f from this test includes the amount of energy dissipated by crack propagation, viscoelastic mechanisms away from the crack front, and other inelastic irreversible processes (frictional and damage processes at the loading support points) (Doll et al., 2016).

5.3. G_f is one of the parameters used to calculate the FI, which is further used to predict AC mixture fracture potential. It also represents the main parameter input in more complex analyses based on a theoretical crack (cohesive zone) model. In order to be used as part of a cohesive zone model, fracture energy as calculated from the experiment shall be corrected to determine energy associated with crack propagation only. A correction factor may be used to eliminate other sources of inelastic energy contributing to the total fracture energy calculated directly from the experiment.

5.4. This test method and FI can be used to rank the cracking resistance of asphalt mixtures containing various asphalt binders, modifiers of asphalt binders, aggregate blends, fibers, and recycled materials.

5.5. The specimens can be readily obtained from SGC compacted cylinders or from pavement cores with a diameter of 150 mm.

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6. APPARATUS

6.1. *Testing Machine*—An I-FIT system consists of a closed-loop axial loading device, a load measuring device, a bend test fixture, specimen deformation measurement devices, and a control and data acquisition system. A constant displacement-rate device, such as a closed loop, feedback-controlled servo-hydraulic load frame, shall be used.

Note 1—An electromechanical, screw-driven machine may be used if results are comparable to a closed loop, feedback-controlled servo-hydraulic load frame.

6.1.1. *Axial Loading Device*—The loading device shall be capable of delivering loads in compression with a maximum resolution of 10 N and a capacity of at least 10 kN.

6.1.2. *Bend Test Fixture*—The fixture is composed of a loading head, a steel base plate, and two steel rollers with a nominal diameter (*D*) of 25 mm. The tip of the loading head has a contact curvature with a radius of 12.5 ± 0.05 mm. The horizontal loading head shall pivot relative to the vertical loading axis to conform to slight specimen variations. The length of the two roller supports in Figure 2 and Figure 3 shall be a minimum of 65 mm. Illustrations of the loading and supports are shown in Figures 2 and 3.

6.1.2.1. *Method A*—Typically two steel rollers with a nominal diameter of 25 mm are mounted on bearings through their axis of rotation and attached to the steel base plate with brackets. One of the steel rollers may pivot on an axis perpendicular to the axis of loading to conform to slight specimen variations. A distance of 120 ± 0.1 mm between the two steel rollers is maintained throughout the test.

6.1.2.2. *Method B*—An alternate fixture design uses two steel rollers with a nominal diameter of 25 mm that each rotate in a U-shaped roller support steel block. The initial roller position is fixed by springs and backstops that establish the initial test span dimension of 120 ± 0.1 mm. The support rollers are allowed to rotate away from the backstops during the test; but remain in contact with the sample.

6.1.3. *Internal Displacement Measuring Device*—The displacement measurement can be performed using the machine's stroke (position) transducer if the resolution of the stroke is sufficient (0.01 mm or lower). The fracture test displacement data may be corrected for system compliance, loading-pin penetration and specimen compression by performing a calibration of the testing system.

6.1.4. *External Displacement Measuring Device*—If an internal displacement measuring device does not exist or has insufficient precision, an externally applied displacement measurement device such as a linear variable differential transducer (LVDT) accurate to 0.01 mm can be used (Figure 2 and Figure 3).

6.1.5. *Control and Data Acquisition System*—Time and load, and LLD (using external and/or internal displacement measurement device) are recorded. The control data acquisition system is required to apply a constant LLD rate at a precision of 50 ± 1 mm/min and collect data at a minimum sampling frequency of 20 Hz in order to obtain a smooth load–LLD curve.

Note 2—The use of two LLD transducers 180 degrees from one another and on each side of a test specimen may be used. In this approach, an average LLD value is computed to control the test. Controlling the test using an average LLD value may reduce test variability.

6.1.6. *Saw*—Laboratory saw capable of cutting asphalt specimens; must be capable of cutting the notch described in Figure 1.

6.1.7. *Conditioning Chamber*—Water bath or environmental chamber of sufficient size, capable of maintaining a uniform temperature, used within their proper operating temperature range, to conditioned samples at 25 ± 0.5°C. The thermometer for measuring the temperature of water baths shall meet the requirements of M 339M/M 339 with a temperature range of at least 20 to 30°C, and an accuracy of ±0.13°C.

Note 3—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E879 thermistor thermometer, Special order; ASTM E1137/E1137M Pt-100 RTD platinum resistance thermometer, Special order; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, Special order.

6.1.8. *Measuring Device*—Caliper or ruler accurate to ±0.1 mm for specimen thickness and area measurement.

6.1.9. *Oven*—A forced-draft oven, properly standardized, thermostatically controlled, and capable of maintaining a uniform temperature of 95°C within ±3°C. More than one oven may be used, provided each is used within its proper operating temperature range. The thermometer for measuring the temperature of materials shall meet the requirements of M 339M/M 339 with a temperature range of at least 25 to 185°C, and an accuracy of ±0.75°C.

Note 4—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; IEC 60584 thermocouple thermometer, Type T, Class 1; or E2877 digital metal stem thermometer.

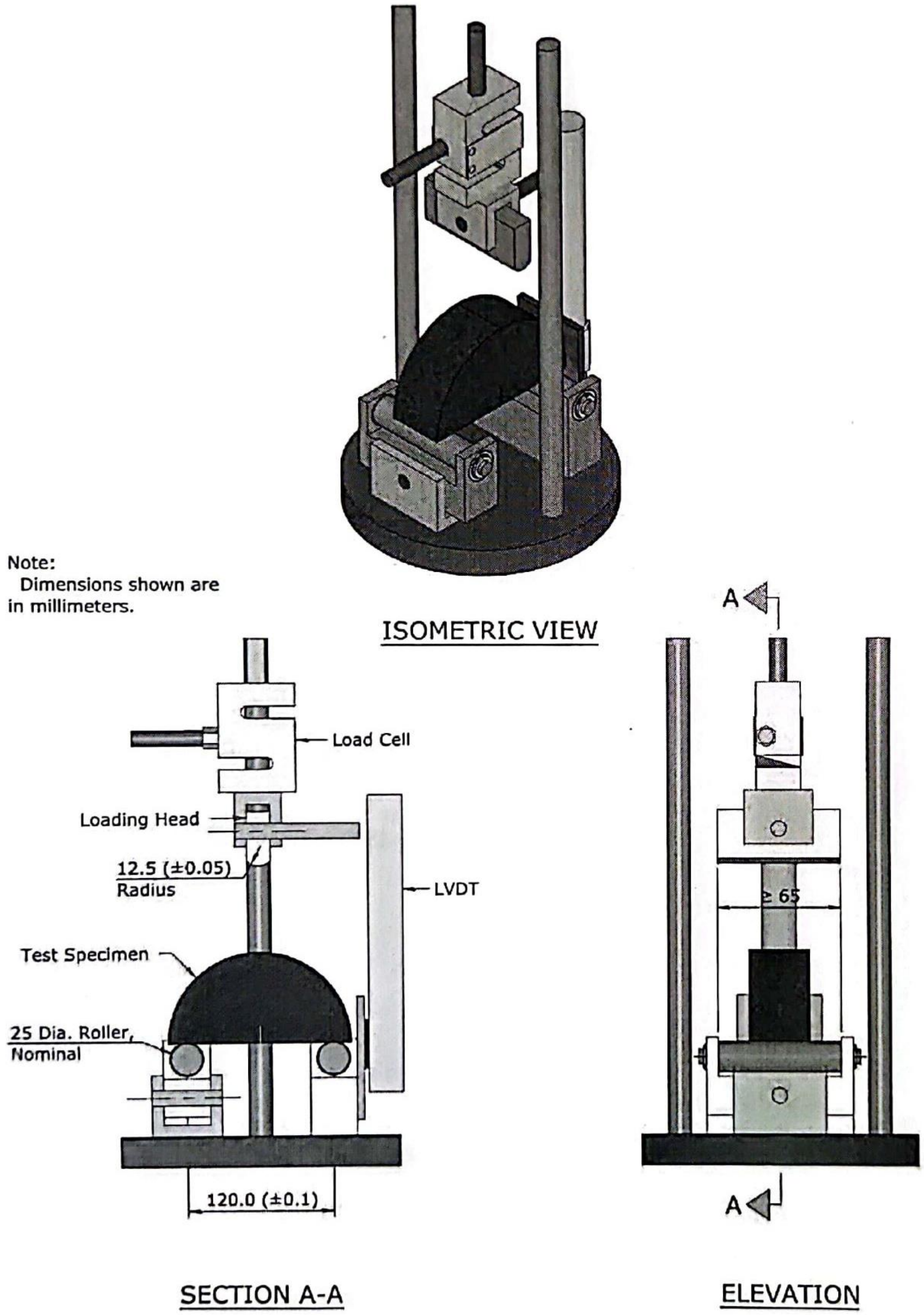
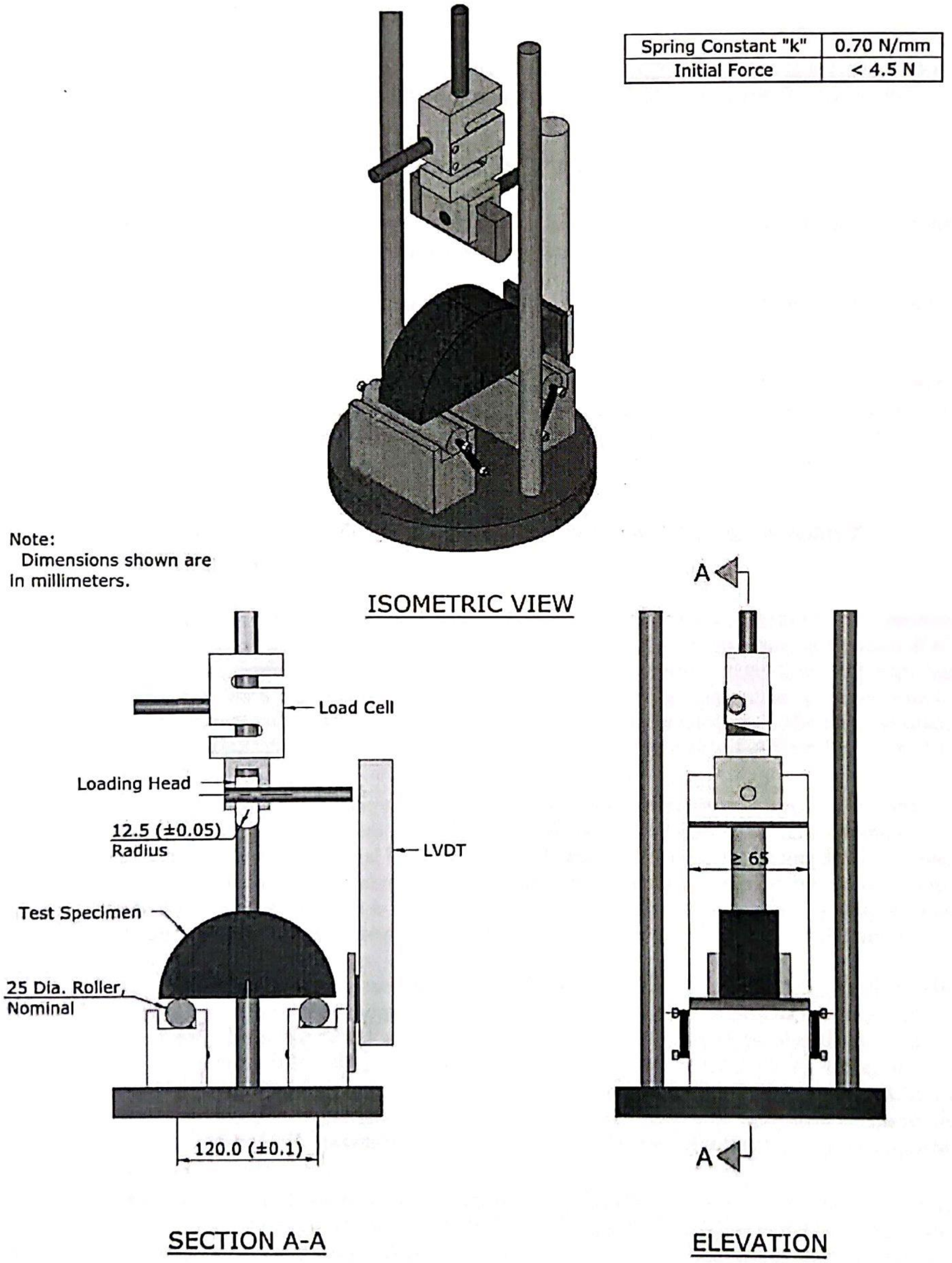


Figure 2—Method A—Isometric, Cross-Section, and Elevation of the I-FIT Fixture (dimensions in millimeters)



Spring Constant "k"	0.70 N/mm
Initial Force	< 4.5 N

Figure 3—Method B—Isometric, Cross-Section, and Elevation of the I-FIT Fixture (dimensions in millimeters)

7. HAZARDS

7.1. Standard laboratory caution should be used in handling, compacting, and fabricating asphalt mixtures test specimens in accordance with T 312 and when using a saw for cutting specimens.

8. CALIBRATION AND STANDARDIZATION

8.1. A water bath as used in AASHTO T 283 or an environmental chamber will be used to maintain the specimen at a constant and uniform temperature.

8.2. Verify the calibration of all measurement components (such as load cells and LVDTs) of the testing system.

8.3. If any of the verifications yield data that does not comply with the accuracy specified, correct the problem prior to proceeding with testing. Appropriate action may include maintenance of system components, calibration of system components (using an independent calibration agency, service by the manufacturer, or in-house resources), or replacement of the system components.

9. PREPARATION OF TEST SPECIMENS AND PRELIMINARY DETERMINATIONS

9.1. *Test Specimen Size*—For mixtures with an NMAS of 19 mm or less, prepare the test specimens from a lab compacted SGC specimen or from pavement cores. If laboratory compacted SGC specimens are used, the final I-FIT specimens shall have smooth parallel faces with a thickness of 50 ± 1 mm and a diameter of 150 ± 1 mm (see Figure 4). If pavement cores are used, refer to Figure 1 for the notch width and notch length dimensions and tolerances. The final pavement core I-FIT specimen dimensions shall be 150 ± 8 mm in diameter with smooth parallel faces 25 to 50 ± 1 mm thick depending on available field layer thickness.

Note 5—A typical laboratory saw for mixture specimen preparation can be used to obtain cylindrical discs with smooth parallel surfaces. A tile saw is recommended for cutting the 15 ± 1 mm notch in the individual I-FIT specimens. Diamond-impregnated cutting faces and water cooling are recommended to minimize damage to the specimen. When cutting the I-FIT specimens into semi-circular halves, it is recommended not to push the two halves against each other because it may create an uneven base surface of the test specimen that can affect the I-FIT results.

9.1.1. *SGC Specimens*—Prepare one laboratory SGC specimen according to T 312 in the SGC with the compaction height a minimum of 160 ± 1 mm. From the middle of each 160 ± 1 mm tall specimen, obtain two cylindrical 50 ± 1 mm thick discs with smooth, parallel faces by saw cutting (see Figure 4). For laboratory compacted specimens, the bulk specific gravity and the air voids shall be determined for each of the two circular discs according to T 269. The air voids for each disc shall be 7.0 ± 1.0 percent. Cut each disc into two dimensionally equivalent halves resulting in four individual I-FIT specimens. A minimum of three individual test specimens are required for one I-FIT result.

Note 6—The height of the gyratory compacted specimens should be 160 ± 1 mm to achieve a target 7.0 ± 1.0 percent air voids in each disc (see Figure 4). If a lab does not have the capability to compact 160 ± 1 mm tall gyratory specimens, then two 115 ± 1 mm tall gyratory specimens may be compacted and used instead to replace each 160 ± 1 mm tall gyratory specimen. A 50 ± 1 mm thick disc will be cut from the middle of each gyratory specimen, which will result in four individual I-FIT specimens (see Figure 4).

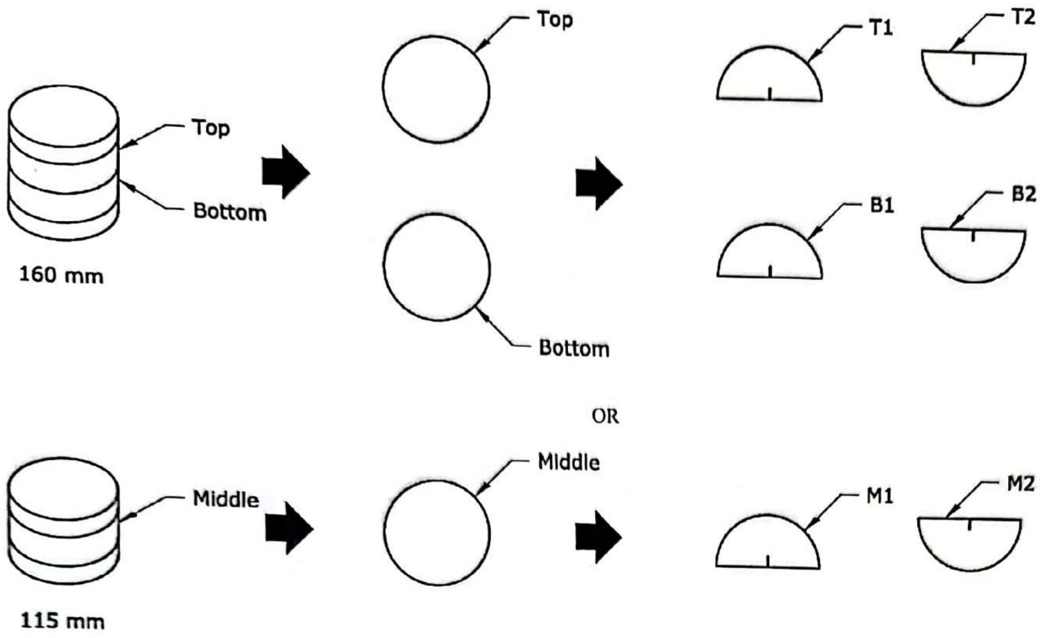


Figure 4—Specimen Preparation from 160 mm or 115 mm Tall SGC Specimens

9.1.2. *Pavement Cores*—Obtain pavement cores in accordance with R 67. Obtain one 150 mm diameter pavement core if the lift thickness is greater than or equal to 100 mm, or two 150 mm diameter pavement cores if the lift thickness is less than 100 mm.

9.1.2.1. *Pavement Core Specimen Preparation*—Prepare four replicate I-FIT specimens using pavement cores obtained from a pavement lift, with smooth, parallel surfaces that conform to the height and diameter requirements specified herein. To preserve and maximize core thickness, the as-compacted face shall be utilized as well as a sawed face. The thickness of test specimens in most cases for pavement cores may vary from 25 to 50 ± 1 mm. If the lift thickness is less than 50 ± 1 mm, test specimens should be prepared as thick as possible but in no case be less than two times the nominal maximum aggregate size of the mixture or 25 ± 1 mm, whichever is greater. If lift thickness is greater than 50 ± 1 mm, a 50 ± 1 mm disc shall be prepared as specified in Section 9.1. Cores from pavements with lifts greater than 75 ± 1 mm may be cut to provide two cylindrical specimens of equal thickness. In the upper-most pavement layer when cored, the as-compacted face will remain intact and one cut will be made to produce a disc at least two times the nominal maximum aggregate size of the mixture or 25 ± 1 mm, whichever is greater. In all subsequent discs cut from that pavement core, two sawed faces may be used to produce smooth, parallel surfaces.

9.1.2.2. *Determining the Bulk Specific Gravity*—Determine the bulk specific gravity directly on each disc obtained from pavement cores according to T 166.

9.1.2.3. *Determining the Air Voids*—The air void contents of each disc shall be determined according to T 269. Pavement cores will not be subject to air void content tolerances.

9.1.2.4. *Cutting Semicircular Test Specimens*—Cut each cylindrical disc in half to produce two dimensionally equivalent semicircular test specimens.

9.2. *Notch Cutting*—Cut a notch along the axis of symmetry of each individual semicircular specimen to a depth of 15 ± 1 mm and ≤2.25 mm in width (see Figure 1).

Note 7—If the notch terminates in an aggregate particle 9.5 mm or larger on both faces of the specimen, the specimen shall be discarded.

9.3. *Determining Specimen Dimensions*—Measure the notch depth on both faces of the specimen and record the average value to the nearest 0.5 mm. Measure and record the ligament length (see Figure 1) and thickness of each specimen. The ligament length may be measured *directly* on both faces of the specimen with the average value recorded, or the ligament length may be measured *indirectly* by subtracting the notch depth from the entire width (radius) of the specimen on both faces of the specimen and averaging the two measurements. Measure the specimen thickness approximately 19.0 mm on either side of the notch and on the curved edge directly across from the notch. Average the three measurements and record as the average thickness to the nearest 0.1 mm.

10. LONG-TERM AGING

10.1. Perform a long-term aging procedure on I-FIT specimens as defined by the specifying agency.

Note 8—The I-FIT specimen long-term aging procedure in Appendix X2 may be used.

11. TEST PROCEDURE

11.1. *Conditioning*—Test specimens shall be conditioned in a water bath or an environmental chamber at 25 ± 0.5°C for 2 h ± 10 min.

11.1.1. *Test Temperature Control*—Immediately after removing the test specimen from the conditioning water bath or environmental chamber, complete positioning and testing of the I-FIT specimen within 5 ± 1 min to ensure that the specimen temperature is maintained.

11.2. *Position Specimen*—Position the test specimen in the test fixture on the rollers so that it is centered in both the "x" and the "y" directions and so that the vertical axis of loading is aligned to pass from the center of the top radius of the specimen through the middle of the notch.

11.3. *Contact Load*—First, impose a contact load of 0.1 ± 0.01 kN in stroke control with a loading rate of 0.05 kN/s.

11.3.1. *Record Contact Load*—Record the contact load to ensure it is achieved.

11.3.2. *Loading*—After the contact load of 0.1 kN is reached, the test is conducted using LLD control at a rate of 50 mm/min. The test stops when the load drops below 0.1 kN.

11.3.3. Repeat Sections 11.1 through 11.3.2 for each test specimen.

12. PARAMETERS

12.1. *Determining Work of Fracture (W_f)*—The work of fracture is calculated as the area under the load–LLD curve (see Figure 5). If the test is stopped prior to reaching 0.1 kN, the remainder of the load–LLD curve should be produced by extrapolation techniques.

The area under the load–LLD curve is calculated using a numerical integration technique. In order to apply the numerical integration, raw load-displacement data shall be divided into two curves described by an appropriate fitting equation. A polynomial equation with a degree of six is sufficient for the curve prior to peak load (Equation 1). An exponential-based function (Equation 2) is used for the post-peak load portion of the curve. Then, analytical integration shall be applied to calculate the area under each curve (Equation 3).

For displacements (u) prior to the peak load ($P_{\max}$):

$$P_1(u) = c_1 \times u^6 + c_2 \times u^5 + c_3 \times u^4 + c_4 \times u^3 + c_5 \times u^2 + c_6 \times u^1 + c_7 \qquad (1)$$

where:

c_i = polynomial coefficients.

For displacements (u) after the peak load ($P_{\max}$) to the cut-off displacement (u_{final}):

$$P_2(u) = \Sigma_i^{n=4} d_i \exp\left[-\left(\frac{u-e_i}{f_i}\right)^2\right] \qquad (2)$$

where:

d, e, f = polynomial coefficients, n is the number of exponential terms.

Work of fracture can be analytically or numerically calculated using the integral equation below and boundaries of displacement:

$$W_f = \int_0^{u_0} P_1(u)\,du + \int_{u_0}^{u_{\text{final}}} P_2(u)\,du \qquad (3)$$

where:

u_0 = displacement at the peak load;

u_{final} = displacement at the 0.1 kN cut-off load.

Note 9—Due to the relative difference between the compliance of testing frame and specimen, displacement recorded may vary. A correction factor may need to be considered to correct recorded displacements when applicable.

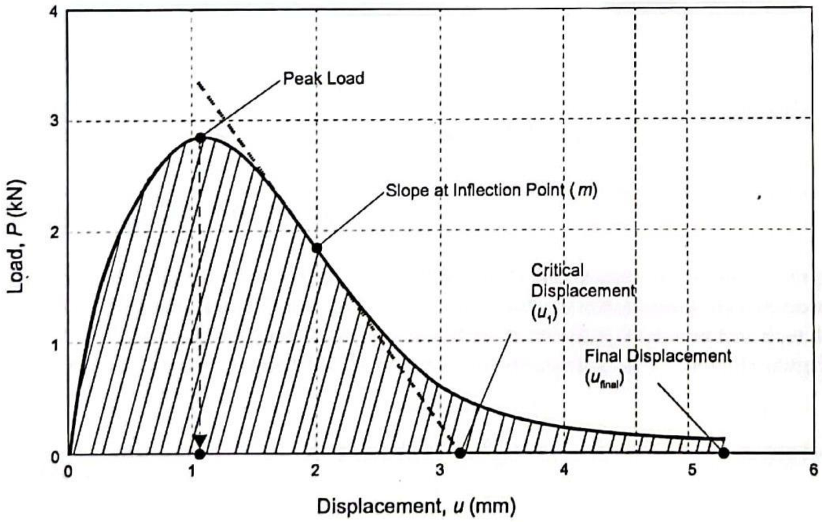


Figure 5—Recorded Load (P)–Load Line Displacement (u) Curve

12.2. *Fracture Energy (G_f)*—The fracture energy G_f, determined as per the RILEM TC 50-FMC (1985) approach, is calculated by dividing the work of fracture (the area under the load–LLD curve; see Figure 5) by the ligament area (the product of the ligament length and the thickness of the specimen) of the I-FIT specimen prior to testing:

$$G_f = \frac{W_f}{\text{Area}_{\text{lig}}} \times 10^6 \qquad (4)$$

where:

G_f = fracture energy (Joules/m^2);
W_f = work of fracture (Joules);
P = load (kN);
u = load line displacement (mm);
Area_{lig} = ligament area = $(r - a) \times t$, (mm^2);
r = specimen radius (mm);
a = notch length (mm);
t = specimen thickness (mm).

Note 10—G_f is a size dependent property. This specification does not aim at calculating size independent G_f. Therefore, cracking resistance of asphalt mixtures quantified with G_f may vary when the notch length to radius ratio changes.

12.3. *Determining Post-Peak Slope (m)*—The inflection point is determined on the load–LLD curve (Figure 5) after the peak load. The slope of the tangential curve drawn at the inflection point represents post-peak slope.

12.4. *Determining Displacement at Peak Load (u_0)*—The displacement when peak load is reached.

12.5. *Determining Critical Displacement (u_1)*—Intersection of the tangential post-peak slope with the displacement axis yields the critical displacement value. A straight line is drawn connecting the inflection point and displacement axis with a slope *m*.

12.6. *Flexibility Index (FI)*—FI can be calculated from the parameters obtained using the load–LLD curve (Al-Qadi et al. (2015), Ozer et al. (2016a), Ozer et al. (2016b)). The factor *A* is used for unit conversion and scaling. *A* is equal to 0.01. Complete details of the analysis procedure are provided in Appendix X1.

$$FI = \frac{G_f}{|m|} \times A \qquad (5)$$

where:

$|m|$ = absolute value of post-peak load slope m (kN/mm).

13. CORRECTION FACTORS

13.1. *Correction Factors for Flexibility Index*—Flexibility index correction factors for pavement core specimen thickness and differences between field and lab compaction may be needed. A thickness correction factor may be applied for pavement cores tested at thickness less than 45 mm. The correction factors may require local calibration to consider locally available materials and mixture design requirements.

14. REPORT

14.1. *Report the following information*:

14.1.1. Bulk specific gravity of each specimen tested, to the nearest 0.001;

14.1.2. Air void content of each disc, to the nearest 0.1 percent;

14.1.3. The number of cut faces for each specimen tested, if pavement cores were used;

14.1.4. Average thickness *t* and average ligament length of each specimen tested, to the nearest 0.1 mm;

14.1.5. Initial notch length *a*, to the nearest 0.5 mm;

14.1.6. Average and coefficient of variation (COV) of peak load, to the nearest 0.1 kN;

14.1.7. Average and COV of recorded time at peak load, to the nearest 0.1 s;

14.1.8. Average and COV of load-line displacement at the peak load (u_0), to the nearest 0.1 mm;

14.1.9. Average and COV of critical displacement (u_1), to the nearest 0.1 mm;

14.1.10. Average and COV of post-peak slope (m), to the nearest 0.1 kN/mm;

14.1.11. Average and COV of fracture energy G_f, to the nearest 1 J/m^2; and

14.1.12. Average and COV of flexibility index to the nearest 0.1.

15. PRECISION AND BIAS

15.1. *Precision:*

15.1.1. *Single-Operator Precision*—The single-operator coefficient of variation of flexibility index has been found to be 27.1 percent. Therefore, results of two properly conducted tests by the same operator on the same material are not expected to differ from each other by more than 75.9 percent of their average.

15.1.2. *Multi-laboratory Precision*—The multi-laboratory coefficient of variation of flexibility index has been found to be 34.1 percent. Therefore, results of two properly conducted tests by two different laboratories on specimens of the same material are not expected to differ from each other by more than 95.5 percent of their average.

Table 1—Precision Estimates[a]

		Components of Variance		Variances	
Material	Average FI	Single Operator	Between Laboratory	Single Operator	Multi-laboratory
2017	5.2	2.36	0.49	2.36	2.85
2018	23.1	36.85	7.64	36.85	44.49
2019	9.6	5.90	9.55	5.90	15.44

		Standard Deviations		Coefficients of Variation (%)	
Material	Average FI	Single Operator	Multi-laboratory	Single Operator	Multi-laboratory
2017	5.2	1.54	1.69	29.6	32.5
2018	23.1	6.07	6.67	26.3	28.9
2019	9.6	2.43	3.93	25.3	41.0

[a] Based on a multi-laboratory study of state departments of transportation, private, and academic laboratories in 2017, 2018, and 2019. Three materials (all 9.5-mm NMAS mixtures) with varying contents of RAP were used (a different mixture was used each year). Approximately 12 specimens were tested per material on at least 30 devices per year.

15.2. *Bias*—No information can be presented on the bias of the procedure because no material having an accepted reference value is available.

16. KEYWORDS

16.1. Asphalt mixture; flexibility index; fracture energy; Illinois flexibility index test (I-FIT); semicircular bend (SCB); stiffness; work of fracture.

APPENDIXES

X1. CALCULATIONS[2]

X1.1. *Scope*:

X1.1.1. This appendix presents the framework and algorithms used to process the load–LLD curve and to compute the critical variables such as fracture energy, slope (after the crack begins propagating), and flexibility index. The algorithm consists of the following steps:

X1.1.1.1. Preprocessing the raw load–LLD curve;

X1.1.1.2. Pre-peak calculations; and

X1.1.1.3. Post-peak calculations.

X1.2. *Preprocessing*:

X1.2.1. The algorithm starts with preprocessing the raw test output file containing the load and displacement data. The first step of pre-processing is to trim the tail of the curve. The data points whose load values are smaller than 0.1 kN are removed. Because the load–LLD curve exhibits different characteristics before and after the peak load, the trimmed load–LLD curve is divided into two parts: pre-peak and post-peak. To do this, the peak load at which maximum load value is reached is identified. The values of the load–LLD curve before the peak load are assigned to the pre-peak segment; the remaining data are assigned to the post-peak segment. The calculations required for pre-peak and post-peak segments are explained in Sections X1.3 and X1.4.

X1.3. *Pre-Peak Calculations*:

X1.3.1. *The following steps are completed to process the pre-peak segment of the load–LLD curve*:

X1.3.1.1. The beginning (u_i, P_i) and end (u_0, P_{max}) coordinates of the load–LLD curve are captured.

X1.3.1.2. A polynomial equation with a degree of six is fitted to the pre-peak segment of the load–LLD curve (Equation X1.1).

$$P_1(u) = c_1 \times u^6 + c_2 \times u^5 + c_3 \times u^4 + c_4 \times u^3 + c_5 \times u^2 + c_6 \times u^1 + c_7 \qquad (X1.1)$$

where:

c_i = polynomial coefficients.

X1.3.1.3. A new set of data is generated with equal displacement increments using the polynomial function bounded by the beginning and end points found in Section X1.3.1.1. The increments used to divide the data are found by dividing the displacement at the peak load by 1000. A new displacement vector (u_{pre}) is generated from u_i to u_0 with calculated increments. The new loading vector is computed by substituting the value of the displacement vector in Equation X1.1. The purpose of generating a dataset with higher resolution is to increase the accuracy of the numerical integration described in Section X1.3.1.4.

X1.3.1.4. Numerical integration is applied to calculate area under the pre-peak segment of the load–LLD curve. The integral for area calculation is given in Equation X1.2. A trapezoidal integration technique is used for the numerical integration of Equation X1.2. When analytical integration tools are available, analytical integration is recommended to improve accuracy.

$$W_f\,(\text{pre-peak}) = \int_0^{u_0} P_1(u)\,du \qquad (X1.2)$$

X1.3.1.5. When the load–LLD curve starts with a residual load at zero displacement, the curve needs to be extrapolated to modify the area calculated in the previous step. In such cases, the curve is linearly extrapolated to the displacement coordinate where the load is zero. The displacement at the zero load (u_r) is found. The area under the extrapolated segment is added to calculate total pre-peak area X1. Numerical integration is applied to find the residual area shown by the additional term in Equation X1.3. The second part of the sum comes from the additional area of extrapolation.

$$W_f\,(\text{pre-peak}) = \int_0^{u_0} P_1(u)\,du + u_r \times P_r \times 0.5 \qquad (X1.3)$$

where:

P_r = residual load at zero displacement; and

u_r = calculated displacement at zero load.

X1.4. *Post-Peak Calculations*:

X1.4.1. An algorithm was developed to process the post-peak segment of the load–LLD curve to calculate area under the curve as well as the inflection point and slope at the inflection point. Explanations of each step are given in Sections X1.4.1.1 through X1.4.1.3.

X1.4.1.1. The beginning (u_0, P_0) and end (u_f, P_f) coordinates of the post-peak load–LLD curve are captured (see Figure X1.1). The raw data records are stored in two vectors as $u_{\text{post}} = \{u_0, \ldots, u_f\}$ and $P_{\text{post}} = \{P_0, \ldots, P_f\}$.

X1.4.1.2. In this step, candidate lower bounds for parameter f in Equation X1.4 are initialized and kept in a vector. This parameter can govern the first derivative of the post-peak segment resulting in abnormal slope values. For example, if a lower bound is not defined for this parameter, it may go to zero, which creates a spike-like, spurious slope. On the other hand, if the bound is defined too high, accuracy of the fitted curve may be compromised. Therefore, candidate values for the lower bounds for this parameter were found to be $f_{\text{bounds}} = \{0.9, 0.7, 0.5, 0.3, 0.1, 0.05, 0.01, 0.005, 0.001\}$. The optimum value is found iteratively looping over the values initialized in the f_{bounds}. The order of the values should be descending.

$$P_2(u) = \Sigma_i^{n=4}\, d_i \exp\left[-\left(\frac{u-e_i}{f_i}\right)^2\right] \qquad (X1.4)$$

where:

d, e, f = polynomial coefficients, and

n = number of exponential terms.

X1.4.1.3. All model parameters in Equation X1.4 are regularized by setting lower and upper bounds for each of them. Upper and lower bounds for each parameter except f are initialized as 10 and –10, respectively. Because of the limitations of the regression function used in MATLAB (the function called “fit”), the regularization had to be conducted in a heuristic way.

X1.4.1.3.1. A regression function that input u_{post} and P_{post} are developed by fitting the Gaussian function (Equation X1.4) to the post-peak segment of the data bounded by the limits defined in Section X1.4.1. The number of Gaussian terms is selected as four. Then, the inflection points at which the second derivative of the fitted equation becomes zero are extracted, and the first derivatives indicating the slopes (m_i) are computed at the extracted inflection points (u_i).

X1.4.1.3.2. It is possible that the second derivative of the fitted equation $P_2(u)$ may not have any roots (i.e., there is no inflection point; hence, no slope can be found). If $P_2(u)$ does not have any roots, the next value in the vector fbounds should be selected before proceeding with the remaining steps. If a root or roots of $P_2(u)$ exists, proceed to the next step.

X1.4.1.3.3. At each inflection point found, draw the tangential slope by extrapolating a line intersecting the displacement axis, as shown in Figure X1.1. The first derivative value at the inflection is defined as the post-peak slope (m) as shown below.

$$m = \left[\frac{\partial P_2(u)}{\partial u}\right]_{u=u_{\text{inf}}} \tag{X1.5}$$

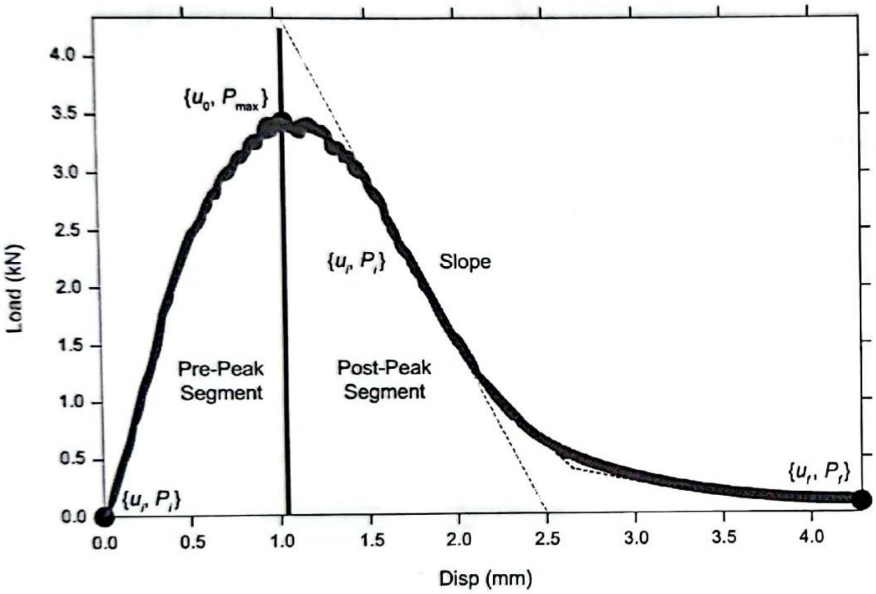


Figure X1.1—Demonstration of Pre-Peak and Post-Peak Segments

X1.4.1.3.4. It is common that the fitted equation may produce more than one slope when there is more than one root found in the previous step. There is only one slope considered consistent with the definition of the tests; the remaining slopes are spurious and need to be eliminated. To find the most representative slope and eliminate the unrealistic slope(s), three visual based criteria are implemented. The criteria, grading, and elimination processes are as follows:

- *Criterion 1*—Incremental displacement values (u_n) are generated with equal increments between u_0 and u_i. A linear slope equation, $S(u)$, is described by using the slope (see Equation X1.5) and passing through the inflection point (u_i). The mean value of difference between slope equation and post-peak load–LLD curve is calculated using Equation X1.6.

$$C1 = \frac{\Sigma_{n=1}^{M}\left[S(u_n) - P_2(u_n)\right]}{M} \tag{X1.6}$$

where:

M = number of displacement values such that ($u_0 < u_n < u_i$). Equal sizes of increments are used to create M-times displacement values (u_n). M may vary depending on the length between u_0 and u_i;

$S(u_n)$ = value of slope equation calculated at $u = u_n$; and

$P_2(u_n)$ = value of post-peak load–LLD curve calculated at $u = u_n$.

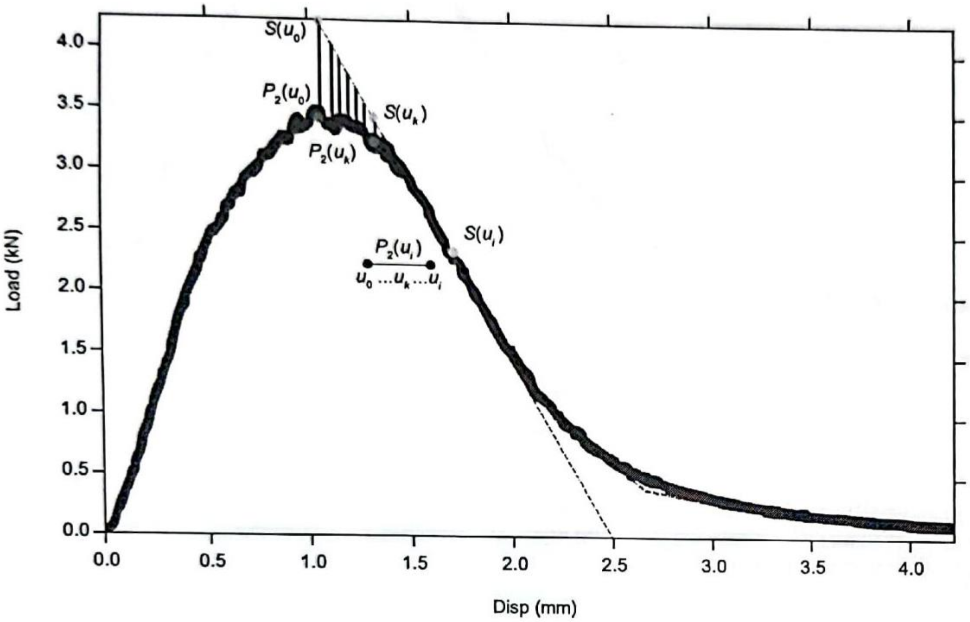


Figure X1.2—Checking Mean Difference for Criterion 1

- *Criterion 2*—Incremental displacement values (u_n) are generated with equal increments between u_0 and u_i. The u_i is found by taking 30 percent of $P_i = P_2(u_i)$ (load corresponding to the inflection point) (see Figure X1.3). The same linear slope equation, $S(u)$, is used as in Criterion 1. The mean value of difference between slope equation and post-peak load–LLD curve is calculated using Equation X1.7.

$$C2 = \frac{\sum_{n=1}^{M}\left[P_2(u_n) - S(u_n)\right]}{M} \tag{X1.7}$$

where:

M = number of displacement values such that ($u_0 < u_n < u_i$). Equal sizes of increments are used to create M-times displacement values (u_n). M may vary depending on the length between u_0 and u_i;

$S(u_n)$ = value of slope equation calculated at $u = u_n$;

$P_2(u_n)$ = value of post-peak load–LLD curve calculated at $u = u_n$.

The ideal slope line should be perfectly tangential or remain below the fitted curve. Therefore, the slope lines with negative means are eliminated. The grading scheme for this criterion is similar to the previous one. If more than one slope remains after elimination, slopes are ranked in an ascending order according to the mean difference (C2). The slope with lowest mean difference is ranked highest.

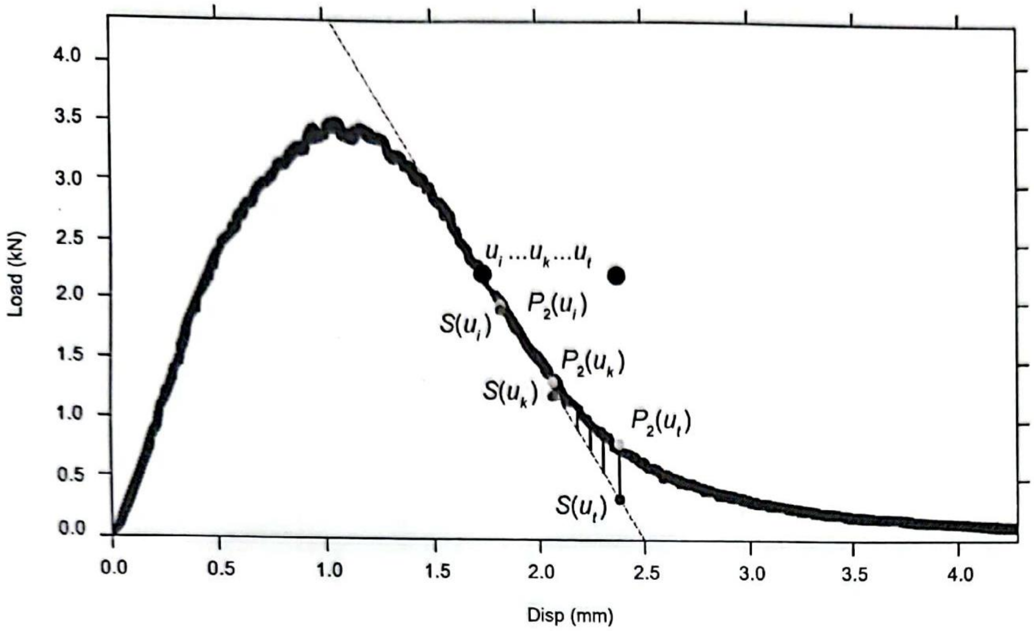


Figure X1.3—Checking Mean Difference for Criterion 2

- *Criterion 3*—The value of this criterion is –x coordinate of inflections points (i.e., u_i). If there are multiple candidates for slope line, they are ranked with an ascending order according to their u_i. For example, slopes found at smaller inflection points ranked higher than the slope found at the tail part of the curve.

X1.4.1.3.5. If at least one realistic slope is found, and the R2 of the fit is higher than 0.997, the fit is accepted and the loop is stopped. In that case, the framework jumps to Section X1.4.4 to calculate fracture energy and report the representative slopes along with other required test outcomes. Otherwise, the loop continues—that is, the next value from f_{bound} is selected to modify the lower bound for the parameter f. Sections X1.4.1.3.1 through X1.4.1.3.5 are repeated until a representative slope and satisfactory R2 is found.

X1.4.1.4. Using the satisfactory fit, $P_2(u)$, and representative inflection point and post-peak slope values (m), the test parameters required in the report section of the specification are calculated.

X1.4.1.4.1. Representative slope is reported as the one with the highest score from the grading process (Section X1.4.1.3.4).

X1.4.1.4.2. Similar to the pre-peak area calculation, a new displacement vector between up and u_{final} by an increment of 0.005 is generated. Then corresponding load values are calculated by feeding this generated displacement vector to the fitted regression functions. The purpose of generating new sets of data with increased resolution is to increase the accuracy of the numerical integration in the next step.

X1.4.1.4.3. A trapezoidal numerical integration technique (Figure X1.2) is employed for the integral shown in Equation X1.8 to calculate the area under the post-peak segment of the curve.

$$W_f(\text{post-peak}) = \int_{u_0}^{u_{\text{final}}} P_2(u)du \qquad (X1.8)$$

X1.4.1.4.4. The total area under the load–LLD curve is found by adding the pre-peak and post-peak areas. Then the work of fracture is calculated using the Equation X1.9.

$$W_f = W_f\,(\text{post-peak}) + W_f\,(\text{pre-peak}) \qquad (X1.9)$$

X1.4.1.4.5. Total energy and slope are inputted to Equations X1.10a and X1.10b to compute fracture energy and flexibility index.

$$G_f = \frac{W_f}{\text{Area}_{lig}} \times 10^6 \qquad (X1.10a)$$

$$FI = \frac{G_f}{|m|} \times As \qquad (X1.10b)$$

X2. LONG-TERM AGING PROCEDURE

X2.1. *Scope*:

X2.1.1. This appendix includes and summarizes the findings of the R27-175 study conducted by the Illinois Center for Transportation through the Illinois Department of Transportation to evaluate the long-term aging effects on hot mix asphalt surface mixtures using the Illinois Flexibility Index Test and to develop a corresponding long-term-aging protocol.

X2.2. *Procedure*:

X2.2.1. Prepare surface mixture test specimens according to Section 9.

X2.2.2. Place the four test specimens, notched face down, on a tray (pan), with a barrier between the test specimens and the tray (e.g., parchment paper, a non-stick cooking mat, heavy duty aluminum foil).

X2.2.3. Place the tray with the specimens in a preheated force-draft oven set at 95 ± 3°C (203 ± 5°F).

X2.2.4. Leave the specimens (undisturbed) in the oven at this temperature for 72 h ± 1 h.

X2.2.5. Remove the entire tray from the oven and place in front of a cooling fan at room temperature for at least 1 h.

X2.2.6. If the specimen is not cooled in front of a fan, allow the specimens to cool at room temperature overnight.

X2.2.7. Remove the specimen from the barrier.

X2.2.8. After the specimens have cooled and the barrier has been removed, proceed to Section 11.

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[1] Formerly AASHTO Provisional Standard TP 124. First published as a full standard in 2021.

[2] Appendix X1 written by Hasan Ozer, Osman Erman Gungor, and Imad Al-Qadi, Illinois Center for Transportation, University of Illinois at Urbana-Champaign.

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Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: December 1, 2023

Standard Practice
for
Laboratory Conditioning of Asphalt Mixtures

Reference AASHTO R 30-22

AASHTO Section	***Illinois Modification***
1.1	Replace with the following: This standard practice describes procedures for mixture conditioning of hot mix asphalt (HMA). Conditioning requirements for volumetric mixture design, short-term conditioning of specimens for Hamburg Wheel testing and I-FIT, specimens for strength and TSR testing, and long-term aging for I-FIT specimens are addressed.
2.1	Revise the individual AASHTO Standards with the appropriate Illinois Modified AASHTO Standards:
2.1	Add reference to: Illinois modified AASHTO T 393, Determining the Fracture Potential of Asphalt Mixtures Using the Illinois Flexibility Index Test (I-FIT)
3.	Replace with the following: For mixture conditioning for volumetric mixture design, specimens for Hamburg Wheel testing, specimens for I-FIT, and specimens for strength and TSR testing, a mixture of aggregate and asphalt binder is conditioned in a forced-draft oven at the mixture's specified compaction temperature.
4.	Replace with the following: The properties and performance of HMA can be more accurately predicted by using conditioned test samples. The mixture conditioning for the volumetric mixture design procedure, for Hamburg Wheel test and I-FIT specimens and for specimens for strength and TSR testing is designed to allow for binder absorption.
5.2	Replace the first sentence with: Thermometers – Thermometers shall have a suitable range from 10 to 232˚C (50 to 450˚F). The thermometers may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.75˚C (± 1.35˚F) (See Note 1).
5.3	Add: A splitter to reduce a sample into homogenous, smaller portions, and a chute for transferring the mixture sample into the gyratory mold.
7.1	Replace with the following: *Mixture Conditioning for Volumetric Mixture Design, for Hamburg Wheel Test and I-FIT Specimens, and for specimens for Strength and TSR Testing:*

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: December 1, 2023

Standard Practice
for
Laboratory Conditioning of Asphalt Mixtures

Reference AASHTO R 30-22

AASHTO Section	***Illinois Modification***
7.1.1	Replace the first two sentences with the following: The mixture conditioning for the volumetric mixture design procedure, for short-term conditioning of Hamburg Wheel test and I-FIT specimens, and for specimens for strength and TSR testing applies to laboratory-prepared, loose mixture only. Mixture conditioning is only required when conducting quality control or quality assurance testing on plant-produced mixture for I-FIT long-term aging specimens and as specified for warm mix asphalt (WMA) mixtures.
7.1.1 Note 2	Delete
7.1.2	Replace with the following: Place the mixture in a pan and spread the mixture to an even thickness ranging between 1 in. (25 mm) and 2 in. (50 mm). The aging may take place either: a. Immediately after mixing but before compaction (without being cooled down), or b. After the mixture has been cooled down to room temperature. The mixture shall be placed in the oven, which has been pre-heated to compaction temperature, for the appropriate time specified below. For testing of all mixtures with low-absorptive aggregate, place the mixture and pan in the conditioning oven pre-heated to the mixture's specified compaction temperature ± 5 ˚F (± 3 ˚C) for 1 hr. ± 5 min. prior to compaction. (1 hr. of oven time, not the time the mixture was held at compaction temperature, is used.) For testing of all mixtures with high-absorptive aggregate, place the mixture and pan in the conditioning oven pre-heated to the mixture's specified compaction temperature ± 5 ˚F (± 3 ˚C) for 2 hrs. ± 5 min. prior to compaction. (2 hrs. of oven time, not the time the mixture was held at compaction temperature, is used.)
7.1.2 New Note	Add New Note 2: Surfaces of the mechanical splitter that will come in contact with the HMA, pans, and the loading chute shall be lightly coated with an asphalt release agent on the current Qualified Product List or cooking spray to prevent a buildup and loss of asphalt binder and fines.
7.1.2 Note 3	Replace with the following: Note 3 – When SB/SBS/SBR polymer and GTR modified asphalt is used, the required compaction temperature is 305 ± 5 ˚F (152 ± 3 ˚C).

Illinois Modified Test Procedure
Effective Date: June 1, 2012
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Standard Practice
for
Laboratory Conditioning of Asphalt Mixtures

Reference AASHTO R 30-22

<table>
<tr><th>AASHTO Section</th><th>Illinois Modification</th></tr>
<tr><td>7.1.2
New Note</td><td>Note 3A – High-absorptive aggregate mixture is defined as aggregate with a combined absorption greater than 2.5% and all slags.</td></tr>
<tr><td>7.1.2
New Note</td><td>Note 3B – The compaction temperature for non-SB/SBS/SBR polymer and non-GTR modified asphalt is 295 ± 5 ˚F (146 ± 3 ˚C).</td></tr>
<tr><td>7.1.2
New Note</td><td>Note 3C – Short-term conditioning is not permitted for testing plant-produced mixture, except as specified for WMA mixtures.</td></tr>
<tr><td>7.1.2
New Note</td><td>Note 3D – Condition Hamburg Wheel specimens from WMA mixtures from both lab-produced mix and plant-produced mix for two hours in addition to the requirements for HMA.</td></tr>
<tr><td>7.1.2.1
New Section</td><td>Add the following:
Table 1 summarizes the various requirements for short-term conditioning of both HMA and WMA from lab-produced mix and plant-produced mix.</td></tr>
<tr><td>7.1.2.1
New Table</td><td>Add the following:
Table 1
<table>
<tr><th colspan="7">Short Term Conditioning (hours) [1/]</th></tr>
<tr><td></td><td colspan="3">Lab-Produced Mix</td><td colspan="3">Plant-Produced Mix</td></tr>
<tr><td></td><td>Volumetrics</td><td>T-283</td><td>Hamburg /I-FIT</td><td>Volumetrics</td><td>T-283</td><td>Hamburg /I-FIT</td></tr>
<tr><td>HMA</td><td>1 or 2</td><td>1 or 2</td><td>1 or 2</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>WMA</td><td>1 or 2</td><td>1 or 2</td><td>3 or 4</td><td>0</td><td>0</td><td>2</td></tr>
</table>
1/ When two different values are present within a single cell, the correct value is based on whether low or high absorptive aggregates are used.</td></tr>
<tr><td>7.1.4</td><td>Delete the first sentence.</td></tr>
<tr><td>7.2
Replace-ment</td><td>Delete all sections in Section 7.2
Replace Section 7.2 with the following:
I-FIT Long-Term Aging Procedure:</td></tr>
</table>

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: December 1, 2023

Standard Practice
for
Laboratory Conditioning of Asphalt Mixtures

Reference AASHTO R 30-22

AASHTO Section	***Illinois Modification***
7.2.1	Replace with the following: Compact one laboratory SGC cylinder according to T 312 with the compaction height of 160 mm ± 1 mm. Determine the bulk specific gravity (G_{mb}) and air voids of the compacted cylinder according to T 166 and T 269, respectively. The air voids of the 160 ± 1 mm tall SGC cylinder shall be 7.5 ± 0.5%.
7.2.2	Replace with the following: Cut four (4) individual semi-circular test specimens for each test.
7.2.3	Replace with the following: Cut the notch in each test specimen.
New Note	Note 4 - Although the required air voids are determined from the SGC cylinders, it is also required to determine the air voids on the individual semi-circular I-FIT test specimens to identify if 7.5 ± 0.5% air voids in the SGC cylinders is appropriate to produce individual semi-circular test specimens with 7.0 ± 1.0% air voids.
7.2.4	Replace with the following: Place the four (4) test specimens, notched-face down, on a tray (pan), with a “barrier” between the test specimens and the tray (parchment paper, a non-stick cooking mat, heavy duty aluminum foil, etc. are examples of a “barrier”).
7.2.5	Replace with the following: Place the tray with the specimens in a pre-heated force-draft oven set at 95 ± 3˚C (203 ± 5˚F).
7.2.6	Leave the specimens (undisturbed) in the oven at this temperature for 72 hours ± 1 hour.
7.2.7 New Section	Remove the entire tray from the oven and place in front of a cooling fan at room temperature for at least one hour.
New Note 5	Note 5: If the specimen is not cooled in front of a fan, allow the specimens to cool at room temperature overnight.

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: December 1, 2023

Standard Practice
for
Laboratory Conditioning of Asphalt Mixtures

Reference AASHTO R 30-22

AASHTO Section	***Illinois Modification***
7.2.8 New Section	Remove the specimen from the “barrier”.
7.2.9 New Section	After the specimens have cooled and the “barrier” has been removed, submerge them in a 25 ± 0.5˚C (77 ± 1.0˚F) water bath for 2 hours and test according to the IL-mod T 393 procedure.
8.2	Delete all sections
8.3	Delete all sections
9.1	Replace with the following: Asphalt mixtures, conditioning; hot mix asphalt; long-term aging

This Page Is Reserved

Standard Practice for

Laboratory Conditioning of Asphalt Mixtures

AASHTO

AASHTO Designation: R 30-22[1]

Technically Revised: 2022

Editorially Revised: 2022

Technical Subcommittee: 2c, Asphalt–Aggregate Mixtures

1. SCOPE

1.1. This standard practice describes procedures for laboratory conditioning of compacted and uncompacted asphalt mixtures. Two types of conditioning are described: (1) short-term mixture conditioning for volumetric mixture design and mechanical property testing (both of which simulate the precompaction phase of the construction process); and (2) long-term conditioning for mixture mechanical property testing to simulate the aging that occurs in a dense-graded surface layer over the first one to three years of a pavement's life. The procedures for long-term conditioning for mixture mechanical property testing are preceded by the procedure for short-term conditioning. Further information on short- and long-term conditioning is given in NCHRP Report 815.

1.2. *This standard practice 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 the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 339M/M 339, Thermometers Used in the Testing of Construction Materials
- R 68, Preparation of Asphalt Mixtures by Means of the Marshall Apparatus
- T 312, Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor

2.2. *ASTM Standards*:

- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples

2.3. *International Electrotechnical Commission Standard*:

- IEC 60584-1: 2013 Thermocouples - Part 1: EMF Specifications and Tolerances

2.4. *Reference*:

- NCHRP. *NCHRP Report 815: Short-Term Conditioning of Asphalt Mixtures*. National Cooperative Highway Research Program Project 09-52, TRB, National Research Council, Washington, DC, 2015

8.2.2. Mixture conditioning duration in laboratory (nearest minute).

8.3. *Report the following long-term conditioning information, if applicable*:

8.3.1. Long-term mixture conditioning temperature in laboratory (nearest 1°C); and

8.3.2. Long-term mixture conditioning duration in laboratory (nearest 5 min).

9. KEYWORDS

| 9.1. Asphalt mixtures; conditioning; HMA; long-term conditioning; short-term conditioning; WMA.

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[1] This standard is based on SHRP Product 1031.

3. SUMMARY OF PRACTICE

For short-term mixture conditioning, a mixture of aggregate and binder is conditioned in a forced-draft oven for 2 h at 116°C for warm mix asphalt (WMA) and at 135°C for hot mix asphalt (HMA). For long-term mixture conditioning, a compacted mixture of aggregate and binder is conditioned in a forced-draft oven for 5 days at 85°C.

4. SIGNIFICANCE AND USE

The properties and performance of asphalt mixtures can be more accurately predicted by using conditioned test samples. The short-term mixture conditioning is designed to allow for binder absorption during the mixture design and to simulate the plant-mixing effects on the mixture. The long-term mixture conditioning is designed to simulate the aging a compacted dense-graded surface mixture will undergo during the first one to three years of service.

5. APPARATUS

5.1. *Oven*—A forced-draft oven, thermostatically controlled, capable of maintaining any desired temperature setting from room temperature to 176°C within ±3°C. Oven(s) shall be capable of operation at the temperatures required, as corrected, if necessary, by standardization. More than one oven may be used, provided each is used within its proper operating temperature range.

5.2. *Thermometers*—Thermometers for measuring the temperature of materials shall meet the requirements of M 339M/M 339 with a temperature range of at least 25 to 185°C, and an accuracy of ±0.75°C (see Note 1).

Note 1—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; or IEC 60584 thermocouple thermometer, Type T, Class 1.

5.3. *Miscellaneous*—A metal pan for heating aggregates, a shallow metal pan for heating uncompacted asphalt mixtures, a metal spatula or spoon, timer, and gloves for handling hot equipment.

6. HAZARDS

6.1. This standard involves the handling of hot binder, aggregate, and asphalt mixtures, which can cause severe burns if allowed to contact skin. Follow standard safety precautions to avoid burns.

7. MIXTURE CONDITIONING PROCEDURES

7.1. *Short-Term Mixture Conditioning*:

7.1.1. The short-term mixture conditioning applies to laboratory-prepared, loose mixtures only. No mixture conditioning is required when conducting quality control or acceptance testing on plant-produced mixtures.

Note 2—The agency may identify the need to heat the plant-produced mixture to its compaction temperature to represent field conditions. NCHRP Report 815 observed some volumetric differences between short-term aged LMLC (laboratory-mixed/laboratory-compacted) specimens and corresponding PMPC (plant-mixed/plant-compacted) specimens when using highly absorptive aggregates.

7.1.2. Place the mixture in a pan, and spread it to an even thickness ranging between 25 and 50 mm. Place the mixture and pan in a forced-draft oven for 2 h ± 5 min at a temperature of 116 ± 3°C for WMA or 135 ± 3°C for HMA.

Note 3—For modified binders, the agency should consider the manufacturer's recommendations for compaction temperatures as the conditioning temperature.

7.1.3. Stir the mixture after 60 ± 5 min to maintain uniform conditioning.

Note 4—Short-term conditioning is now applicable to both determination of volumetric properties as well as mechanical tests intended to assess the behavior of the mixture in the early years of the pavement's life (e.g., rutting tests). Prior versions of this standard included a section titled "Short-Term Conditioning for Mixture and Mechanical Property Testing", which required conditioning for 4 h ± 5 min at 135 ± 3°C. That requirement has since been deleted. Specification limits developed based on the prior conditioning requirement may no longer be appropriate.

7.1.4. After 2 h ± 5 min, remove the mixture from the forced-draft oven. The conditioned mixture is now ready for compaction or testing.

7.2. *Long-Term Mixture Conditioning*:

7.2.1. The long-term conditioning procedure applies to laboratory-prepared asphalt mixtures that have been subjected to the short-term conditioning procedure described in Section 7.1, plant-mixed asphalt mixtures, and compacted roadway specimens.

7.2.2. *Preparing Samples for Long-Term Mixture Conditioning:*

7.2.2.1. When preparing compacted specimens from loose asphalt mixtures, compact the specimens in accordance with one of the following methods: Superpave Gyratory Compactor (T 312) or Marshall Apparatus (R 68). Following compaction, completely cool the test specimen.

Note 5—Specimen cooling may be scheduled as an overnight step, but may be accelerated by placing the specimen in front of a fan.

7.2.2.2. Prior to long-term conditioning of field cores, samples must be cut, trimmed, and dried to a constant mass.

7.2.3. Place the compacted test specimens in the conditioning oven for 120 ± 0.5 h at a temperature of 85 ± 3°C.

7.2.4. After 120 ± 0.5 h, turn the oven off; open the doors, and allow the test specimen to cool to room temperature. Do not touch or remove the specimen until it has cooled to room temperature.

Note 6—Cooling to room temperature will take approximately 16 h.

7.2.5. After cooling to room temperature, remove the test specimen from the oven. The long-term-conditioned specimen is now ready for testing as required.

8. REPORT

8.1. Report the binder grade, binder content (nearest 0.1 percent), and the aggregate type and gradation, if applicable.

8.2. *Report the following short-term mixture conditioning information*:

8.2.1. Mixture conditioning temperature in laboratory (nearest 1°C); and

MAXIMUM SPECIFIC GRAVITY

DEFINITION

MAXIMUM SPECIFIC GRAVITY G_{mm} (D)

Maximum specific gravity uses the definition "The ratio of the mass (weight) of any volume of a material to the mass of an equal volume of water. The volume used in these definitions is the volume of a voidless mix as opposed to the bulk specific gravity which uses the total volume of the mix, including voids. When this is applied to a loose, uncompacted mix, it consists of:

1. Solid Aggregate
2. Asphalt Cement
3. Pore space in the aggregate particles which are filled with absorbed asphalt and trapped air.

During the design stage, as well as throughout production, it is important to know the percent air voids and density of the mixture. The air voids are air pockets in the mixture. When air pockets are present the weight per volume of mix is referred to as the bulk specific gravity [G_{mb} (d)]. When there are no air voids present in the mixture it is at its maximum weight per volume and is, therefore, referred to as the maximum specific gravity [G_{mm} (D)].

This section provides step-by-step instructions to determine the maximum specific gravity [G_{mm} (D)] followed by the "Illinois Procedure for Determining Maximum Specific Gravity of Bituminous Paving Mixtures". **Note: Explanation and terminology of Specific Gravity and Density for Hot-Mix Asphalt can be found on page 7-9 and 7-10 herein.**

Weighing-In-Water Method

CALIBRATE PYCNOMETER

NOTE: Determine the temperature of the water bath prior to suspending pycnometer in the bath.

A. Suspend the pycnometer in water bath
  (1) at 77° ± 1.8° F (25° ± 1° C)
  (2) allow container to stabilize in water bath for 10 minutes (± 1 minute)

B. Determine the mass of the container when submerged and **record weight on worksheet found on (Page 7-5)**.

C. Dump water out and place container in suspension apparatus again, allow scale to stabilize and obtain second weight.

D. Repeat step C a second time and obtain your third and final weight.

E. Average all three weights and designate as **(B)**.

SAMPLE PREPARATION

A. Split sample to size needed

  (1) For correct sample size see page 7-19, Section 6-Sampling, Section 6.3, Table 1.

  (2) Take even split - do not adjust.

  (3) Two approximately even samples per mix

  ***** Upper limit is governed by size of pycnometer.

B. Separate particles of sample by hand

TESTING

A. Weigh sample - **(A)**

B. Place sample in pycnometer and cover with water at 77° F ± 1.8° F (25° C ± 1°).

C. Remove entrapped air with vacuum of 730 mm of Hg (28.7 inches) or greater for 15 minutes ± 2 minutes. Agitate the container and contents during the vacuum period either continuously by a mechanical device or manually by vigorous shaking at intervals of about two minutes.

D. Suspend the pycnometer in water bath
   (1) at 77° ± 1.8° F (25° ± 1° C)
   (2) for 10 minutes (± 1 minute)

E. Determine the mass of the container and contents when submerged.

F. Designate the mass of the container and the sample in water as **(C)**.

G. Calculate maximum specific gravity G_{mm} (D)

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

Where:

A = mass of oven-dry sample in air
B = mass of pycnometer submerged in water at 77°± 1.8°F (25°±1°C)
C = mass of sample and pycnometer submerged in water at 77°± 1.8°F (25°±1°C)

H. Average results of two samples per test

This Page Is Reserved

Maximum Specific Gravity (G_{mm}) Worksheet
(Weighing-In-Water Method)

Name______________________________

		Sample	
		1	2
1. Dry sample weight	(A)	________	________
2. Averaged calibrated Pycnometer weight (Pycnometer suspended in water bath)	(B)	________	________
3. Vacuumed sample weight (Pycnometer + sample suspended in water bath)	(C)	________	________
4. Maximum Specific Gravity (report to 3 places, **[2.xxx]**)		________	________

$$\frac{\mathbf{A}}{\mathbf{A + B - C}}$$

Average G_{mm}(D) ________ **(2.xxx)**

Pycnometer Calibration Weights

1. ___________ ___________

2. ___________ ___________

3. ___________ ___________

(A) = Oven dry sample weight

(B) = Calibrated Pycnometer weight

(C)= Vacuumed sample + Pycnometer suspended In water bath

This Page Is Reserved

PROCEDURE FOR MIXES WITH HIGH ABSORPTIVE AGGREGATE, USED ONLY WITH THE APPROVAL OF THE ENGINEER

A. Complete test as indicated

B. Drain sample and spread in shallow pan

C. Use electric fan to dry surface water

   (1) Weigh at 15 minute intervals until loss is less than 0.5 g per interval

D. Obtain final surface dry sample weight - (A')

E. Substitute A' for A in denominator of the formula

Weighing-In-Water Formula

$$G_{mm}\,(D) = \frac{A}{A' + B - C}$$

Weighing-In-Air Formula

$$G_{mm}\,(D) = \frac{A}{A' + D - E}$$

This Page Is Reserved

Specific Gravity and Density
for
Hot-Mix Asphalt

The subjects of specific gravity and density are not difficult. However, metric/English conversion and local usage of the terminology may be confusing. This in intended to describe these concepts in an abbreviated manner. The student is advised to be familiar with the "official" definitions of density and specific gravity.

A note of caution - In some common metric conventions, specific gravity and density may have equal numeric values. In the SI metric convention (used by IDOT) and English system, this is not true. The table below illustrates this.

	DENSITY			SPECIFIC GRAVITY
	ENGLISH	METRIC	SI	ENGLISH, METRIC SI
Water	62.4 #/ft^3	1.0 g/cc	1000 kg/m^3	1.0
Aggregate	156 #/ft^3	2.5 g/cc	2500 kg/m^3	2.5

TERMINOLOGY

DENSITY:

Definition - The mass (weight) of a material per unit volume, expressed in SI units as kg/m^3, [mass (kg) / volume (m^3)]. The English equivalent is pounds per cubic foot. See the examples above.

Significance - The density of an HMA sample is taken into account in the specific gravity calculation in AASHTO T 166 (Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens). AASHTO T 166 compares the mass (weight) of a sample in air and water to directly calculate specific gravity. The density measurement is "invisible" in the formula.

SPECIFIC GRAVITY:

Definition - The ratio of the mass (weight) of any volume of a material to the mass of an equal volume of water. The units of mass and volume in this ratio cancel resulting in a dimensionless measurement. The specific gravity of water is 1.0. Materials heavier than water will have S.G. values greater than 1.0. It is convenient to consider the S.G. as the number of times heavier than water a material is for the same volume. See examples below.

Significance - Two different tests calculate the specific gravity of a mix at different compacted conditions. The results are then used to calculate percent air voids in compacted HMA samples. These are described below.

BULK SPECIFIC GRAVITY, (G_{mb} or Gravity$_{\text{mix bulk}}$) - The specific gravity of a ***compacted*** HMA mixture that includes trapped air voids. Also known in Illinois as Little d, or "d". G_{mb} is directly calculated by AASHTO T 166.

MAXIMUM SPECIFIC GRAVITY, (G_{mm} or Gravity$_{\text{mix maximum}}$) - The theoretical maximum specific gravity of an HMA mixture. This is calculated by measuring the density of a "voidless" sample, through the vacuum saturation of a ***loose*** HMA sample (AASHTO T 209). Also known in Illinois as Big D or “D”.

Material	Example Specific Gravity	Density (S.G. x Density of Water	
		SI	English
Water	1.000	1,000 kg/m^3	62.4 #/ft^3
Aggregate	2.716 (G_{sb})	2,716 kg/m^3	169.5 #/ft^3
Asphalt Cement	1.030 (G_b)	1,030 kg/m^3	64.3 #/ft^3
Hot-Mix Asphalt	2.442 (G_{mb}) 2.535 (G_{mm})	2,442 kg/m^3 2,535 kg/m^3	152.4 #/ft^3 158.2 #/ft^3

AIR VOIDS -vs- DENSITY:

The design, plant control, and field control of HMA includes the analysis of air voids in the mix. Different terms are customarily used to describe laboratory and field voids.

For lab-compacted mix, the terms “air voids” or “voids” are used to describe the percent air voids in a specimen.

For field-compacted mix, “density”, “percent density”, and “in place” or “field voids” are the terms that also define percent air voids. Many times people in the field will use the term “density” when they are really talking about percent density. When discussing field compaction, percent density is usually expressed as a percentage of the maximum theoretical density. See the calculations below for further explanation.

CALCULATIONS

The following three formulas apply to lab and field void calculations. In all cases, the percent air voids is computed using the measured Bulk Specific Gravity and Maximum Specific Gravity.

d/D **Or** **G_{mb}/G_{mm}**	Yields a decimal that indicates the amount of compaction of the mix relative to the maximum density (D). e.g. 2.442 ÷ 2.535 = 0.963
d/D x 100 **Or** **G_{mb}/G_{mm} x 100**	Converts this decimal to a percentage. (0.963 x 100 = 96.3%) Here the phrase “96.3% density” is actually an abbreviation of “96.3% of theoretical maximum density. Thus, there are two related uses for the term “Density” in describing HMA. One is the mass/volume as defined earlier. The second represents the percent of field compaction.
(100) - (d/D x 100) **Or** **(100) - (G_{mb}/G_{mm} x 100)**	Converts the percent theoretical density to percent air voids. (100) - (96.3) = 3.7%. This is the normal convention for expressing lab air voids.

Illinois Modified Test Procedure
Effective Date: February 5, 2008
Revised Date: December 1, 2023

Standard Method of Test
for
Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures

Reference AASHTO T 209-23

AASHTO *Section*	***Illinois Modification***
2.1	Delete Reference to AASHTO Standard R 97
New Section 2.3	Replace all references to AASHTO R 97 with the following Manual of Test Procedures Appendices: • Appendix B6 – HMA QC/QA Initial Daily Plant and Random Samples • Appendix B7 – Determination of Random Density Procedures • Appendix E3 – PFP & QCP Random Density Procedure • Appendix E4 – PFP & QCP HMA Random Jobsite Sampling
3.1.2	Replace with the following: *Residual Pressure* – the pressure remaining in the vacuum vessel after a vacuum (negative pressure) is applied. The residual pressure is based on, and measured with, an absolute manometer.
5.4.1	Replace with the following: When a vacuum pump is used, a suitable trap of one or more 1000-ml filter flasks, or equivalent, may be installed between the vacuum vessel and vacuum source to reduce the amount of water vapor entering the vacuum pump.
5.7	Replace the first sentence with the following: Thermometer (Mass Determination in Air) – A liquid-in-glass thermometer or other thermometric device, accurate to 0.5˚C (1˚F) of suitable range with subdivisions of 0.5˚C (1˚F). The thermometer shall be standardized at the test temperature at least every 12 months. The thermometers may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ±0.25˚C (±0.45˚F) (See Note 4).
5.8	Replace the first sentence with the following: *Drying Oven* – A thermostatically controlled drying oven capable of maintaining a temperature of 110 ± 5°C (230 ± 9°F).
5.8	Replace the last sentence with the following: The thermometers for measuring the oven temperature may optionally meet the requirements of M 339M/339 and optionally have an accuracy of ± 0.75 ˚C (± 1.35 ˚F) (See Note 5).

Illinois Modified Test Procedure
Effective Date: February 5, 2008
Revised Date: December 1, 2023

Standard Method of Test
for
Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures

Reference AASHTO T 209-23

AASHTO *Section*	***Illinois Modification***
Note 5	Replace with the following: **Note 5** - Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; IEC 60584 thermocouple thermometer, Type T, Class 1; or E2877 digital metal stem thermometer.
5.9	Replace the second sentence with the following: For Mass Determination in Water, a liquid-in-glass thermometer or other thermometric device, accurate to 0.5˚C (1˚F) shall be used to measure the temperature of the water bath. The thermometer shall be standardized at least every 12 months. The thermometers for measuring the temperature of water baths may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.25 ˚C (± 0.45 ˚F) (See Note 6).
5.9.1	Replace with the following: The water bath shall be maintained at a constant temperature of 25 ± 1°C (77 ± 1.8°F) during testing.
5.9.2	Replace with the following: When using the mass determination-in-water technique (Section 11.1), the water bath must be suitable for immersion of the suspended container with its deaerated sample.
7.2.1	Replace the first sentence with the following: Dry the sample to a constant mass at a temperature of 105 ± 5˚C (221 ± 9˚F). Constant mass shall be defined as the mass at which further drying does not alter the mass more than 0.5 gram in 1 hour.
10.1	Replace the third sentence with the following: Agitate the container and contents during the vacuum period by vigorously shaking the container or moderately striking the side of the container with a rubber mallet each at intervals of about 2 min.
12.2	Delete (Including Equation 3 and Note 9)

Illinois Modified Test Procedure
Effective Date: February 5, 2008
Revised Date: December 1, 2023

Standard Method of Test
for
Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures

Reference AASHTO T 209-23

AASHTO ***Section***	***Illinois Modification***
13	This section shall be used only with approval of the Engineer.
13.3	Replace with the following: To calculate the specific gravity of the sample, substitute the final surface-dry mass determined in Section 13.2 for A in the denominator of Equation 1 or 2 as appropriate.
A1.1.1	Replace the fourth sentence with the following: If the three masses are within 0.3 g, use the average as B in Equation 1.
A1.1.2	Delete Sentences 4, 5, & 6
A1.2.1	Replace the sixth sentence with the following: If the three masses are within 0.3 g, use the average of the three masses as D in Equation 2.
A1.2.2	Delete Sentences 4, 5, & 6

This Page Is Reserved

Standard Method of Test for

Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures

AASHTO Designation: T 209-23

Technically Revised: 2023

Technical Subcommittee: 2c, Asphalt–Aggregate Mixtures

1. SCOPE

1.1. This test method covers the determination of the theoretical maximum specific gravity/gravity mix maximum (G_{mm}) and density of uncompacted asphalt mixture at 25°C (77°F).

Note 1—The precision of the method is best when the procedure is performed on samples that contain aggregates that are completely coated. In order to assure complete coating, it is desirable to perform the method on samples that are close to the optimum asphalt binder content.

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 concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.4. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 231, Weighing Devices Used in the Testing of Materials
- M 339M/M 339, Thermometers Used in the Testing of Construction Materials
- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- R 30, Laboratory Conditioning of Asphalt Mixture
- R 47, Reducing Samples of Asphalt Mixtures to Testing Size
- R 61, Establishing Requirements for Equipment Calibrations, Standardizations, and Checks
- R 67, Sampling Asphalt Mixtures after Compaction (Obtaining Cores)
- R 97, Sampling Asphalt Mixtures

2.2. *ASTM Standards*:

- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E879, Standard Specification for Thermistor Sensors for General Purpose and Laboratory Temperature Measurements
- E1137/E1137M, Standard Specification for Industrial Platinum Resistance Thermometers
- E2877, Standard Guide for Digital Contact Thermometers

2.3. *International Electrotechnical Commission Standards*:

- IEC 60584-1: 2013 Thermocouples - Part 1: EMF Specifications and Tolerances
- IEC 60751: 2008 Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors

3. TERMINOLOGY

3.1. *Definitions*:

3.1.1. *density, as determined by this test method*—the mass of a cubic meter of the material at 25°C (77°F) in SI units, or the mass of a cubic foot of the material at 25°C (77°F) in inch-pound units.

3.1.2. *residual pressure, as employed by this test method*—the pressure in a vacuum vessel when vacuum is applied.

3.1.3. *specific gravity, as determined by this test method*—the ratio of a given mass of material at 25°C (77°F) to the mass of an equal volume of water at the same temperature.

4. SIGNIFICANCE AND USE

4.1. The theoretical maximum specific gravity (G_{mm}) and density of asphalt mixture are intrinsic properties whose values are influenced by the composition of the mixtures in terms of types and amounts of aggregates and asphalt materials.

4.1.1. These properties are used to calculate percent air voids in compacted asphalt mixture.

4.1.2. These properties provide target values for the compaction of asphalt mixture.

4.1.3. These properties are essential when calculating the amount of asphalt binder absorbed by the internal porosity of the individual aggregate particles in asphalt mixture.

5. APPARATUS

5.1. Follow the procedures for performing equipment calibrations, standardizations, and checks that conform to R 18 and R 61.

5.2. *Vacuum Container*:

5.2.1. The vacuum containers described must be capable of withstanding the full vacuum applied, and each must be equipped with the fittings and other accessories required by the test procedure being employed. The opening in the container leading to the vacuum pump shall be covered by a piece of 0.075-mm (No. 200) wire mesh to minimize the loss of fine material.

5.2.2. The capacity of the vacuum container should be between 2000 and 10 000 mL and depends on the minimum sample size requirements given in Section 6.3. Avoid using a small sample in a large container.

5.2.3. *Bowl for Mass Determination in Water Only (Section 11.1)*—Either a metal or plastic bowl with a diameter of approximately 180 to 260 mm (7 to 10 in.) and a bowl height of at least 160 mm (6.3 in.) equipped with a transparent cover fitted with a rubber gasket and a connection for the vacuum line.

5.2.4. *Flask for Mass Determination in Air Only (Section 11.2)*—A thick-walled volumetric glass flask with a factory-inscribed line and a rubber stopper with a connection for the vacuum line.

5.2.5. *Pycnometer for Mass Determination in Air Only (Section 11.2)*—A glass, metal, or plastic pycnometer with a volume defined by means of a glass capillary stopper, capillary lid, or glass plate.

5.3. *Balance*—A balance conforming to the requirements of M 231, Class G 2. The balance shall be standardized at least every 12 months.

5.3.1. For the mass determination-in-water method (Section 11.1), the balance shall be equipped with a suitable apparatus and holder to permit determining the mass of the sample while suspended below the balance. The wire suspending the holder shall be the smallest practical size to minimize any possible effects of a variable immersed length.

5.4. *Vacuum Pump or Water Aspirator*—Capable of evacuating air from the vacuum container to a residual pressure of 3.4 kPa (25 mmHg).

5.4.1. When an oil vacuum pump is used, a suitable trap of one or more filter flasks, or equivalent, shall be installed between the vacuum vessel and vacuum source to reduce the amount of water vapor entering the vacuum pump.

5.5. *Vacuum Measurement Device*—Residual pressure manometer[1] or vacuum gauge to be connected directly to the vacuum vessel and capable of measuring residual pressure down to 3.4 kPa (25 mmHg) or less (preferably to zero).

Note 2—Residual pressure in the vacuum container, measured in millimeters of mercury, is the difference in the height of mercury in the Torricellian vacuum leg of the manometer and the height of mercury in the other leg of the manometer that is attached to the vacuum container.

The device shall be standardized at least annually and be readable to at least 0.2 kPa (2 mmHg). It shall be connected at the end of the vacuum line using an appropriate tube and either a "T" connector on the top of the vessel or a separate opening (from the vacuum line) in the top of the vessel to attach the hose. To avoid damage, the manometer shall not be situated on top of the vessel.

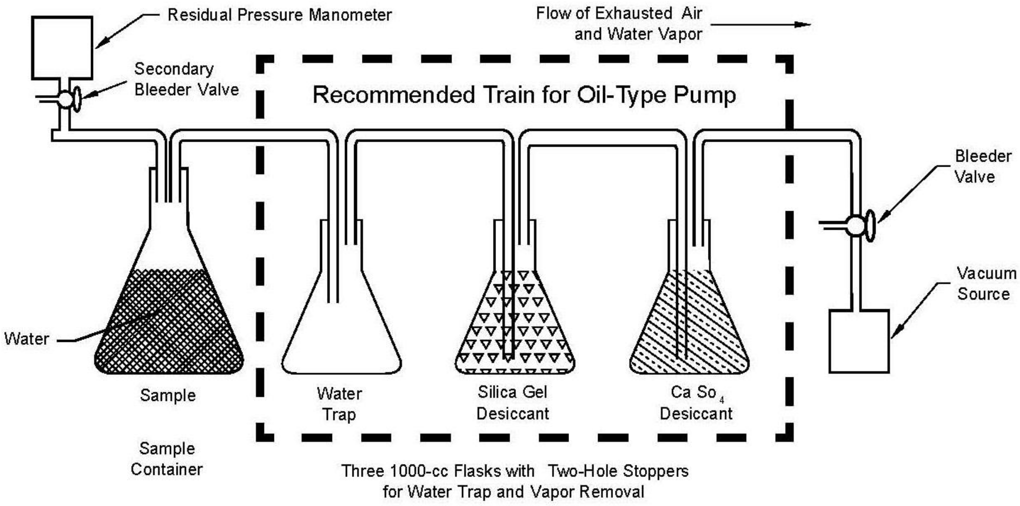

Figure 1—Example of Suitable Arrangement of Testing Apparatus

Note 3—An example of a suitable arrangement of the testing equipment is shown in Figure 1. In the figure, the purpose of the train of small filter flasks is to trap water vapor from the vacuum container that otherwise would enter the oil in the vacuum pump and decrease the pump's ability to provide adequate vacuum.

5.6. *Bleeder Valve*—attached to the vacuum train to facilitate adjustment of the vacuum being applied to the vacuum container.

5.7. *Thermometer (Mass Determination in Air)*—For measuring the temperature of the mass determination in air, meeting the requirements of M 339M/M 339 with a temperature range of at least 20 to 45°C (68 to 113°F) and an accuracy of ±0.25°C (±0.45°F) (Note 4).

Note 4—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E879 thermistor thermometer; ASTM E1137/E1137M Pt-100 RTD platinum resistance thermometer, Class A; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, Class AA.

5.8. *Drying Oven*—A thermostatically controlled drying oven capable of maintaining a temperature of 135 ± 5°C (275 ± 9°F) or 105 ± 5°C (221 ± 9°F). The oven(s) for heating and drying shall be capable of operation at the temperatures required as corrected, if necessary, by standardization. More than one oven may be used, provided each is used within its proper operating temperature range. The thermometer for measuring the oven temperature shall meet the requirements of M 339M/M 339 with a temperature range of at least 90 to 150°C (194 to 302°F) and an accuracy of ±1.25°C (±2.25°F) (Note 5).

Note 5—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E2877 digital metal stem thermometer; ASTM E230/E230M thermocouple thermometer, Type T, Standard Class; or IEC 60584 thermocouple thermometer, Type T, Class 2.

5.9. *Water Bath*—Of sufficient size, capable of maintaining a uniform temperature when used within the proper operating temperature range, to determine the mass determination in water at 25 ± 1°C (77 ± 2°F). The thermometer for measuring the temperature of water baths shall meet the requirements of M 339M/M 339 with a temperature range of at least 20 to 45°C (68 to 113°F) and an accuracy of ±0.25°C (±0.45°F) (Note 6).

Note 6—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E879 thermistor thermometer; ASTM E1137/E1137M Pt-100 RTD platinum resistance thermometer, Class A; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, Class AA.

5.9.1. For bowls, a water bath capable of maintaining a constant temperature between 20 and 30°C (68 and 86°F) is required.

5.9.2. When using the mass determination-in-water technique (Section 13.1), the water bath must be suitable for immersion of the suspended container with its deaerated sample.

5.10. *Protective Gloves*—Used when handling glass equipment under vacuum.

6. SAMPLING

6.1. *Plant-Produced*:

6.1.1. Obtain the sample in accordance with R 97 or R 67 (cores).

6.1.2. Reduce the sample in accordance with R 47.

6.2. *Laboratory-Prepared*:

6.2.1. When necessary, reduce samples prepared or produced in a laboratory in accordance with R 47.

6.3. The size of the sample shall conform to the following requirements. Samples larger than the capacity of the container may be tested a portion at a time.

Table 1—Minimum Sample Sizes

Nominal Maximum Aggregate Size, mm	Minimum Sample Size, g
37.5 or greater	4000
19 to 25	2500
12.5 or smaller	1500

7. SAMPLE PREPARATION

7.1. *Laboratory-Prepared Samples*:

7.1.1. Samples prepared in a laboratory shall be short-term conditioned according to R 30. This conditioning shall be combined with any warming described in Section 7.3.

7.2. *Plant-Produced Samples*:

7.2.1. Plant-produced samples may be short-term conditioned according to R 30 as specified by the agency (Note 7).

Note 7—Short-term conditioning at the specified temperature is especially important when absorptive aggregates are used. This short-term conditioning will ensure the computation of realistic values for the amount of asphalt absorbed by the aggregate and void properties of the mix. Plant-produced asphalt mixtures should be evaluated to make sure short-term conditioning has taken place during production and delivery.

7.3. Separate the particles of the asphalt mixture sample by hand, taking care to avoid fracturing the aggregate, so that the particles of the fine aggregate portion are not larger than 6.3 mm ($^1/_4$ in.). If an asphalt mixture sample is not sufficiently soft to be separated manually, place it in a pan and warm it in an oven until it can be separated as described.

7.4. Determine and record the mass of the empty vacuum container.

7.5. Cool the sample to room temperature, and place the sample in the vacuum container. A container within a container is not to be used. Determine and record the mass of the sample and container. Subtract the mass of the container from the mass of the sample and the container. Record the net mass of the sample as A.

7.6. Add sufficient water at a temperature of approximately 25°C (77°F) to cover the sample completely.

Note 8—The release of entrapped air may be facilitated by the addition of a suitable wetting agent such as Aerosol OT in concentration of 0.001 percent or 0.2 g in 20 L of water. This solution is then diluted by about 20:1 to make a wetting agent of which 5 to 10 mL may be added to the apparatus.

TEST METHOD A—MECHANICAL AGITATION

8. APPARATUS

8.1. In addition to the apparatus listed in Section 5, the following apparatus is required for Method A:

8.1.1. *Mechanical Shaker*—Shaker for removing air from asphalt mixture.

9. PROCEDURE

9.1. Remove air trapped in the sample by applying gradually increased vacuum until the residual pressure manometer reads 4.0 ± 0.6 kPa (30 ± 5 mmHg). Maintain this residual pressure for 15 ± 1 min. Agitate the container and contents using the mechanical device during the vacuum period. Glass vessels should be shaken on a resilient surface such as a rubber or plastic mat, and not on a hard surface, so as to avoid excessive impact while under vacuum.

9.2. At the end of the vacuum period, release the vacuum by increasing the pressure at a rate not to exceed 8 kPa (60 mmHg) per second and proceed with one of the mass determination methods in Section 11.

TEST METHOD B—MANUAL AGITATION

10. PROCEDURE

10.1. Remove air trapped in the sample by applying gradually increased vacuum until the residual pressure manometer reads 4.0 ± 0.6 kPa (30 ± 5 mmHg). Maintain this residual pressure for 15 ± 1 min. Agitate the container and contents during the vacuum period by vigorously shaking at intervals of about 2 min. Glass vessels should be shaken on a resilient surface such as a rubber or plastic mat, and not on a hard surface, so as to avoid excessive impact while under vacuum.

10.2. At the end of the vacuum period, release the vacuum by increasing the pressure at a rate not to exceed 8 kPa (60 mmHg) per second and proceed with one of the mass determination methods in Section 11.

11. MASS DETERMINATION

11.1. *Mass Determination in Water*—Suspend the container and contents in a water bath at 25 ± 1°C (77 ± 2°F). Determine and record the mass after a 10 ± 1 min immersion. Designate the mass of the sample and container in water as *C*.

11.2. *Mass Determination in Air*—Fill the flask or any one of the pycnometers with water and adjust the contents to a temperature of 25 ± 1°C (77 ± 2°F). Determine and record the mass of the container and contents, completely filled, in accordance with Section A1.2.1 within 10 ± 1 min after the vacuum has been released. Designate this mass as *E*.

12. CALCULATION

12.1. *Theoretical maximum specific gravity (G_{mm})*:

12.1.1. Calculate the theoretical maximum specific gravity (G_{mm}) of the sample at 25°C (77°F) as follows:

12.1.2. *Mass Determination in Water*:

$$G_{mm} = \frac{A}{A+B-C} \quad (1)$$

where:

A = mass of the oven-dry sample in air, g;

B = mass of the container submerged in water, g, determined in accordance with Section A1.1; and

C = mass of the sample and container in water, g.

12.1.3. *Mass Determination in Air*:

$$G_{mm} = \frac{A}{A+D-E} \quad (2)$$

where:

A = mass of the oven-dry sample in air, g;

D = mass of the container filled with water, g; determined in accordance with Section A1.2; and

E = mass of the container filled with the sample and water, g.

12.2. For large samples tested a portion at a time (see Section 6.3), calculate the weighted average theoretical maximum specific gravity (G_{mm}) using the mass of the oven-dry sample in air and the theoretical maximum specific gravity (G_{mm}) of each portion tested as follows:

12.2.1. *Weighted Average Theoretical Maximum Specific Gravity [$G_{mm(avg)}$]*:

$$G_{mm(avg)} = \frac{\sum\left(A_x \times G_{mm_x}\right)}{\sum A_x} \quad (3)$$

where:

Ax = mass of the oven-dry sample in air of each portion, g; and

G_{mm_x} = calculated maximum specific gravity for each portion.

Note 9—An example for calculating the weighted average, if the sample is split into two portions for testing, is provided below. In this example, the dry mass of the first portion is 2681.0 g, and the maximum specific gravity of that portion is 2.476. The dry mass of the second portion is 2866.3 g, and the maximum specific gravity is 2.488.

$$G_{mm(avg)} = \frac{\left(A_1 \times G_{mm_1}\right) + \left(A_2 \times G_{mm_2}\right)}{\left(A_1 + A_2\right)}$$

$$= \frac{(2681.0 \times 2.476) + (2866.3 \times 2.488)}{(2681.0 + 2866.3)}$$

$$= 2.482$$

12.3. *Theoretical maximum density at 25°C (77°F):*

12.3.1. Calculate the corresponding theoretical maximum density at 25°C (77°F) as follows:

Theoretical maximum density at 25°C (77°F) = theoretical maximum specific gravity × 997.1 kg/m^3 in SI units.

or

Theoretical maximum density at 25°C (77°F) = theoretical maximum specific gravity × 62.245 lb/ft^3 in inch-pound units.

where:

The density of water at 25°C (77°F) = 997.1 kg/m^3 in SI units or 62.245 lb/ft^3 in inch-pound units.

13. SUPPLEMENTAL PROCEDURE FOR MIXTURES CONTAINING POROUS AGGREGATE

Note 10—Experiments indicate that this supplemental procedure has an insignificant effect on the test results if the asphalt mixture contains individual aggregate with a water absorption below 1.5 percent.

13.1. If the pores of the aggregates are not thoroughly sealed by an asphalt film, they may become saturated with water during the application of vacuum. To determine if this condition has occurred, proceed as follows after completing Section 11.1 or 11.2. Drain the water from the sample. To prevent the loss of fine particles, decant the water through a towel held over the top of the container. Break several large pieces of aggregate and examine the broken surfaces for wetness.

13.2. If the aggregate has absorbed water, spread the sample before an electric fan to remove the surface moisture. Determine and record the mass at 15-min intervals, and when the loss in mass is less than 0.05 percent for this interval, the sample may be considered to be "surface dry." This procedure requires about 2 h and shall be accompanied by intermittent stirring of the sample. Break conglomerations of the asphalt mixture by hand. Take care to prevent the loss of asphalt mixture particles.

13.3. To calculate the specific gravity of the sample, substitute the final surface-dry mass determined in Section 13.2 for A in the denominator of Equation 2 or 3 as appropriate.

14. REPORT

14.1. *Report the following information:*

14.1.1. G_{mm} and density of the asphalt mixture to the nearest 0.001 for specific gravity or nearest 1 kg/m^3 (0.1 lb/ft^3) for density as follows: sp gr 25/25°C (77/77°F) or density at 25°C (77°F);

14.1.2. Type of asphalt mixture;

14.1.3. Size of the sample;

14.1.4. Number of samples;

14.1.5. Type of container; and

14.1.6. Type of procedure.

15. PRECISION

15.1. Criteria for judging the acceptability of specific gravity test results obtained by this test method are given in the following table:

Table 2—Precision Estimates

Test and Type Index	Standard Deviation (1s)	Acceptable Range of Two Results (d2s)
Test results obtained without use of Section 15		
Single-operator precision[a]	0.0046	0.0131
Multilaboratory precision[a]	0.0068	0.0193

[a] These values represent the 1s and d2s described in ASTM C670.

Note 11—The precision estimates given in Table 2 are based on the analysis of test results from ten pairs of AASHTO re:source Asphalt Mixture Superpave Gyratory proficiency samples. The data analyzed consisted of results from 555 to 870 laboratories for each of the ten pairs of samples. The analysis included mixture designs with asphalt content ranging from 4.0 to 4.8 percent and aggregates with absorption values between 0.2 and 0.5 percent. Data from the mixture design analysis and aggregate analysis can be found on the AASHTO re:source website. The described estimates can be used for Method A and Method B within this standard.

15.2. The figures given in Column 2 are the standard deviations that have been found to be appropriate for the conditions of the test described in Column 1. The figures given in Column 3 are the limits that should not be exceeded by the difference between the results of two properly conducted tests. Multilaboratory precision has not been verified for 4500-mL or larger pycnometers.

15.3. The values in Column 3 are the acceptable range for two tests. When more than two results are being evaluated, the range given in Column 3 must be increased. Multiply the standard deviation(s) in Column 2 by the multiplier given in Table 1 of ASTM C670 for the number of actual tests.

Example for three tests: 0.0046 × 3.3 = 0.015.

Additional guidance and background is given in ASTM C670.

16. KEYWORDS

16.1. Agitation; asphalt mixture; maximum density; maximum specific gravity; pycnometer; vacuum.

ANNEX A

(Mandatory Information)

A1. STANDARDIZATION OF BOWLS, FLASKS, AND PYCNOMETERS

A1.1. *Standardization and Check of Bowl for Mass Determination in Water*:

A1.1.1. *Standardization*—Immerse an empty bowl in water at 25 ± 1°C (77 ± 2°F) for 10 ± 1 min. Determine and record the mass of bowl. Perform this process three times. If the range of the three masses is less than or equal to 0.3 g, use the average as B in Equation 1. If the range of the masses is greater than 0.3 g, take corrective action and perform the standardization procedure again.

A1.1.2. *Check*—Perform the mass determination of the bowl as described in Section A1.1.1. If this determination is within 0.3 g of the standardized value, use the standardized value for B. If it is not within 0.3 g, perform the standardization procedure again. For labs that check the bowl standardization frequently (such as daily), calculate the moving average and range of the last three mass determinations. Use the average of the last three masses as B in Equation 1. If the moving range exceeds 0.3 at any time, take corrective action and perform the standardization procedure again.

A1.2. *Standardization and Check of Flask and Pycnometer for Mass Determination in Air*:

A1.2.1. *Standardization*—Fill the flask or pycnometer with water at approximately 25°C (77°F). Use a glass capillary stopper, capillary lid, or glass plate to ensure all entrapped air is removed. Stabilize the flask or pycnometer at 25 ± 1°C (77 ± 2°F) for 10 ± 1 min. Determine and record the mass of the flask or pycnometer, water, and lid. Perform this process three times. If the range of the three masses is less than or equal to 0.3 g, use the average of the three masses as D in Equation 2. If the variation of the masses is greater than 0.3 g, take corrective action and perform the standardization procedure again.

A1.2.2. *Check*—Perform the mass determination of the pycnometer, water, and lid once as described in Section A1.2.1. If this determination is within 0.3 g of the standardized value, use the standardized value for D. If it is not within 0.3 g, repeat the standardization procedure. For labs that check the pycnometer standardization frequently (such as daily), calculate the moving average and range of the last three mass determinations. Use the average of the last three masses as D in Equation 2. If the moving range exceeds 0.3 at any time, take corrective action and perform the standardization procedure again.

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[1] Sargent Welch, 39745 Gauge-Vacuum, Mercury Prefilled (or equivalent).

Weighing-In-Air Method

CALIBRATE PYCNOMETER

NOTE: Determine the temperature of the water bath prior to placing pycnometer and lid in bath.

A. Place pycnometer and capillary lid in water bath.
    (1) 77° ± 1.8° F (25° ± 1° C).
    (2) 10 minutes (± 1 minute)

B. Place lid on pycnometer - seat firmly pressing out excess water and entrapped air.

C. Remove pycnometer, with lid still firmly seated, from bath and wipe dry.

D. Weigh pycnometer, lid and water **and record weight on worksheet found on (Page 7-31)**.

E. Place pycnometer and lid back into bath, and repeat steps B thru D two more times.

F. Average all three weights. **(D)**

SAMPLE PREPARATION

A. Split sample to size needed

    (1) For correct sample size see page 7-19, Section 6-Sampling, Section 6.3, Table 1

    (2) Take even split - do not adjust

    (3) Two approximately even samples per mix

    ***** Upper limit is governed by size of pycnometer.

B. Separate particles of sample by hand

TESTING

A. Weigh sample - **(A)**

B. Place sample in pycnometer and cover with water at 77° F ± 1.8° F (25° C ± 1°).

C. Remove entrapped air with vacuum of 730 mm of Hg (28.7 inches) greater for 15 minutes ± 2 minutes. Agitate the container and contents during the vacuum period either continuously by a mechanical device or manually by vigorous shaking at intervals of about two minutes.

D. Submerge pycnometer and sample in water bath. Also place lid in bath at this time.

  (1) Water at 77° ± 1.8° F (25° ± 1° C)

  (2) 10 ± 1 minute

E. Cover with capillary lid, seat firmly pressing out water and entrapped air

F. Remove pycnometer, with lid still firmly seated, from bath and wipe dry

G. Weigh pycnometer, lid, sample and water - **(E)**

H. Calculate maximum specific gravity G_{mm} **(D)**

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

Where:

A = mass of oven-dry sample in air
D = mass of pycnometer (in air) filled with water and lid seated firmly at 77°± 1.8°F (25°±1°C)
E = mass of pycnometer (in air) filled with sample, water and lid seated firmly at 77°± 1.8°F (25°±1°C)

I. Average results of two samples per test

Maximum Specific Gravity (G_{mm}) Worksheet
(Weighing-In-Air Method)

Name______________________________

		Sample 1	Sample 2
1. Dry sample weight	**(A)**	________	________
2. Averaged calibrated Pycnometer weight (Pycnometer + lid + water)	**(D)**	________	________
3. Vacuumed sample weight (Pycnometer + lid + water + sample)	**(E)**	________	________
4. Maximum Specific Gravity (report to 3 places, **[2.xxx]**)		________	________

$$\frac{A}{A + D - E}$$

Average G_{mm}(D) ________ **(2.xxx)**

Pycnometer Calibration Weights

4. ___________ ___________

5. ___________ ___________

6. ___________ ___________

(A) = Mass of oven-dry sample in air, g

(D) = Calibrated Pycnometer weight

(E) = Vacuumed sample + Pyc., lid, & water

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CORE DENSITY DETERMINATION

Most commonly, nuclear density gauges are used to determine the density of compacted hot-mix asphalt. But in order for the nuclear density gauge to give accurate results, the gauge must be correlated with the densities of cored Hot-Mix asphalt specimens taken from the roadway. Core densities are also used on some special mixtures which cannot be accurately tested using a nuclear density gauge or when conditions exist that won't allow the use of a nuclear density gauge.

With the introduction of PFP (Payment for Performance) and QCP (Quality Control for Performance) contracts, core density determination of HMA materials is the required method used to determine contractor compliance on IDOT projects.

This section describes the method for determining core densities. Also see Illinois Modified Test Procedure for Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface Dry Specimens, AASHTO T 166. This Specification is included in the Bulk Specific Gravity section of this manual.

PURPOSE OF TEST

A. Determine the density of compacted HMA pavement.

B. Correlating a HMA mixture to a nuclear density gauge.

CORE SPECIMEN REMOVAL FROM THE PAVEMENT

A. Determine the core specimen removal locations on the project

B. If nuclear density testing is to be performed at the same core specimen test locations, the nuclear density testing needs to be completed at test locations before core specimen removal can begin. This applies all gauges to be used on the project; Contractor, State, Local Agency or Consultant.

   Note: It is necessary to keep any additional traffic off of the pavement test locations once the nuclear density testing has been completed to avoid any additional compaction of the pavement test locations.

C. Allow the pavement test locations to adequately cool before cutting the core specimens. The time needed for cooling the pavement test locations can be significantly shortened by applying ice or dry ice on each of the test locations or flooding the test locations with water.

   Note: Pavement test locations need to be cooled properly before coring and removal of the core specimens. Damage to the core specimen can be experienced during the coring and removal process if the mixture is too warm. This damage can/will adversely affect the final test results.

   On PFP (Payment for Performance) or QCP (Quality Control for Performance) contracts, these adverse test results will lead to financial penalties being imposed on contractors resulting in a loss of contract money.

D. Core specimens need to be properly identified as to the location from which they were taken. This helps to ensure the test results are correctly matched to nuclear density results or to help locate out of specification materials.

E. Cored pavement locations are required to be properly repaired by the contractor. When using non-shrinking grout, the repair needs to be flush with the existing pavement (no more than a 1/4" depression). The non-shrink grout needs to be properly mixed and then transferred to a dry core hole.

A complete listing of approved repair materials can be found on the IDOT website at: http://www.dot.state.il.us/materials/materialslist.html

Note: It is not permissible to mix the non-shrink grout directly in the core hole using the remaining water left in the core hole from the coring process. By directly mixing the non-shrink grout in the cored hole allows the grout material to settle creating too large of a depression after the grout sets.

PREPARE CORE SPECIMENS FOR TESTING

A. Core specimens need to be properly identified and marked for proper tracking of the specimens and test results during the testing process. Paint sticks are a good tool for this purpose. Keel or crayon should be avoided since the markings could potentially wear off during the testing process allowing samples or test results to be misidentified.

B. During the coring process, the core drill needs to penetrate sufficiently into the lift of material below the lift of material to be tested. Any foreign or base material that remains attached to the core specimen after core removal from the pavement needs to be separated from the desired lift of HMA mixture that is to be tested.

Two approved methods:

(1) Freezing and separating.

The core specimens are placed into a freezer for approximately 1 hour. A hammer and sharp chisel are then used to separate the different lifts of materials by lightly tapping along the line of demarcation that identifies the different lifts of materials. The two different lifts of material will usually separate after three or four taps in different locations around the core specimen. This method works well when the material being tested has been placed on a flat base surface.

(2) Sawing.

A large chop saw or concrete saw is used to cut the different materials at the line of demarcation. Although messier than the hammer and chisel, this method can be very accurate in separating the different materials. This method works well when the desired material is adjoined to the base with a milled or rough surface.

C. Remove loose material.

Once the final core specimens have been obtained the core specimens need to be brushed to remove any loose material that could be lost during the testing process. This loose material could affect the weights and ultimately the final test results.

EQUIPMENT*

A. Electronic balance of sufficient capacity, readable to 0.1 g, with suspension apparatus.

B. Water tank with overflow for submerged weights.

C. Thermometer capable of reading 77° F (25° C) to nearest 0.2° F (0.1° C).

D. Container of sufficient volume to submerge cores in 77° F ± 1.8° F (25° ± 1° C) water.

E. Gloves, pans, spatulas, brushes.

* Equipment can be shared with the Illinois Modified Test Procedure for Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface Dry Specimens, AASHTO T 166.

PROCEDURE TO DETERMINE DENSITY OF CORE SPECIMENS

A. **<u>Method C</u>** (a rapid test method, destroys the core specimen):

(1) Determine height of the core specimen.

(2) Determine original weight of the core specimen.

(3) Soak core specimen on its curved side for 4 ± 1 minutes in a temperature-controlled water bath at 77° F ± 1.8° F (25°C ± 1°C).

(4) Determine submerged weight of the core specimen. **(C)**

(5) Pat the core specimen to saturated surface-dry condition with damp towel.

(6) Determine saturated surface-dry weight of the core specimen. **(B)**

(7) Determine and record the tare weight of an empty pan

(8) Place the core specimen in the empty pan on its curved side. Determine and record the weight of the pan and core specimen.

(9) Place the core specimen into a 230° F ± 9° F (110° ± 5° C) oven and dry to a constant mass (when the weight does not change by more than 0.5 g in any successive one hour weighing).

(10) Determine oven-dry weight of the core specimen **(A)** and perform the calculations.

B. **Method A** (a slow test method, the core specimen remains intact):

(1) Determine height of the core specimen.

(2) Determine original weight of the core specimen (moisture is still present).

(3) Place the core specimen into a low temperature oven [125° F ± 5° F (52° ± 3° C)] and dry to a constant mass (when weight does not change by more than 0.5g in any successive one hour weighing).

(4) Allow the core specimen to return to room temperature.

(5) Determine oven dry weight of the core specimen. **(A)**

(6) Soak the core specimen on its curved side for 4 ± 1 minutes in a temperature-controlled water bath at 77° F ± 1.8° F (25°C ± 1°C).

(7) Determine submerged weight of the core specimen. **(C)**

(8) Pat the core specimen to saturated surface-dry condition with damp towel.

(9) Determine saturated surface-dry weight of the core specimen. **(B)**

(10) Perform the calculations.

CALCULATIONS:

A.

$$\text{Bulk Specific Gravity} = \frac{\mathbf{A}}{\mathbf{B-C}}$$

Example:

1359.7 (A)
1376.1 (B)
794.4 (C)

$$\frac{1359.7}{1367.1-794.4} = 2.3741924 \text{ or } 2.374$$

NOTE: Bulk Specific Gravity results are rounded to 3 decimal places.

B.

$$\text{Percent Density} = \frac{\textbf{Bulk Specific Gravity}}{\textbf{Maximum Specific Gravity}} \ \mathbf{X} \quad \mathbf{100}$$

Example:

2.374 (Bulk Sp. Gr.)
2.546 (Max. Sp. Gr.)

$$\frac{2.374}{2.546} = 100 = 93.2443 = 93.2\%$$

NOTE: Percent density results are rounded to 1 decimal place.

C. For nuclear correlation purposes the obtained bulk specific gravity shall be converted to density (unit weight), in kilograms per cubic meter, or pounds per cubic-foot, according to the formula:

Density = Bulk Specific Gravity X 1,000 results in kg/m³

Example: **2.374 X 1000 kg/m³ = 2374 kg/m³**

NOTE: kg/m³ results are rounded to a whole number.

Density = Bulk Specific Gravity X 62.4 results in #/ft³ (pcf)

Example: **2.374 X 62.4 #/ft³ = 148.1376 #/ft³ = 148.1 #/ft³**

NOTE: #/ft³ results are rounded to 1 decimal place.

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STRIPPING TEST

Some asphalt pavement mixtures, at high temperature, which are exposed to moisture (rain, flooding, etc.), may be prone to stripping of Asphalt Binder (AB) off of the aggregates. Such mixtures require an anti-strip additive be added during mix production.

The Illinois Modified Test Procedure for AASHTO T283, Resistance of Compacted Bituminous Mixture to Moisture Induced Damage, is used to identify mixtures which are susceptible to moisture damage.

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Illinois Modified Test Procedure
Effective Date: March 1, 2003
Revised Date: December 1, 2023

Standard Method of Test
For
Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage

Reference AASHTO T 283-22

AASHTO Section	***Illinois Modification***
1.1	Replace the first sentence with the following: This method covers preparation of specimens and the measurement of the change of diametral tensile strength resulting from the effects of water saturation and accelerated water conditioning of compacted asphalt mixtures.
2.1	Replace with the following: *Referenced Illinois modified AASHTO Standards:* ▪ R 30, Mixture Conditioning of Hot-Mix Asphalt (HMA) ▪ T 166, Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens ▪ T 209, Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures ▪ T 245, Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus ▪ T 312, Preparing and Determining the Density of Hot-Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
2.1.1	Illinois Manual of Test Procedures: ▪ Appendix B4, Hot-Mix Asphalt Test Strip Procedures ▪ Appendix B6, Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples ▪ Appendix B7, Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations ▪ Appendix B17, Procedure for Introducing Additives to Hot Mix Asphalt Mixtures and Testing in the Lab ▪ Appendix E3, PFP and QCP Random Density Procedure ▪ Appendix E4, PFP and QCP Hot Mix Asphalt Random Jobsite Sampling
2.2	▪ Delete
3.1	Replace the first sentence with the following: This method is intended to evaluate the effects of saturation and accelerated water conditioning of compacted asphalt mixtures.
3.2	Replace with the following: Numerical indices of retained indirect-tensile properties are obtained by comparing the properties of laboratory specimens subjected to moisture conditioning with the similar properties of dry specimens.

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AASHTO Section	***Illinois Modification***
4.1	Replace the fourth sentence with the following: The other subset is subjected to vacuum saturation**,** followed by a warm-water soaking cycle, before being tested for indirect tensile strength.
5.1	Replace with the following: Equipment for preparing and compacting specimens from T 312.
5.3	Replace with the following: Balance and water bath from T 166 for immersing the specimen under water while suspended under a weighing device.
5.4.1	Replace with the following: Water bath of sufficient size, capable of maintaining a uniform temperature of 60 ± 1 °C (140 ± 1.8 °F). The water bath and the thermometer for measuring the temperature of the water bath shall meet the requirements listed in the Illinois Department of Transportation document, “Hot-Mix Asphalt QC/QA Laboratory Equipment”. The thermometer for measuring the temperature of the water bath may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.25 °C (± 0.45 °F) (see Note 1).
5.4.2	Replace with the following: Water bath of sufficient size, capable of maintaining a uniform temperature of 25 ± 1 °C (77 ± 1.8 °F). The water bath and the thermometer for measuring the temperature of the water bath shall meet the requirements listed in the Illinois Department of Transportation document, “Hot-Mix Asphalt QC/QA Laboratory Equipment”. The thermometer for measuring the temperature of the water bath may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.25 °C (± 0.45 °F) (see Note 2).
Note 2	Replace with the following: **Note 2** - Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E879 thermistor thermometer; ASTM E1137/E1137M Pt-100 RTD platinum resistance thermometer, Class A; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, Class AA.
5.5	Delete
5.6	Delete
5.7	Delete

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AASHTO Section	***Illinois Modification***
5.10	Replace with the following: Ovens – shall meet the temperature requirements listed in the document “Hot-Mix Asphalt Laboratory Equipment”. Thermometers for measuring temperature of aggregate, binder, and asphalt mixtures shall have a suitable range to determine 50 – 450 °F (10 – 232 °C). The thermometers may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 1.35 °F (± 0.75 °C) (see Note 3). **Note 3** - Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; IEC 60584 thermocouple thermometer, Type T, Class 1; or E2877 digital metal stem thermometer.
5.12	Replace the second sentence with the following: For 100 mm (4 in.) diameter field-mixed, field-compacted pavement cores only, the loading strips shall be 12.7 mm (0.5 in.) wide and for all specimens 150 mm (5.91 in.) diameter, the loading strips shall be 19.05 mm (0.75 in.) wide.
6.1	Replace the first paragraph with the following: Prepare mixture for at least six specimens for each test, half to be tested dry and the other half to be tested after partial saturation and moisture conditioning (Note 4).
Note 5	Renumber as Note 4.
6.1.2.1 New Section	When an anti-stripping additive is used, the procedure in Appendix B17 of the Illinois Manual of Test Procedures for adding and mixing the additive shall be followed.
6.1.2.2 New Section	Odor neutralizing additives, if used, shall be added to the asphalt binder according to the manufacturer’s recommended dosage rate and procedure prior to mixing the asphalt with the heated aggregates.

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AASHTO Section	***Illinois Modification***
6.2	Replace with the following: Prepared compacted specimens shall be 7.0 ± 1.0 percent air voids except SMA mixtures which shall be compacted to 6.0 ± 1.0 percent air voids. This level of voids can be obtained by adjusting the mass of the mixture, or adjusting the number of gyrations or specimen height in T 312. The most effective way to adjust voids, while maintaining a compacted height of 95 mm is to make slight changes in the weight of the loose material to be compacted. The exact procedure must be determined experimentally for each mixture before compacting the specimens for each set. (Note 4)
6.3	Replace with the following: Specimens 150 mm (5.91 in.) diameter by 95 ± 5 mm (3.75 ± 0.20 in.) thick are used.
6.4	Replace with the following: Place the mixture in a pan and cool at room temperature.
6.5	Replace with the following: Short-term aging of laboratory prepared mixtures shall be done according to Illinois-modified AASHTO R 30.
6.6	Replace with the following: Compact the specimens according to the method in T 312. The mixture shall be compacted to 7.0 ± 1.0 percent air voids except SMA mixtures which shall be compacted to 6.0 ± 1.0 percent air voids.
6.7	Delete
6.8	Replace with the following: Allow the extracted specimens to cool to a room temperature 25 ± 5 °C (77 ± 9 °F). Remove the specimens from the molds (Note 5).
Note 6	Renumber as Note 5.
6.9	Replace the second sentence with the following: The air void content shall be within 7.0 ± 1.0 percent except SMA mixtures which shall be within 6.0 ± 1.0 percent air voids.

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Reference AASHTO T 283-22

AASHTO Section	***Illinois Modification***
Note 7	Renumber as Note 6.
7.1	Replace with: Obtain field-mixed asphalt mixture sample in accordance with Appendix B.6 or E.4 of sufficient size to determine G_{mm} and make at least six specimens. Appendix B.6 shall be used in QC/QA applications and Appendix E.4 shall be used in QCP or PFP applications.
7.3	Replace with the following: Make at least six specimens for each test, half to be tested dry and the other half to be tested after partial saturation and moisture conditioning (Note 6).
7.3.1	Replace with the following: Prepared compacted specimens shall be 7.0 ± 1.0 percent except SMA mixtures which shall be compacted to 6.0 ± 1.0 percent air voids. This level of voids can be obtained by adjusting the mass of the mixture, or adjusting the number of gyrations or specimen height in T 312. The most effective way to adjust voids, while maintaining a compacted height of 95 mm is to make slight changes in the weight of the loose material to be compacted. The exact procedure must be determined experimentally for each mixture before compacting the specimens for each set. (Note 6)
7.4	Replace with the following: Specimens 150 mm (5.91 in.) in diameter by 95 ± 5 mm (3.75 ± 0.20 in.) thick are used.
7.5	Replace with the following: No loose-mix curing as described in Section 6.5 shall be performed on the field-mixed samples. After sampling, place the mixture in an oven until it reaches the compaction temperature ± 3°C (5°F). Then, compact the specimen according to the method in T 312. The mixture shall be compacted to 7.0 ± 1.0 percent air voids except SMA mixtures which shall be compacted to 6.0 ± 1.0 percent air voids.
7.6	Replace with the following: Allow the extracted specimens to cool to a room temperature of 25 ± 5°C (77 ± 9°F). Remove the specimens from the molds (Note 5).

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AASHTO Section	***Illinois Modification***
7.7	Replace with the following: Determine the air voids according to Sections 9.3 and 9.4. The air void content shall be within 7.0 ± 1.0 percent except SMA mixtures which shall be within 6.0 ± 1.0 percent air voids.
8.1	Replace the first sentence with the following: Select locations on the completed pavement to be sampled and obtain cores according to Appendix B.7 or E.3. Appendix B.7 shall be used in QC/QA applications and Appendix E.3 shall be used in QCP or PFP applications.
8.1.1 New Section	The pavement may be cored with the objective of performing a forensic analysis of the in-situ conditions of the in-place, compacted mixture. In that case, the core specimens should be kept in a leak-proof plastic bag until testing to preserve the in-situ conditions. The testing should be conducted as soon as possible after coring.
9.1	Replace with the following: Use the gyratory compactor height printout sheet to determine the specimen thickness (t). If the gyratory height printout sheet is not available determine the specimen thickness by taking four measurements at approximately quarter points on the periphery of the specimen and recording the average of these measurements as the thickness of the specimen.
9.6	Replace the first sentence with the following: For those specimens to be subjected to vacuum saturation and a warm-water soaking cycle, calculate the volume of air voids (V_a) in cubic centimeters using the following equation:
Note 8	Renumber as Note 7.
10.1	Replace with the following: One subset will be tested dry, and the other will be partially vacuum-saturated and soaked in warm water before testing.

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AASHTO Section	***Illinois Modification***
10.2	Replace with the following: The dry subset will be stored at room temperature until testing. The specimens shall then be placed in a 25 ± 1°C (77 ± 1.8°F) water bath for 2 hrs ± 10 min with a minimum 25 mm (1 in.) of water above their surface. Then test the specimens as described in Section 11.
10.3	Delete
10.4.1	Replace with the following: Place the specimen in the vacuum container. Fill the container with potable water at room temperature so that the specimens have at least 25 mm (1 in.) of water above their surface.
10.4.2	Replace with the following: Saturate the specimen to 70 to 80 percent by applying a vacuum (Note 8). For forensic core testing, pavement core specimens shall be saturated for 3 minutes under a vacuum of 20 to 25 inches of Mercury before proceeding to Section 10.4.10.
Note 8	Replace with the following: Apply a vacuum of 13 to 67 kPa absolute pressure (10 to 26 in. Hg partial pressure) for a short time (approximately 1 to 10 minutes).
10.4.3	Replace with the following: Remove the vacuum and leave the specimen submerged in water for a short time (approximately 1 to 10 minutes).
Note 10	Renumber as Note 9.
10.4.9	Delete.
10.4.10	Replace the first sentence with the following: Place the specimens, flat side down, into a 60 ± 1 °C (140 ± 1.8° F) water bath for 24 hrs ± 1 hr. Delete the last sentence.

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AASHTO Section	***Illinois Modification***
10.4.11	Replace the first sentence with: After 24 hrs ± 1 hr in the 60 ± 1°C (140 ± 1.8°F) water bath, remove the specimens and place them in a water bath at 25 ± 1°C (77 ± 1.8°F) for 2 hrs ± 10 min. Replace the fourth sentence with: Not more than 15 min should be required for the water bath to reach 25 ± 1°C (77 ± 1.8°F).
11.1	Replace with: Determine the indirect-tensile strength of dry and conditioned specimens at 25 ± 1°C (77 ± 1.8°F).
11.1.1	Replace the first sentence with the following: Remove the specimen from the 25 ± 1°C (77 ± 1.8°F) water bath. Insert the following at the end: Note 7: If a chart recorder is used, the 10,000 pound scale should be used for 150 mm (5.91 in.) specimens and the 5,000 pound scale should be used for 4 in. (100 mm) field pavement core specimens.
11.1.2	Replace the last sentence with the following: Inspect the interior surface for evidence of cracked or broken aggregate; visually estimate the approximate degree of moisture damage on a scale from “1” to “3” (with “3” being the most stripped) according to the Illinois procedure “Stripping of Hot-Mix Asphalt Mixtures Visual Identification and Classification” and record the observations.
12.1 New Notes	Add the following at the end: Note 8. The actual diameter of a gyratory specimen is 150 mm (5.91 in.). Note 9: If the strength is converted from metric to English units, use the factor: 1 kPa = 0.14504 psi (1 psi = 6.895 kPa).

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AASHTO Section	***Illinois Modification***
12.2	Replace the first sentence with the following: Express the numerical index of resistance of asphalt mixtures to the detrimental effect of water as the ratio of the original strength that is retained after the moisture conditioning. Add the following at the end: The minimum tensile strength and TSR values for 150 mm (5.91 in.) specimens shall be according to Article 1030.05(c) of the current IDOT Standard Specifications for Road and Bridge Construction. The minimum TSR for 4-inch (100 mm) field-mixed, field-compacted pavement cores only shall be 0.75.
15.1	Delete.

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Standard Method of Test for

Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage

AASHTO Designation: T 283-22

Technically Revised: 2022 **Editorially Revised: 2022**

Technical Subcommittee: 2d, Proportioning of Asphalt–Aggregate Mixtures

1. SCOPE

1.1. This method covers preparation of specimens and the measurement of the change of diametral tensile strength resulting from the effects of water saturation and accelerated water conditioning, with a freeze–thaw cycle, of compacted asphalt mixtures. The results may be used to predict long-term stripping susceptibility of the asphalt mixture and evaluate liquid antistripping additives that are added to the asphalt binder or pulverulent solids, such as hydrated lime or portland cement, which are added to the mineral aggregate.

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 concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.4. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 339M/M 339, Thermometers Used in the Testing of Construction Materials
- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- R 30, Laboratory Conditioning of Asphalt Mixtures
- R 47, Reducing Samples of Asphalt Mixtures to Testing Size
- R 67, Sampling Asphalt Mixtures after Compaction (Obtaining Cores)
- R 68, Preparation of Asphalt Mixtures by Means of the Marshall Apparatus
- R 97, Sampling Asphalt Mixtures
- T 166, Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens

- T 167, Compressive Strength of Hot Mix Asphalt
- T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures
- T 245, Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus
- T 247, Preparation of Test Specimens of Hot Mix Asphalt (HMA) by Means of California Kneading Compactor
- T 312, Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor

2.2. *ASTM Standards*:

- D3387, Standard Test Method for Compaction and Shear Properties of Bituminous Mixtures by Means of the U.S. Corps of Engineers Gyratory Testing Machine (GTM) (withdrawn 2020; no replacement)
- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E879, Standard Specification for Thermistor Sensors for General Purpose and Laboratory Temperature Measurements
- E1137/E1137M, Standard Specification for Industrial Platinum Resistance Thermometers
- E2877, Standard Guide for Digital Contact Thermometers

2.3. *International Electrotechnical Commission Standards*:

- IEC 60584-1: 2013 Thermocouples - Part 1: EMF Specifications and Tolerances
- IEC 60751: 2008 Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors

3. SIGNIFICANCE AND USE

3.1. This method is intended to evaluate the effects of saturation and accelerated water conditioning, with a freeze–thaw cycle, of compacted asphalt mixtures. This method can be used to test: (a) asphalt mixtures in conjunction with mixture design testing (lab-mixed, lab-compacted); (b) asphalt mixtures produced at mixing plants (field-mixed, lab-compacted); and (c) asphalt mixture cores obtained from completed pavements of any age (field-mixed, field-compacted).

3.2. Numerical indices of retained indirect-tensile properties are obtained by comparing the properties of laboratory specimens subjected to moisture and freeze–thaw conditioning with the similar properties of dry specimens.

4. SUMMARY OF METHOD

4.1. Test specimens for each set of mix conditions, such as those prepared with untreated asphalt binder, asphalt binder treated with antistripping agent, or aggregate treated with lime, are prepared. Each set of specimens is divided into subsets. One subset is tested in dry condition for indirect-tensile strength. The other subset is subjected to vacuum saturation and a freeze cycle, followed by a warm-water soaking cycle, before being tested for indirect-tensile strength. Numerical indices of retained indirect-tensile strength properties are calculated from the test data obtained by the two subsets: dry and conditioned.

5. APPARATUS

5.1. Equipment for preparing and compacting specimens from one of the following: R 68, T 167, T 247, T 312, or ASTM D3387.

5.2. Equipment for determining the theoretical maximum specific gravity (G_{mm}) of the asphalt mixture from T 209.

5.3. Balance and water bath from T 166.

5.4. Water baths shall be capable of maintaining a temperature as required.

5.4.1. Water bath of sufficient size, capable of maintaining a uniform temperature of 60 ± 1°C (140 ± 2°F). The thermometer for measuring the temperature of the water bath shall meet the requirements of M 339M/M 339 with a temperature range of at least 55 to 65°C (131 to 149°F) with an accuracy of ±0.25°C (±0.45°F) (see Note 1).

Note 1—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E879 thermistor thermometer; ASTM E1137/E1137M Pt-100 RTD platinum resistance thermometer, Class A; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, Class AA.

5.4.2. Water bath of sufficient size, capable of maintaining a uniform temperature of 25 ± 0.5°C (77 ± 0.9°F). The thermometer for measuring the temperature of the water bath shall meet the requirements of M 339M/M 339 with a temperature range of at least 20 to 30°C (68 to 86°F) with an accuracy of ±0.13°C (±0.22°F) (see Note 2).

Note 2—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E879 thermistor thermometer; ASTM E1137/E1137M Pt-100 RTD platinum resistance thermometer, Special order; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, Special order.

5.5. Freezer maintained at –18 ± 3°C (0 ± 5°F). The thermometer for measuring the temperature of the freezer shall meet the requirements of M 339M/M 339 with a temperature range of at least –25 to –10°C (–13 to 14°F) with an accuracy of ±0.75°C (±1.35°F) (see Note 3).

Note 3—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E2877 digital metal stem thermometer; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; or IEC 60584 thermocouple thermometer, Type T, Class 1.

5.6. A supply of plastic film for wrapping specimens; heavy-duty, leakproof plastic bags to enclose the saturated specimens; and masking tape.

5.7. 10-mL graduated cylinder.

5.8. Pans having a surface area of 48 400 to 129 000 mm^2 (75 to 200 in.^{2}) in the bottom and a depth of at least 25 mm (1 in.).

5.9. A tape, rule or calipers for measuring specimen thickness.

5.10. Forced-draft oven, properly standardized, thermostatically controlled, and capable of maintaining any desired temperature setting from room temperature to 176°C (350°F) within ±3°C (±5°F). More than one oven may be used, provided each is used within its proper operating temperature range. Thermometer for measuring the temperature of materials shall meet the requirements of M 339M/M 339 with a temperature range of at least 25 to 185°C (77 to 365°F), and an accuracy of ±0.75°C (see Note 4).

Note 4—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; or IEC 60584 thermocouple thermometer, Type T, Class 1.

5.11. Loading jack and ring dynamometer from T 245, or a mechanical or hydraulic testing machine from T 167, to provide a range of accurately controllable rates of vertical deformation, including 50 mm/min (2 in./min).

5.12. Steel loading strips with a concave surface having a radius of curvature equal to the nominal radius of the test specimen. For specimens 100 mm (4 in.) in diameter, the loading strips shall be 12.7 mm (0.5 in.) wide, and for specimens 150 mm (6 in.) in diameter, the loading strips shall be 19.05 mm (0.75 in.) wide. The length of the loading strips shall exceed the thickness of the specimens. The edges of the loading strips shall be rounded to the appropriate radius of curvature by grinding.

6. PREPARATION OF LABORATORY-MIXED, LABORATORY-COMPACTED SPECIMENS

6.1. Prepare mixture for at least six specimens for each test, half to be tested dry and the other half to be tested after partial saturation and moisture conditioning with a freeze–thaw cycle (Note 5).

Note 5—It is recommended that mixture for at least two additional specimens for each set be prepared. These specimens can then be used to establish compaction procedures for specimen void content as given in Section 6.2 and the vacuum saturation technique as given in Section 10.4.

6.1.1. If G_{mm} is unknown, prepare additional mixture according to R 30 Section 7.1, and determine the G_{mm} according to T 209.

6.1.2. Prepare mixtures in batches large enough to make at least three specimens or, alternatively, prepare a batch large enough to just make one specimen at a time. If preparing a multispecimen batch, split the batch into single-specimen quantities before placing in the oven.

6.2. Prepared compacted specimens shall be 7.0 ± 0.5 percent air voids. This level of voids can be obtained by adjusting the mass of the mixture; the number of blows in R 68; adjusting foot pressure, number of tamps, leveling load, or some combination in T 247; or adjusting the number of gyrations or specimen height in T 312 or ASTM D3387. The effective adjustment must be determined experimentally for each mixture before compacting the specimens for each set. (Note 5).

6.3. Specimens 100 mm (4 in.) in diameter by 63.5 ± 2.5 mm (2.5 ± 0.1 in.) thick, or 150 mm (6 in.) in diameter by 95 ± 5 mm (3.75 ± 0.20 in.) thick are used. Specimens 150 mm (6 in.) in diameter by 95 ± 5 mm (3.75 ± 0.20 in.) thick should be used if aggregate larger than 25 mm (1 in.) is present in the mixture.

6.4. Place the mixture in a pan and cool at room temperature for 2 ± 0.5 h.

6.5. Place the cooled mixture in a 60 ± 3°C (140 ± 5°F) oven for 16 ± 1 h for curing. The pans should be placed on spacers to allow air circulation under the pan if the shelves are not perforated.

6.6. Place the mixture in an oven for 2 h ± 10 min at the compaction temperature ±3°C (5°F). Determine compaction temperature according to R 30.

6.7. Compact the specimens according to one of the following methods: R 68, T 167, T 247, T 312, or ASTM D3387 to 7.0 ± 0.5 percent air voids.

6.8. Remove the specimens from the molds (Note 6).

Note 6—Due to the elevated air void content and potential instability of the specimens, ensure that each specimen is adequately cool and stable before removing from the mold.

6.9. Determine air voids according to Sections 9.3 and 9.4. The air void content must be within 7.0 ± 0.5 percent.

7. PREPARATION OF FIELD-MIXED, LABORATORY-COMPACTED SPECIMENS

7.1. Obtain field-mixed asphalt mixture sample in accordance with R 97 of sufficient size to determine G_{mm} and make at least six specimens.

Note 7—It is recommended that mixture for at least two additional specimens for each set be obtained. These specimens can then be used to establish compaction procedures for specimen void content as given in Section 7.3.1 and the vacuum saturation technique as given in Section 10.4.

7.2. Determine G_{mm} by T 209.

7.3. Make at least six specimens for each test, half to be tested dry and the other half to be tested after partial saturation and moisture conditioning with a freeze–thaw cycle (Note 7).

7.3.1. Prepared compacted specimens shall be 7.0 ±0.5 percent air voids. This level of voids can be obtained by adjusting the mass of the mixture, the number of blows in R 68; adjusting foot pressure, number of tamps, leveling load, or some combination in T 247; or adjusting the number of revolutions in T 312 or ASTM D3387. The exact procedure must be determined experimentally for each mixture before compacting the specimens for each set. (Note 7)

7.4. Specimens 100 mm (4 in.) in diameter by 63.5 ± 2.5 mm (2.5 ± 0.1 in.) thick, or 150 mm (6 in.) in diameter by 95 ± 5 mm (3.75 ± 0.20 in.) thick are used. Specimens 150 mm (6 in.) in diameter by 95 ± 5 mm (3.75 ± 0.20 in.) thick should be used if aggregate larger than 25 mm (1 in.) is present in the mixture.

7.5. No loose-mix curing as described in Section 6.5 shall be performed on the field-mixed samples. After sampling, divide the sample to obtain the desired size in accordance with R 47. Next, place the mixture in an oven until it reaches the compaction temperature ±3°C (5°F). Then compact the specimen according to one of the following methods: R 68, T 167, T 247, T 312, or ASTM D3387 to 7.0 ± 0.5 percent air voids.

7.6. Remove the specimens from the molds (Note 6).

7.7. Determine air voids according to Sections 9.3 and 9.4. The air void content must be within 7.0 ± 0.5 percent.

8. PREPARATION OF FIELD-MIXED, FIELD-COMPACTED SPECIMENS (CORES)

8.1. Select locations on the completed pavement to be sampled, and obtain cores according to R 67. When testing pavement layers with a thickness less than or equal to 63.5 mm (2.5 in.), use 100-mm (4-in.) diameter cores. Otherwise, use either 100-mm (4-in.) or 150-mm (6-in.) diameter cores.

8.2. Obtain at least six cores for each set of mix conditions. Additional cores may be required to determine G_{mm} by T 209.

8.3. Separate the core layers as necessary by sawing them or by other suitable means, and store the layers to be tested at room temperature until they are dry.

8.4. No loose-mix curing (Section 6.5) or compacted-mix curing (Section 6.6) shall be performed on the field-mixed, field-compacted specimens (cores).

9. EVALUATION AND GROUPING OF SPECIMENS

9.1. Determine each specimen thickness (t) by measuring to 1mm ($^1/_{16}$ in.) in four locations around the specimen and averaging or, if the specimen is prepared by T 312, use the final height from the Superpave Gyratory Compactor.

9.2. Record each specimen diameter (D) as defined in Section 6.3, 7.4, or 8.1, as appropriate.

9.3. Determine each bulk specific gravity (G_{mb}) by Method A of T 166. Express the volume (E) of the specimens, or the saturated, surface-dry mass minus the mass in water, in cubic centimeters.

9.4. Calculate the percentage of air voids (P_a).

$$P_a = 100\left(1 - \frac{G_{mb}}{G_{mm}}\right) \quad (1)$$

where:

G_{mb} = the bulk specific gravity; and;

G_{mm} = the theoretical maximum specific gravity.

9.5. Separate the specimens into two subsets, of at least three specimens each, so that the average air voids of the two subsets are approximately equal.

9.6. For those specimens to be subjected to vacuum saturation, a freeze cycle, and a warm-water soaking cycle, calculate the volume of air voids (V_a) in cubic centimeters using the following equation:

$$V_a = \frac{P_a E}{100} \quad (2)$$

where:

V_a = volume of air voids, cm^3;

P_a = air voids, percent; and

E = volume of the specimen, cm^3.

Note 8—A data sheet that is convenient for use with this test method is shown as Table 1.

10. PRECONDITIONING OF TEST SPECIMENS

10.1. One subset will be tested dry, and the other will be partially vacuum saturated, subjected to freezing, and soaked in warm water before testing.

10.2. Wrap the dry subset with plastic or place in a heavy-duty, leakproof plastic bag.

10.3. Place the specimens in a water bath with the conditioned subset according to Section 10.4.11.

10.4. *The other subset shall be conditioned as follows:*

10.4.1. Place the specimen in the vacuum container supported a minimum of 25 mm (1 in.) above the container bottom by a perforated spacer. Fill the container with potable water at room temperature so that the specimens have at least 25 mm (1 in.) of water above their surface.

10.4.2. Saturate the specimen to 70 to 80 percent by applying a vacuum (Note 9).

Note 9—Apply a vacuum for approximately 5 to 10 min. at approximately 13 to 67 kPa absolute pressure (10 to 26 in.Hg partial pressure). The time required for some specimens to achieve 70 and 80 percent may be less than 5 min. In addition, some specimens may require the use of an absolute pressure of greater than 67 kPa (26 in.Hg partial pressure) or less than 13 kPa (10 in.Hg partial pressure).

10.4.3. Remove the vacuum and leave the specimen submerged in water for approximately 5 to 10 min.

10.4.4. Damp-dry the specimen by blotting it with a damp towel, and determine the surface-dry mass (B') as quickly as possible (the entire operation is not to exceed 15 s). Any water that seeps from the specimen during the weighing operation is considered part of the saturated specimen. Each specimen shall be immersed and weighed individually.

Note 10—Terry cloth has been found to work well for an absorbent cloth. Damp is considered to be when no water can be wrung from the towel.

10.4.5. Calculate the volume of absorbed water (J') in cubic centimeters by use of the following equation:

$$J' = B' - A \tag{3}$$

where:

J' = volume of absorbed water, cm^3;

B' = mass of the saturated, surface-dry specimen after partial vacuum saturation, g; and

A = mass of the dry specimen in air, g (Section 9.3).

10.4.6. Determine the degree of saturation (S') by comparing the volume of absorbed water (J') with the volume of air voids (V_a) from Section 9.6 using the following equation:

$$S' = \frac{100J'}{V_a} \tag{4}$$

where:

S' = degree of saturation, percent.

10.4.7. If the degree of saturation is between 70 and 80 percent, proceed to Section 10.4.9.

10.4.8. If the degree of saturation is less than 70 percent, repeat the procedure beginning with Section 10.4.1 using more vacuum and/or time. If the degree of saturation is more than 80 percent, the specimen has been damaged and must be discarded. In this case, repeat the procedure on the next specimen beginning with Section 10.4.1 using less vacuum and/or time.

10.4.9. Cover each of the vacuum-saturated specimens tightly with a plastic film (Saran Wrap® brand or equivalent). Place each wrapped specimen in a plastic bag containing 10 ± 0. 5 mL of water and seal the bag. Place the plastic bags containing the specimens in a freezer at a temperature of −18 ± 3°C (0 ± 5°F) for a minimum of 16 h. Remove the specimens from the freezer.

10.4.10. Place the specimens in a bath containing potable water at 60 ± 1°C (140 ± 2°F) for 24 ± 1 h. The specimens should have a minimum of 25 mm (1 in.) of water above their surface. As soon as possible after placement in the water bath, remove the plastic bag and film from each specimen.

10.4.11. After 24 ± 1 h in the 60 ± 1°C (140 ± 2°F) water bath, remove the specimens and place them and the dry subset in a water bath at 25 ± 0.5°C (77 ± 1°F) for 2 h ± 10 min. The specimens should have a minimum of 25 mm (1 in.) of water above their surface. It may be necessary to add ice to the water bath to prevent the water temperature from rising above 25°C (77°F). Not more than 15 min should be required for the water bath to reach 25 ± 0.5°C (77 ± 1°F).

10.4.12. Remove the specimens from the water bath, and test them as described in Section 11.

11. TESTING

11.1. Determine the indirect-tensile strength of dry and conditioned specimens at 25 ± 0.5°C (77 ± 1°F).

11.1.1. Remove the specimen from 25 ± 0.5°C (77 ± 1°F) water bath, and determine the thickness (t') according to Section 9.1. Place it between the steel loading strips and then place the specimen and loading strips between the two bearing plates in the testing machine. Care must be taken so that the load will be applied along the diameter of the specimen. Apply the load to the specimen, by means of the constant rate of movement of the testing machine head, at 50 mm/min (2 in./min).

11.1.2. Record the maximum compressive strength noted on the testing machine, and continue loading until a vertical crack appears. Remove the specimen from the machine, and pull it apart at the crack. Inspect the interior surface for evidence of cracked or broken aggregate; visually estimate the approximate degree of moisture damage on a scale from "0" to "5" (with "5" being the most stripped), and record the observations in Table 1.

Table 1—Moisture Damage Laboratory Data Sheet (Nonmandatory Information)

Project

Additive Dosage

Compaction Method Effort

Date Tested By

Sample identification									
Diameter, mm (in.)	D								
Thickness, mm (in.)	t								
Dry mass in air, g	A								
SSD mass, g	B								
Mass in water, g	C								
Volume ($B - C$), cm^3	E								
Bulk specific gravity (A/E)	G_{mb}								
Maximum specific gravity	G_{mm}								
% air voids [$100(G_{mm} - G_{mb})/G_{mm}$]	P_a								
Volume of air voids ($P_aE/100$), cm^3	V_a								
Load, N (lbf)	P								
Saturated min @ kPa (psi) or mmHg (in.Hg)									
Thickness, mm (in.)	t'								
SSD mass, g	B'								
Volume of absorbed water ($B' - A$), cm^3	J'								
% saturation ($100J'/V_a$)	S'								
Load, N (lbf)	P'								
Dry strength [$2000P/\pi tD$ ($2P/\pi tD$)], kPa (psi)	S_1								
Wet strength [$2000P'/\pi t'D$ ($2P/\pi t'D$)], kPa (psi)	S_2								
Visual moisture damage (0 to 5 rating)									
Cracked/broken aggregate?									
TSR (S_2/S_1)									

12. CALCULATIONS

12.1. *Calculate the tensile strength as follows:*

SI units:

$$S_t = \frac{2000P}{\pi t D} \qquad (5)$$

where:

S_t = tensile strength, kPa;
P = maximum load, N;
t = specimen thickness, mm; and
D = specimen diameter, mm.

U.S. Customary units:

$$S_t = \frac{2P}{\pi t D} \qquad (6)$$

where:

S_t = tensile strength, psi;
P = maximum load, lbf;
t = specimen thickness, in.; and
D = specimen diameter, in.

12.2. Express the numerical index of resistance of asphalt mixtures to the detrimental effect of water as the ratio of the original strength that is retained after the moisture and freeze–thaw conditioning. Calculate the tensile strength ratio to two decimal places as follows:

$$\text{tensile strength ratio (TSR)} = \frac{S_2}{S_1} \qquad (7)$$

where:

S_1 = average tensile strength of the dry subset, kPa (psi); and
S_2 = average tensile strength of the conditioned subset, kPa (psi).

13. REPORT

13.1. *Report the following information:*

13.1.1. Number of specimens in each subset;

13.1.2. Average air voids of each subset;

13.1.3. Tensile strength of each specimen in each subset;

13.1.4. Tensile strength ratio;

13.1.5. Results of visually estimated moisture damage observed when the specimen fractures; and

13.1.6. Results of observations of cracked or broken aggregate.

14. KEYWORDS

14.1. Accelerated water conditioning; diametral tensile strength; freeze–thaw cycle; liquid antistripping additives; long-term stripping; portland cement; pulverulent solids; water saturation.

15. REFERENCE

15.1. ASTM D979/D979M, Standard Practice for Sampling Bituminous Paving Mixtures.

TENSILE STRENGTH RATIO (TSR)

1. Split out 8 samples using the formula on page 6-16 herein.

2. Gyrate the sample to 95±5 mm and allow the sample to cool and then determine % air voids.

3. Determine percent voids of the pilot bricks. Then determine the adjustment of the sample size needed to achieve 6.0%-8.0% voids in test samples. If necessary, gyrate a pilot brick to check sample size. Gyrate as many additional pilot bricks as needed.

4. Heat all remaining samples to 295° ± 5°F and compact with gyratory compactor to 95±5 mm.

5. Determine (p. 6-9) G_{mb}(d) and percent voids. Group bricks into 2 sets, 3 bricks in each set. Sets are to be grouped so that the average percent voids in Set 1 is about the same as Set 2. Leave all bricks in 25˚C bath.

6. Calculate weights for 70%-80% saturation of set to be conditioned.

7. Remove unconditioned set from 25˚C bath and place on rack until ready for Tensile Strength testing.

8, 9, and 10: Steps for saturation of conditioned set.

8. **Check SSD weights of conditioned set prior to vacuuming to ensure they are not already within saturation limits.**

9. Place set to be conditioned in vacuum chamber and begin saturation at predetermined magnitude and hold vacuum for 1 to 10 minutes. If saturation weight limits are not achieved, increase vacuum as needed until 70%-80% saturated weight is achieved.

10. Once 70%-80% of saturation is achieved, record final saturated weight. Remove the vacuum and leave the specimen submerged in water for a short time (approximately 1 to 10 minutes) to allow bricks to stabilize.

11. Place conditioned bricks in 140°F±1.8°F bath flat side down for 24 hours +/-1 hour. Record time bricks go into bath.

12. After 24 hours, +/-1 hour, both sets are placed in 77°F±1.8°F bath for 2 hours, +/- 10 minutes. Conditioned set recommended be placed flat side down. Unconditioned set can be placed on curved side.

13. After the 2 hours, +/- 10 minutes, temperature stabilization, run Tensile Strength test on both sets. Record your results.

14. Convert load readings into Tensile Strength kPa.

15. Compute TSR value and report results.

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FORMULAS FOR TSR

BULK SPECIFIC GRAVITY G_{mb} $= \frac{A}{B-C}$

A = Original Weight
B = Saturated Surface Dry Weight
C = Submerged Weight

VOLUME in cc = **B - C** if wt is in grams

% VOIDS = $[(G_{mm} - G_{mb}) / G_{mm}] \times 100$

VOIDS (cc) = (% Voids / 100) X Volume

WT. FOR 70% SATURATION = [Voids (cc) X .70] + Original Wt.

WT. FOR 80% SATURATION = [Voids (cc) X .80) + Original Wt.

FINAL % SATURATION = [(Final Sat. Wt. - Orig. Wt.) / (Voids (cc)] X 100

SPLIT TENSILE STRENGTH (St) = (2,000,000 X P) / (t X D X 3.1416)

WHERE: **St** = Split tensile strength, kPa (psi)
P = maximum load, kilonewtons (lbs.)
t = Specimen thickness, mm (in.)
D = Specimen diameter, mm (in.) (150 mm)

TSR = Average “St” of Conditioned / Average “St” of Unconditioned

NOTE: Determination of Need for Anti-Stripping Additive. The Department will determine during mixture design if an additive is needed in the mix to prevent stripping. The determination will be made on the basis of tests made in accordance with the Department’s accepted methods and procedures. To be considered acceptable by the Department as a mixture not susceptible to stripping, the ratio of conditioned to unconditional split tensile strengths (TSR) shall be equal to or greater than 0.85. Mixtures, with or without an additive, with TSR’s less than 0.85 will be considered unacceptable.

NOTES:

Read load to the nearest 0.05 kN.

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STRIPPING TEST WORKSHEET

LAB # :		DESIGN LAB:		INSPECTOR:	
MIX #:		MATL. CODE:		DATE:	

MATL. CODE	MATL. NAME	SOURCE NO.	BLEND

SPECIMEN #			1	2	3	4	5	6
THICKNESS	t		OBTAIN & MEASURE TO THE NEAREST WHOLE mm OR 1/16 “					
ORIG. WT.	A		OBTAIN					
SSD WT.	B		OBTAIN					
SUB WT.	C		OBTAIN					
VOLUME			CALCULATION (B-C) =**VOLUME**					
Gmb			CALCULATION (A/ VOLUME) = Gmb					
% VOIDS			CALCULATION - 1 [(((Gmb/ Gmm)*100)-100) = % VOIDS					
VOIDS (CC)			CALCULATION (((%VOIDS /100)* VOLUME)) =VOIDS (CC)					
Gmm		OBTAIN						
				AVG SP. GR.:	CALC.		AVG. % VOIDS:	CALC.

SPECIMEN # UNCONDITIONED	DETERMINED BY GROUPING			
SPECIMEN # CONDITIONED	DETERMINED BY GROUPING			
WEIGHT FOR 70% SATURATION	CALC. ((VOIDS (CC) *0.70) + A)))			
WEIGHT FOR 80% SATURATION	CALC. ((VOIDS (CC) *0.80) + A)))			
FINAL SATURATION WEIGHT	OBTAIN			AVG. SAT.
FINAL % SATURATION	CALC. **(SEE NOTE #1)**			CALC.

	CONDITIONED		UNCONDITIONED
SPEC # (S)	DETERMINED BY GROUPING		DETERMINED BY GROUPING
LOAD (kN)	OBTAIN FROM GRAPHS (ROUND TO THE NEAREST 0.05)		
TENS. STR. (kPa)	((2,000,000 *P) / (t * D * 3.1416)) = TENS. STR. kPa		

CONDITIONED		UNCONDITIONED	
AVG. TENS. STR.	**SEE NOTE #2**	AVG. TEN. STR.	**SEE NOTE #3**
TENSILE STRENGTH RATIO	**SEE NOTE #4**	# BLOWS	OBTAIN

NOTE #1: [(((FINAL SAT. WT. –A) / VOIDS (CC)) *100)] = FINAL % SATURATION
NOTE #2: AVERAGE OF THE 3 CONDITIONED TENSILE STRENGTHS
NOTE #3: AVERAGE OF THE 3 UNCONDITIONED TENSILE STRENGTHS
NOTE #4: (CONDITIONED AVERAGE / UNCONDITIONED AVERAGE) TO THE NEAREST 0.01

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STRIPPING TEST WORKSHEET

LAB # :
MIX #:
DESIGN LAB:
MATL. CODE:
INSPECTOR:
DATE:

MATL. CODE	MATL. NAME	SOURCE NO.	BLEND

SPECIMEN #	⇨	1	2	3	4	5	6
THICKNESS	t						
ORIG. WT.	A						
SSD WT.	B						
SUB WT.	C						
VOLUME	⇨						
Gmb	⇨						
% VOIDS	⇨						
VOIDS (CC)	⇨						
Gmm							

AVG SP GR.:
AVG. % VOIDS:

SPECIMEN # UNCONDITIONED				
SPECIMEN # CONDITIONED				
WEIGHT FOR 70% SATURATION				
WEIGHT FOR 80% SATURATION				
FINAL SATURATION WEIGHT				AVG. SAT.
FINAL % SATURATION				

	CONDITIONED			UNCONDITIONED		
SPEC # (S)						
LOAD (kN)						
TENS. STR. (kPa)						

CONDITIONED		UNCONDITIONED	
AVG. TENS. STR.		AVG. TENS. STR.	
TENSILE STRENGTH RATIO		# BLOWS	

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CONTROL CHARTS & CALCULATIONS

DEFINITIONS

Control Charts: A visual representation of test results, observations, or measurements arranged in an orderly sequence in respect to time. Control charts provide the means of measuring the effectiveness of process control, detecting lack of control, and directing a course of action to restore control.

Control Limits: Mathematical limits placed on controlled properties, which when exceeded initiate action, by those responsible for process control, and/or acceptance of hot-mix asphalt. These limits may be arbitrary, i.e. established on the basis of previous experience, or by purely statistical means.

Random Samples: Samples selected within unit of material or time interval in such a manner that each element of material is given an equal chance of being selected for testing or measurement. Random samples thus are based on chance rather than purpose.

Initial Daily Plant Samples: Samples obtained between the first half-hour to one and one half-hour (l/2 to l l/2 hour) of the daily production of a particular mixture.

Check Samples: The opposite of random samples. Samples located within a unit of time or material for a specific purpose. This may be to verify an observation or conclusion, such as a retest or as a means of confirmation of corrective action. Such samples are permitted under certain circumstances. Their non-random nature should always be recognized in data analysis.

Test Frequency: The number of tests, measurements, or observations which are obtained within a specified interval of time or unit of material.

Average: The sum of a series of test results or measurements divided by the number of values or measurements included in the sum. Also known as the arithmetic mean (calculator key symbol x).

"Moving" Average: The average of (n) consecutive values obtained over elapsed time and/or units(s). Such values always represent the most recently obtained test results or measurements within the prescribed group of observations (n).

"Trend": A period in time when two or more moving average points move away from the target value in either direction (±), thus producing a steep angled line. Three points shall define a trend for a line with a gradual angle.

CHECK SAMPLE

A technician wishes to obtain a sample other than the required samples. His purpose is to assure that the plant is operating properly. This is a check test, as he suspects that a problem might exist that will require correction. It is certainly permissible, yet the results should be identified as (NR), e.g. "Non-Random". It should not replace either of the required plant samples.

CALCULATING AVERAGES (x)

EXAMPLE:

A technician obtains n=4 consecutive test values of Air Voids: 5.l, 3.2, l.7, 3.0

What is the Average (x)?

Solution: The sum of the values is l3.0. The number of values,
n=4. The average is l3 ÷ 4 = 3.3

"MOVING" AVERAGE CALCULATION

EXAMPLE:

The specifications require moving averages of 4. A technician obtains n=8 consecutive Air Void test values: 5.l, 3.2, l.7, 3.0, 3.l, 2.0, 3.l, 4.2.

What is the moving average after the 4th, 6th, and 8th test?

Solution: The sum of the first four values is l3.0 The moving
average (x) is l3.0 ÷ 4 = 3.3

The sum of values #3, #4, #5, #6, is 9.8 The moving
average thus is 9.8 ÷ 4 = 2.5

The sum of values #5, #6, #7, #8 is l2.4. The moving
average thus is l2.4 ÷ 4 = 3.l

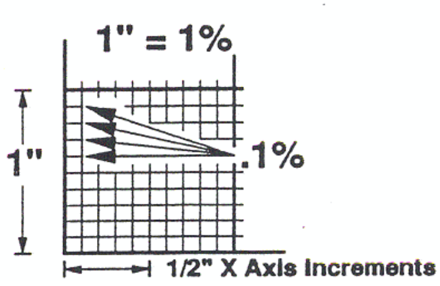
You will note that the moving average always includes consecutive numbers most immediately preceding the value of interest.

LEGEND

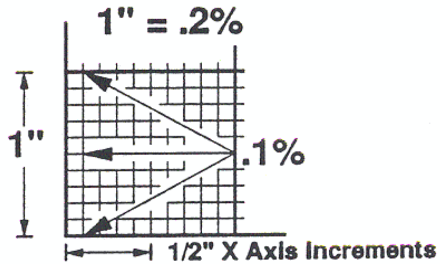
○	INDIVIDUAL TEST
□	MOVING AVERAGE
▲	STATE SPLIT TEST (WASHED GRADATIONS)
△	STATE SPLIT INDIVIDUAL TEST
●	WASHED SAMPLE
(○- - -○)	RESAMPLE – (RS) 1/6 004-01
●—	INDIVIDUAL TEST LIMITS
■—	MOVING AVERAGE TEST LIMITS
——	TARGET FROM JOB MIX FORMULA

Examples of Scales for Control Charts

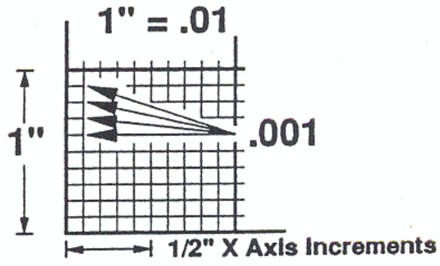
Air Voids, Field VMA, Minus No. 200, Field Density



Asphalt Binder Content



Gravities (Bulk or Max. Theoretical)



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Hot-Mix Asphalt QC/QA Control Charts
Appendix B.8

Effective: May 1, 1993
Revised: December 1, 2021

A. Scope

1. All required Contractor test results, including resample tests, listed in Article 1030.09 shall be plotted on Control Charts. (No check tests shall be plotted on these Control Charts.)

2. Control Charts shall be maintained by the Contractor in the field laboratory. Contractor test results shall be recorded within 24 hours of sampling. The Engineer shall be provided access to the Control Charts at all times.

3. Rounded values shall follow the document “Hot-Mix Asphalt Rounding Test Values”.

B. General Procedures

1. Control Charts shall be computer generated (10 divisions per 1 in. [25 mm]). The vertical scale used shall conform to the following requirements in respect to the rounded values of:

    Gradation - 1% per 2.5 divisions (1 in. [25 mm] = 4.0%).

    Air Voids, Field VMA, Minus No. 200 (75-µm), Field Density - 0.1% per division (1 in. [25 mm] = 1.0%).

    Asphalt Binder Content — 0.1% per 5 divisions (1 in. [25 mm] = 0.2%).

    Specific Gravity (Bulk or Maximum Theoretical) - 0.001 per division (1 in. [25 mm] = 0.01).

2. The horizontal scale shall be arranged such that each randomly selected test value obtained is plotted at ½ in. (12.5-mm) intervals.

    Note. When the QMP Package is used to generate Control Charts, 8.5” X 11.0” page format shall be used to produce the required divisions per 1 in.

Illinois Department of Transportation

Hot-Mix Asphalt QC/QA Control Charts
Appendix B.8
Effective: May 1, 1993
Revised: December 1, 2021

C. Symbols and Control Limits

1. Individual test values shall be represented on Control Charts by open circles centered on the correct test value except that washed extraction gradations shall be denoted by a solid circle. Moving average values shall be represented by open squares centered on the correct value. State assurance test values shall be represented by solid triangles for washed extraction gradations and by open triangles for dry gradations. All symbols shall be 0.1 in. (2.5 mm) in their largest dimension.

2. Individual test values shall be connected by dashed lines. Moving average data points shall be connected by solid lines.

3. Target values shall be represented on Control Charts by horizontal solid lines. Appropriate control limits (solid lines) for each control parameter shall extend horizontally across the chart and be identified with an appropriate solid symbol corresponding to the type of test it represents, i.e., individual or moving average.

D. Individual Test Values and Moving Average

1. Moving averages are applicable to all values. The moving average is the average of four consecutive test values and is determined by starting with the fourth test value and averaging it with the three preceding test values. Plotting the average thereafter will be done in a similar manner starting with the test value just completed. Rounding procedures for the moving average are the same as used for the individual test values.

   The moving average for minus No. 200 (75 µm) for HMA production control shall include both washed extraction gradation and adjusted dry gradation individual results. When a given sublot includes both washed extraction and dry gradation test results for the minus No. 200 (75 µm), only the washed extraction gradation shall be used in the moving average.

   The moving average for G_{mm} of a new mixture shall be established initially with the results from the first plant sample and shall include more tests in the moving average as they occur until the moving average of four is established. Unless otherwise specified by the Engineer, the moving average for G_{mm} of a previously placed mixture shall begin with the most recent moving average of four and shall be averaged with subsequent test results.

2. At the bottom of the chart under the line on which the individual test data is plotted, the following information shall be listed:

    a. Date and specific time (include a.m. or p.m.) of sampling.

    b. Lot Number.

    c. Test Sequence.

    d. Quantity of material represented (produced since previous test).

    e. Initials of person performing the test.

    f. Use "(rs)" to denote resample.

E. Test Strip Values

1. Test values obtained from a test strip shall be placed at the beginning of the Control Charts. Once all these tests have been completed and their values recorded, two vertical double black lines shall be drawn on the graph ½ in. (12.5 mm) apart.

2. After completion of an acceptable test strip, production under QC/QA shall be initiated with the agreed upon targets and appropriate limits being placed on the graph. Individual required QC plant test results shall be recorded from this point on with a moving average being established at the completion of the fourth test.

F. Adjusting Targets

1. If the adjustments in gradation or asphalt binder content are required in order to maintain proper voids, they shall be made according to Article 1030.10 and shall be appropriately documented on the Control Charts.

2. When an adjustment to the Target value is made, two vertical double black lines shall be drawn on the graph ½ in. (12.5 mm) apart. The new target value plus upper and lower control values will be placed on the chart. The moving average will continue as though the adjustment had not taken place.

Illinois Department of Transportation

Hot-Mix Asphalt QC/QA Control Charts
Appendix B.8

Effective: May 1, 1993
Revised: December 1, 2021

G. Resample Test Values

The Contractor resample tests shall be denoted by a circle (closed for washed gradations and open for all other tests) with its value placed on the vertical line, which corresponds to the time or lot from which the resample was taken. A circle shall be drawn around a failed test value and the corresponding resample test value. Both the failed test value and the resample test value shall be used as individual points in determining moving averages.

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Hot-Mix Asphalt Rounding Test Values
Appendix B.28

Effective Date: December 1, 2021

A. Scope

The intent of rounding is to limit the number of digits in an observed or calculated value to those considered significant for the purpose of determining conformance with specification limits.

If improperly applied, rounding may contribute to loss of precision and result in increased risk to either the Department or Contractor.

B. Rounding Test Values

The following are the appropriate significant digits to which test values are to be rounded for parameters described in the Section 1030:

Test	Significant Digits
Gradation (% Passing);	Nearest whole percent (1%)
Field Density; Air Voids; Field VMA; Minus No. 200 (75-µm); Asphalt Binder Content	Nearest one-tenth percent (0.1%)
Bulk Specific Gravity, G_{mb}; Maximum Specific Gravity, G_{mm}	Nearest one-thousandth (0.001)

Rounding of test results shall be according to the document Illinois Modified ASTM E 29, "Using Significant Digits in Test Data to Determine Conformance with Specifications".

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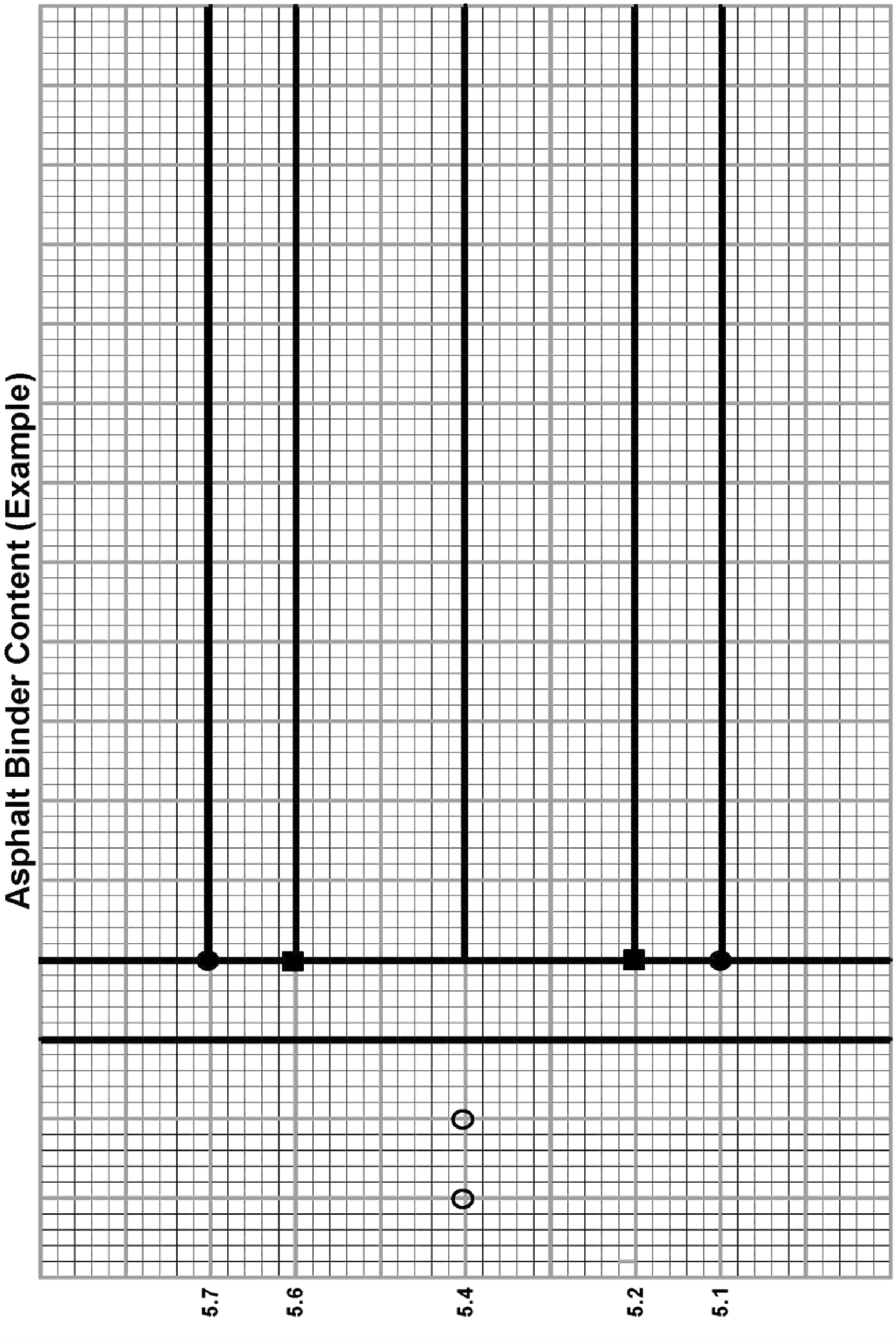
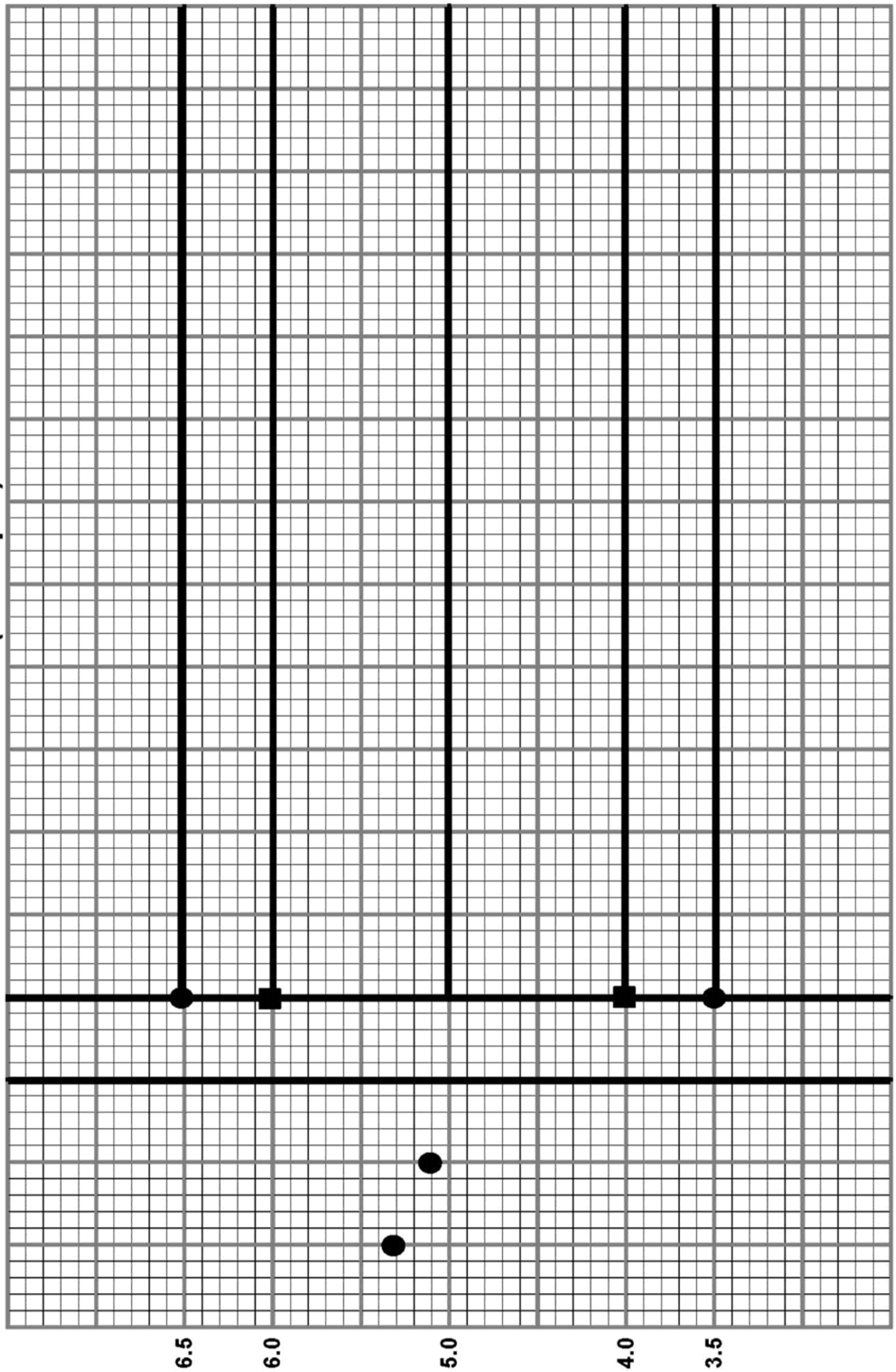


Asphalt Binder Content (Example)

PROBLEMS ASSOCIATED WITH MIX ASPHALT BINDER CONTENT

-#200 SIEVE (Example)



PROBLEMS ASSOCIATED WITH MIX
-200 SIEVE (-75 MICRON)

Chapter 4
Homework

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HOT-MIX ASPHALT QC/QA
RANDOM DENSITY LOCATIONS
HOMEWORK PROBLEM

With the given information below calculate the random density test site locations.

Problem: The contractor is paving a distance of 3.2 miles today at a thickness of 2.5 inches. The beginning station number is 16+32. Determine at what frequency the contractor will take random tests and calculate the stations for the required tests. Refer to class problem on page 4-47 thru 4-49 for an example on how to layout problem. Use the backside of this sheet to work the problem.

Use the random numbers table found below and use the pattern shown to you.

0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.876	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.777	0.491	0.523	0.665	0.919	0.146
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.281	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.454	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.659	0.463	0.994	0.307	0.631	0.422
0.116	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939
0.636	0.195	0.614	0.486	0.629	0.663	0.619	0.007	0.296	0.456
0.630	0.673	0.665	0.666	0.399	0.592	0.441	0.649	0.270	0.612
0.804	0.112	0.331	0.606	0.551	0.928	0.830	0.841	0.702	0.183
0.360	0.193	0.181	0.399	0.564	0.772	0.890	0.062	0.919	0.875
0.183	0.651	0.157	0.150	0.800	0.875	0.205	0.446	0.648	0.685

Start with random number 0.685 and continue to the left.

Random Density Locations
Homework Problem
Worksheet

Instructions for Nuclear Density Field Problem

- **Part 1(Page HW-7)**

  Calculate average nuclear density field readings and copy results to field density form on page HW-9.

- **Part 2 (Page HW-9)**

  Use the given information below, along with the needed job data information and average nuclear readings from HW-7 to complete as much of the form on HW-9, as possible. (Directions for filling out the form are located in Chapter 4 on pages 4-17 thru 4-23.) Use the first determined station location from the Random Density Location problem found on page HW-3.

GIVEN: **Maelynn Smith works as a Nuclear Density Tester for the contractor Asphalt by Day (916-03). The standard count ran on the gauge was 2118, which was completed the same day as the field testing. The gauge was calibrated on January 15, 2023. Use the job stamp information found on the core correlation worksheet. Testing took place on the first lift of surface mixture on the southbound driving lane of IL 32. Maelynn took her first required density test for the 15th day of production. The QC Manager for this project is Aaron Thompson who also works for Asphalt by Day.**

This Page Is Reserved

Job Data

DATE: 06/26/2023
CONTRACT: 74226
JOB #: C9701423
ROUTE: IL 32
COUNTY: Moultrie
SECTION: (1,2) RS-3
BASE MATERIAL: Milled Surface
MIX #: 87BIT1023
MIX CODE: 19523
USE: Surface

Gauge #	**28769**
Layer Thickness	**2.5”**
Gmm	**2.444**
m=	**1.026**
b=	**-117.9**
Lift Number:	**.1**

Gauge No.	**28769**

Field Worksheet

STATION: ____________

1)	**2341**				
2)	**2379**				
3)	**2390**				
4)	**2365**				
5)	**2335**				

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Illinois Department of Transportation

Quality Assurance
Nuclear Density Report QC/QA

I.D. No. ____________

Inspector No. ____________ Date Sampled ____________ Seq. No. ____________ County ____________

Bit Mix Plant ____________ Bit Mix Code ____________ Equip. ____________ QA Y Section ____________

Contract No. ____________ Job No. ____________ Target Dens. ____________ Route ____________

Respons. Loc. ____________ Lab ________ Standard Count ____________ Project ____________

Start Date ____________ Complete Date ____________

Gauge # ____________ Calib. Date ____________

Mode ____________ Probe Depth ____________

Correlation Data

M= ____________

B= ____________

	Date Laid	Station	Ref	Lift No. (Thick)	Lit d (Gmb)	Big D (Gmm)	% Den	Result	Type Insp	Den Kg/m^3	Lot
1											
2											
3											
4											
5											

REMARKS

1 ____________

2 ____________

3 ____________

4 ____________

5 ____________

Test No.	1			2			3			4			5		
Offset	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3
Average															

CC: ____________ Tester ____________ Agency ____________

____________ Inspector ____________ Agency ____________

MISTIC INPUT
Date Entered ____________
Initials ____________

'FOR DTY03303'

Printed 11/30/2011

BMPR MI303N (Rev. 07/02/09)
Formerly MI 303N

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Chapter 5 Homework

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Homework
Calculating Asphalt Correction Factor and Corrected Asphalt Binder for a Test Sample

Calculate the average asphalt correction factor with the information given below:

Sample	**#1**	**#2**
Known Percent Asphalt (AB)	4.8 (Mix Design Asphalt)	4.8 (Mix Design Asphalt)
Sample and Basket	8563 g	8588 g
Basket Weight	7025 g	7032 g
Sample Weight	_____ g	_____ g
Weight Loss	79 g	82 g
Temperature Compensation	0.07	0.09
Percent Loss		
Correction Factor		
Average Correction Factor		

With the given information below and the average asphalt correction factor you calculated above, calculate the corrected asphalt binder for this production test sample.

Given Information:

Wb = 1418 g
Wa = 1341g
Cf = average correction factor from example above.
Mc = 0.08
Temp. Comp. = 0.12

Corrected AB = _________%

This Page Is Reserved

Chapter 9
Homework

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STRIPPING TEST WORKSHEET

LAB # :		DESIGN LAB:		INSPECTOR:	
MIX #:		MATL. CODE:		DATE:	

MATL. CODE	MATL. NAME	SOURCE NO.	BLEND

SPECIMEN #	→	1	2	3	4	5	6
THICKNESS	t	95	95	95	95	95	95
ORIG. WT.	A	3806.3	3802.1	3808.5	3807.0	3809.0	3791.6
SSD WT.	B	3820.4	3820.0	3825.8	3826.8	3827.4	3810.1
SUB WT.	C	2170.1	2165.8	2177.4	2181.9	2181.6	2155.9
VOLUME	→						
Gmb	→						
% VOIDS	→						
VOIDS (CC)	→						
Gmm	2.474						
			AVG SP. GR:			AVG. % VOIDS:	

SPECIMEN # UNCONDITIONED	1	2	3	
SPECIMEN # CONDITIONED	4	5	6	
WEIGHT FOR 70% SATURATION				
WEIGHT FOR 80% SATURATION				
FINAL SATURATION WEIGHT	3884.8	3887.8	3884.6	AVG. SAT.
FINAL % SATURATION				

	CONDITIONED			UNCONDITIONED		
SPEC # (S)	4	5	6	1	2	3
LOAD (kN)	12.40	12.50	12.05	13.10	12.85	13.20
TENS. STRENGTH(kPa)						

CONDITIONED		UNCONDITIONED	
AVG. TENS. STRENGTH		AVG. TEN. STRENGTH	
TESILE STRENGTH RATIO			

QCST2.DOC

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Chapter 10 Homework

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HOMEWORK PROBLEM
SETTING UP A CONTROL CHART FOR #200 SIEVE MATERIAL HOT BIN /COMBINED BELT & IGNITION OVEN BURNS

The objective of this exercise is to familiarize the student with setting up and plotting Control Charts.

1. The Adjusted Job Mix Formula (AJMF) for the #200 sieve has been established at 4.5

2. Make a Control Chart for this #200 sieve.
   A. Plot the information listed below. Calculate and plot the moving average.
   B. Indicate where corrective action should be taken as defined by Specifications.
   C. Explain the corrective action.

3. Use the information in the “Hot-Mix Asphalt QC/QA Control Charts/Rounding Test Values” and “Specifications for Hot-Mix Asphalt” which are found in this manual.

Date	Time	Mixture Laid (Tons)	Washed Ignition Burn (%)	State Sample Results (%)	Re-Sample (%)	Lot Number	Test Sequence Number
9-01-23	8:30 a	250	4.8	-	-	000-01	
“	11:30 a	450	4.5	-	-	000-02	
9-04-23	6:30 a	300	4.8	-	-	001-01	1
“	11:15 a	1800	4.8	-	-	001-01	2
9-05-23	7:00 a	350	5.3	-	-	002-01	1
“	11:40 a	1600	6.2	-	-	002-01	2
“	2:15 p	2000	-	-	6.0	002-01	2R1
9-06-23	7:30 a	200	3.7	-	-	003-01	1
“	12:30 p	1700	4.0	3.8	-	003-01	2
9-07-23	7:00 a	300	2.7	-	-		
“	1:00 p	1900	-	-	4.4		
“	3:30 p	2300	4.1	-	-		
9-08-23	6:30 a	450	4.0	-	-		
“	1:15 p	1900	3.7	6.0	-		
9-11-23	6:40 a	150	3.0	-	-		
“	11:05 a	1500	3.5	-	-		
9-12-23	7:10 a	250	3.1	-	-		
“	1:25 p	1400	3.1	-	-		
9-13-23	6:50 a	300	4.7	4.5	-		
“	1:10 p	1575	4.7	-	-		
9-14-23	7:20 a	275	4.6	-	-		
9-15-23	7:50a	150	4.2	-	-		

HMA I Homework

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Chapter 4
Homework Solutions

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HOT-MIX ASPHALT QC/QA
RANDOM DENSITY LOCATIONS
HOMEWORK PROBLEM

With the given information below calculate the random density test site locations.

Problem: The contractor is paving a distance of 3.2 miles today at a thickness of 2.5 inches. The beginning station number is 16+32. Determine at what frequency the contractor will take random tests and calculate the stations for the required tests.

Use the random numbers table found below and use the pattern shown to you.

0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.876	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.777	0.491	0.523	0.665	0.919	0.146
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.281	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.454	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.659	0.463	0.994	0.307	0.631	0.422
0.116	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939
0.636	0.195	0.614	0.486	0.629	0.663	0.619	0.007	0.296	0.456
0.630	0.673	0.665	0.666	0.399	0.592	0.441	0.649	0.270	0.612
0.804	0.112	0.331	0.606	0.551	0.928	0.830	0.841	0.702	0.183
0.360	0.193	0.181	0.399	0.564	0.772	0.890	0.062	0.919	0.875
0.183	0.651	0.157	0.150	0.800	0.875	0.205	0.446	0.648	0.685

Start with random number 0.685 and continue to the left.

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CHAPTER 10
HOMEWORK SOLUTION

1) 3.2 miles x 5280 ft/mi = 16,896 ft.

2) Pavement 2.5 inches so technician will take a test every 2,640 ft.

3) 16,896 total feet ÷ 2,640 ft = 6.4 tests

4) 6 full length tests and 1 partial length

5) Partial test length is calculated by taking 0.4 X 2,640 = 1,056 ft.

6) 7 total tests

7) Beginning and ending station of each lot below, as well as, the station location for each test site.

Lot #	**1**		**2**		**3**		**4**		**5**		**6**		**7**	
Length	**2640**		**2640**		**2640**		**2640**		**2640**		**2640**		**1056**	
Beg. Sta.	16+32	to	42+72	to	69+12	to	95+52	to	121+92	to	148+32	to	174+72	to
End. Sta.	42+72		69+12		95+52		121+92		148+32		174+72		185+28	

Lot #	Length	x	Ran. No#	Distance Into Lot		**Station Location**
1	2640	x	0.685	1808	ft.	**34+40**
2	2640	x	0.648	1711	ft.	**59+83**
3	2640	x	0.446	1177	ft.	**80+89**
4	2640	x	0.205	541	ft.	**100+93**
5	2640	x	0.875	2310	ft.	**145+02**
6	2640	x	0.800	2112	ft.	**169+44**
7	1056	x	0.150	158	ft.	**176+30**

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Illinois Department of Transportation

Quality Assurance
Nuclear Density Report QC/QA

I.D. No. -------------------------

Inspector No. **970000000** Date Sampled **062623** Seq. No. **015** County **Moultrie**

Bit Mix Plant **916-03** Bit Mix Code **19523** Equip. **A** QA Y Section **(1,2) RS-3**

Contract No. **74226** Job No. **C9701423** Target Dens. **2261** Route **IL 32**

Responsible Loc. **97** Lab **PC** Standard Count **2118** Project **0**

Start Date **---------------** Complete Date **--------------**

Correlation Data

Gauge # **28769** Calib. Date **011523** M = **1.026**

Mode **BS** Probe Depth **0** B = **-117.9**

	Date Laid	Station	Ref	Lift No. (Thick)	G_{mb} (Lit d)	G_{mm} (Big D)	% Den	Result	Type Insp	Den kg/m^3	Lot
1	**062623**	**34+40**	**SBD**	**.1**	**2.306**	**2.444**	**94.4**	**APPR**	**PRO**	**2305.5**	**015-01**
2											
3											
4											
5											

REMARKS:

1

2

3

4

5

Test No.	1			2			3			4			5		
	34+40														
Offset	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3
			2341												
			2379												
			2390												
			2365												
			2335												
Average			**2362**												

CC: **DE** Tester **Maelynn Smith/** Maelynn Smith Agency **Asphalt by Day**

RE Inspector **Aaron Thompson/** Aaron Thompson Agency **Asphalt by Day**

Contractor

MISTIC INPUT
Date Entered
Initials

/FOR DTY0303N
MI 303N QC/QA

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Chapter 5
Homework Solutions

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Homework
Calculating Asphalt Correction Factor and Corrected Asphalt Binder for a Test Sample

Calculate the average asphalt correction factor with the information given below:

Sample	**#1**	**#2**
Known Percent Asphalt (AB)	4.8 (Mix Design Asphalt)	4.8 (Mix Design Asphalt)
Sample and Basket	8563 g	8588 g
Basket Weight	7025 g	7032 g
Sample Weight	1538g	1556 g
Weight Loss	79 g	82 g
Temperature Compensation	0.07	0.09
Percent Loss	**5.07**	**5.18**
Correction Factor	**0.27**	**0.38**
Average Correction Factor	**0.33**	

With the given information below and the average asphalt correction factor you calculated above, calculate the corrected asphalt binder for this production test sample.

Given Information:

Wb = 1418 g
Wa = 1341g
Cf = average correction factor from example above.
Mc = 0.08
Temp. Comp. = 0.12

Corrected % AB = 4.9

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Chapter 9
Homework Solutions

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STRIPPING TEST WORKSHEET

LAB # :		DESIGN LAB:		INSPECTOR:	
MIX #:		MATL. CODE:		DATE:	

MATL. CODE	MATL. NAME	SOURCE NO.	BLEND

SPECIMEN #	→	1	2	3	4	5	6
THICKNESS	t	95	95	95	95	95	95
ORIG. WT.	A	3806.3	3802.1	3808.5	3807.0	3809.0	3791.6
SSD WT.	B	3820.4	3820.0	3825.8	3826.8	3827.4	3810.1
SUB WT.	C	2170.1	2165.8	2177.4	2181.9	2181.6	2155.9
VOLUME	→	1650.3	1654.2	1648.4	1644.9	1645.8	1654.2
Gmb	→	2.306	2.298	2.310	2.314	2.314	2.292
% VOIDS	→	6.8	7.1	6.6	6.5	6.5	7.4
VOIDS (CC)	→	112.2	117.4	108.8	106.9	107.0	122.4
Gmm	2.474						
			AVG SP GR.:	2.306		AVG. % VOIDS:	6.8

SPECIMEN # UNCONDITIONED	1	2	3	
SPECIMEN # CONDITIONED	4	5	6	
WEIGHT FOR 70% SATURATION	3881.8	3883.9	3877.3	
WEIGHT FOR 80% SATURATION	3892.5	3894.6	3889.5	
FINAL SATURATION WEIGHT	3884.8	3887.8	3884.6	AVG. SAT.
FINAL % SATURATION	72.8	73.6	76.0	74.1

	CONDITIONED			UNCONDITIONED		
SPEC # (S)	4	5	6	1	2	3
LOAD (kN)	12.40	12.50	12.05	13.10	12.85	13.20
TENS. STRENGTH(kPa)	554.0	558.4	538.3	585.2	574.1	589.7

CONDITIONED		UNCONDITIONED	
AVG. TENS. STRENGTH	550.2	AVG. TEN. STRENGTH	583.0
TESILE STRENGTH RATIO	0.94		

QCST2.DOC

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Chapter 10
Homework Solutions

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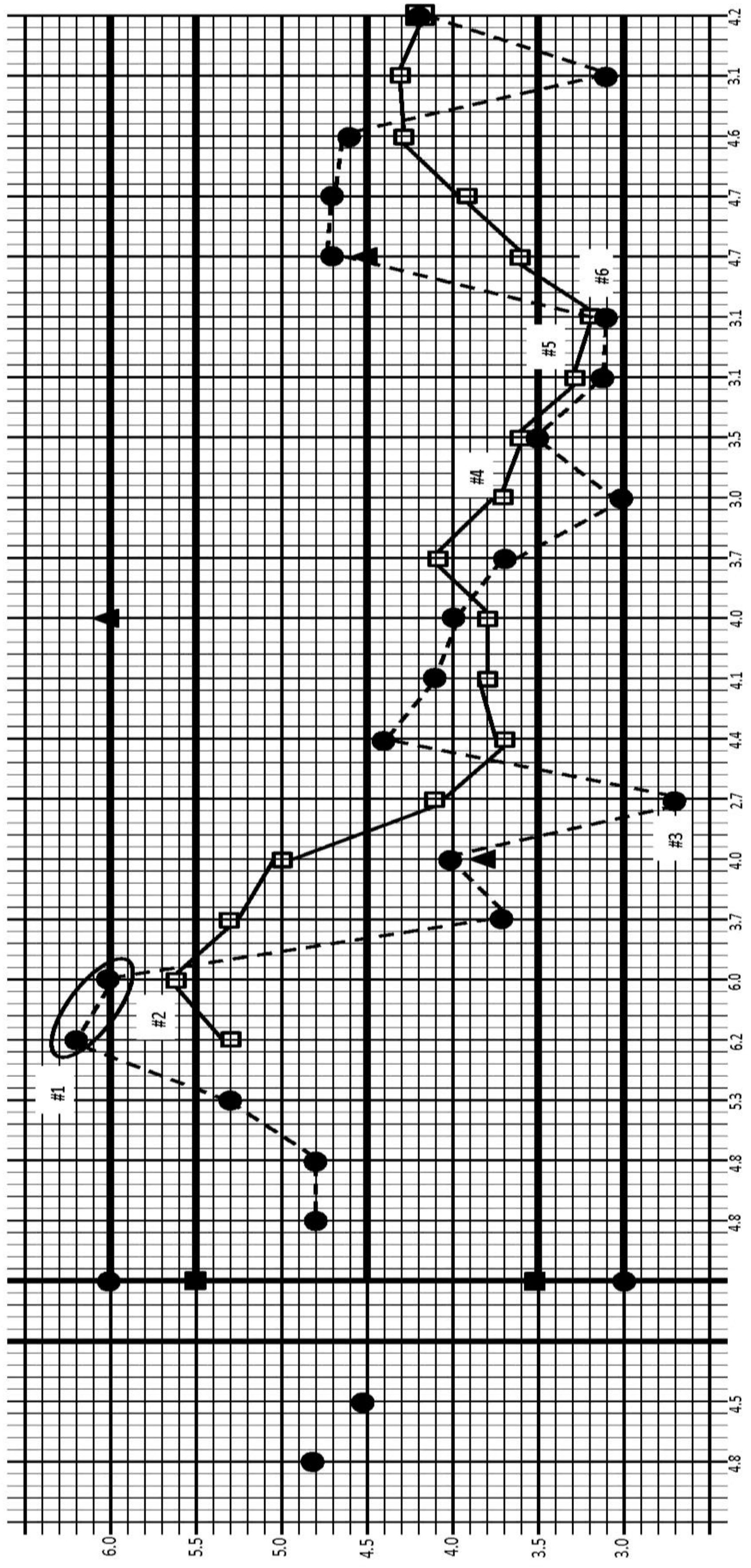

#1 & #3 - Individual test is outside control limits (Resample and Retest)

#2 & #5 - Moving Average Exceeds Limits (Notify the Engineer)

#4 - Trend with three points creating a gradual angle (Contractor shall take corrective action and increase the sampling and testing frequency.)

#6 - Second consecutive Moving Average has exceeded the moving average limits. (Contractor must cease operations. Corrective action ashall be immediately instituted by the Contractor. Mixture production shall not be reinstated with the approval of the Engineer.)

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APPENDICES TABLE OF CONTENTS

PAGE

PAGE

MTP = Manual of Test Procedures for Materials

Illinois Department of Transportation

Hot-Mix Asphalt Laboratory Equipment
Appendix D.4

Effective: April 1, 1997
Revised: December 1, 2021

This document summarizes the minimum requirements for Hot-Mix Asphalt (HMA) quality control (QC), quality assurance (QA), and design laboratories. It is the Contractor's or Consultant's responsibility to ensure that all equipment complies with the applicable test specifications in the *Manual of Test Procedures for Materials*.

1. Quality Control Laboratory and Equipment

    A. QC laboratories shall be 600 sq ft (55 sq m) or greater in size and be located at the mix production site. The laboratory shall have running water and controlled heating and air conditioning capable of maintaining a temperature between 68 – 86 °F (20 - 30 °C). The laboratory shall be properly maintained and contain the necessary equipment and supplies for performing the Quality Control testing. All testing shall be performed at the QC laboratory. All hazardous chemicals shall be properly stored and labeled to meet the associated regulations and standards.

    B. Quality Control Equipment

        1. Balance (1): As defined by Illinois Specification 101 Minimum Requirements for Electronic Balances. Balances used for Illinois Modified AASHTO T 166, Illinois modified AASHTO T 209 (weight in water method), and Illinois Modified AASHTO T 85 shall also include the following:

            a. Suspension apparatus for weighing in water.

            b. Wire or monofilament line, of smallest practical diameter, between the scale and water.

        2. Mixture Bulk Specific Gravity (G_{mb}) Water Bath (1): A water bath as defined by Illinois Modified AASHTO T 166 for immersing the specimen in water while suspended under the weighing device.

        3. Mixture Theoretical Maximum Specific Gravity (G_{mm}) Water Bath (1): A water bath as defined by Illinois Modified AASHTO T 209 for maintaining a constant water temperature, with the following additional requirements:

            a. Commercial grade, built specifically for laboratory use.

            b. Capable of maintaining 77 ± 1.8 °F (25 ± 1 °C).

            c. Sufficient depth to immerse the pycnometer pot and capillary lid.

            d. Having a perforated false bottom or equipped with a shelf at least 2 in. (50 mm) above the bottom of the bath.

        4. Saw or Freezer (1):

Illinois Department of Transportation

Hot-Mix Asphalt Laboratory Equipment
Appendix D.4

(continued)
Effective: April 1, 1997
Revised: December 1, 2021

   a. A saw capable of producing an undamaged specimen.

   b. Or a freezer capable of storing twenty-five 4 in. (100 mm) cores.

5. Metal Pot Pycnometer (2):

   a. Capable of containing a minimum sample weight of 1200 g, which will be completely submerged.

   b. Capillary lid.

   c. Small piece of fine wire mesh over the vacuum hose opening.

6. Manometer (1):

   a. Vacuum gauge or manometer capable of measuring residual pressure down to 30 mm of Hg or less (preferably zero). (Residual pressure is the pressure remaining in a container after a vacuum (negative pressure) is applied. The residual pressure is based on and measured with an absolute manometer.) The manometer or vacuum gauge shall be positioned at the end of the vacuum line and mounted according to the manufacturer’s instructions.

7. Ovens (2) (Note 1):

   a. Aggregates (1): Capable of maintaining 230 ± 9 °F (110 ± 5 °C).

   b. HMA Compaction Oven (1): Capable of maintaining either 295 ± 5 °F (146 ± 3 °C) or 305 ± 5 °F (152 ± 3 °C) as required in IL Modified AASHTO T 312.

   Note 1. In situations where large oven capacity is required, the Department recommends the use of two smaller ovens instead of one large oven. This is due to the problem of maintaining the required temperatures when the doors are frequently opened.

8. Computer and Printer compatible with the Quality Management Program (QMP) Package

9. Sample Splitters:

   a. Aggregate (1 each): As defined by Illinois Modified AASHTO R 76.

   b. Hot-Mix Asphalt (1): As defined by Illinois Modified AASHTO R 76 with the following additional requirements:

Illinois Department of Transportation

Hot-Mix Asphalt Laboratory Equipment
Appendix D.4

(continued)
Effective: April 1, 1997
Revised: December 1, 2021

    i. Length of discharge (catch) pan equals or exceeds total chute width.

    ii. Each chute separated by a vertical metal divider.

10. Sieve Shaker (Mary Ann type or equivalent) (1): Capable of holding 12 in. (305 mm) sieves.

11. Twelve-inch Sieves (2 sets), 2 in. in height (Note 2):

    a. For HMA Labs;

    1-1/2 in. (37.5mm)
    1 in. (25mm)
    3/4 in. (19mm)
    5/8 in. (16 mm)
    1/2 in. (12.5mm)
    3/8 in. (9.5mm)
    1/4 in. (6.3mm)
    No. 4 (4.75mm)
    No. 8 (2.36mm)
    No. 16 (1.18mm)
    No. 30 (600 μm)
    No. 50 (300 μm)
    No. 100 (150 μm)
    No. 200 (75 μm)
    bottom pan and lid

    b. For Aggregate Labs; all HMA Lab sieves and No. 40 and No. 80 sieves are required.

    c. Sieves below the 3/8 in. (9.5mm) may be 1 5/8 in. nominal height (Note 2).

    d. Extra No. 8, 10 or 16 and No. 200 sieves required as wash sieves.

    Note 2. Distance from the top of the frame to the sieve cloth surface

12. Thermometers (4):

    a. Any Thermometric Device (1): As defined by Illinois Modified AASHTO T 209, with a suitable range to determine 77 ± 1.8 °F (25 ± 1 °C).

    b. Metal-stemmed (3): As defined by Illinois Modified AASHTO T 312 with a suitable range to determine 50 – 450 °F (10 – 232 °C).

13. Timer (1): Minimum 20-minute capability.

14. Vacuum Pump (1): Capable of removing entrapped air to a residual pressure of 30 mm Hg.

15. Gyratory Compactor (1) meeting the requirements of Illinois Modified AASHTO T 312.

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Hot-Mix Asphalt Laboratory Equipment
Appendix D.4

(continued)
Effective: April 1, 1997
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16. Printer (1): As defined by Illinois Modified AASHTO T 312.
17. Gyratory Mold-Loading Chute (1):
    a. Capable of holding a minimum of 130 cu in. (2120 cu cm).
    b. Minimum length of 22 in. (560 mm).
    c. Capable of loading entire gyratory sample in one motion without spillage or segregation.
18. Gyratory Specimen Molds (2): As defined by Illinois Modified AASHTO T 312.
19. Specimen Extruder (1):
    a. Does not allow free-fall of specimen.
    b. Diameter of extruding disk must not be less than 5.4 in. (138 mm).
20. Sampling Shovel with sides and back built up 1 – 1.5 in. (25 – 40 mm).
21. Nuclear Asphalt Density Gauge (1): As defined by Illinois Modified ASTM D 2950.
22. Asphalt Content
    a. Ignition Oven (1) as defined by Illinois Modified AASHTO T 308 or,
    b. Solvent Extractions (1) as defined by Illinois Modified AASHTO T 164,
        i. Reflux or,
        ii. Centrifuge and High Speed Centrifuge for Mineral Matter Correction or,
        iii. Automated extraction device or,
    c. Nuclear Asphalt Content Gauge (1) and Related Apparatus: As defined by Illinois Modified AASHTO T 287 “Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method.”
23. Pan with approximate dimensions of 24 in. x 24 in. x 6 in. (L x W x H) for cleaning samples out of baskets after ignition burn (Note 3).

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Hot-Mix Asphalt Laboratory Equipment
Appendix D.4
(continued)
Effective: April 1, 1997
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Note 3. Required if laboratory uses Illinois Modified AASHTO T 308 to determine asphalt content.

2. Mix Design Laboratory and Equipment

   A. Required Items in Addition to the QC Laboratory Equipment

      1. Balance (1): As defined by Illinois Specification 101 Minimum Requirements for Electronic Balances (additional minimum capacity requirements).

      2. Extraction Apparatus (1): As defined by Illinois Modified AASHTO T 164, Test Methods A, B, and F.

         a. Reflux or

         b. Centrifuge and High Speed Centrifuge for Mineral Matter Correction or

         c. Automated extraction device.

      3. Tensile Strength Apparatus:

         a. Loading Device (1): As defined by Illinois Modified AASHTO T 283.

         b. Load-Measuring Device (1):

            i. Sensitivity 10 lb (4.5 kg).

            ii. Accuracy within 1.0%.

         c. Loading Strips: One set for 6 in. (150 mm) specimens: As defined by Illinois Modified AASHTO T 283.

      4. HMA Mixing Oven (1): Capable of maintaining either 295 ± 5 °F (146 ± 3 °C) or 325 ± 5 °F (163 ± 3 °C) as required according to IL Modified AASHTO T 312.

      5. Water Bath (1): As defined by Illinois Modified AASHTO T 283 with the following additional requirements:

         a. Depth at least 6 in. (150 mm).

         b. Having a perforated false bottom or equipped with a shelf at least 2 in. (51 mm) above bottom of bath.

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Hot-Mix Asphalt Laboratory Equipment
Appendix D.4
(continued)
Effective: April 1, 1997
Revised: December 1, 2021

    c. Thermostatically controlled.
    d. Capable of maintaining 140 ± 1.8 °F (60 ± 1 °C).

6. Thermometer for Water Bath 140 °F (60 °C) (1):
    a. Minimum range of 131 – 149 °F (55 – 65 °C).
    b. Graduated in increments less than or equal to 0.4 °F (0.2 °C).
7. Baking Pans (2): Each providing a minimum surface area of 140 sq in. (903 sq cm).
8. Mixing Apparatus (1): As defined by Illinois Modified AASHTO R 35 with a minimum capacity of 12,000 g.

3. QA Laboratory Equipment – in Addition to the Mix Design Laboratory Equipment

No Additional Equipment Needed.

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Model Annual Quality Control Plan for Hot-Mix Asphalt Production
Appendix B.1

Effective Date: May 1, 1993
Revised Date: December 1, 2021

Producer Name: ____

Producer/Supplier No.*: ____

Producer Main Office Mailing Address: ______________________________

City/State/ZIP: ____

Plant(s) City/State/ZIP: ____

*If the location includes more than one plant, this Annual Quality Control (QC) Plan may apply to the other facilities. Include relevant IDOT P/S Numbers under “Plant(s)”.

A. Producer Responsibilities

The Producer is responsible for controlling the equipment, component materials, and production methods to ensure the specified product is obtained. All requirements of the Standard Specifications, the Manual of Test Procedures for Materials, contract-specific documents, Hot-Mix Asphalt (HMA) Level I and II Technician Manuals, and this Annual QC Plan will be adhered to. A Quality Control Addendum shall be completed for each contract and submitted prior to the preconstruction conference.

Where one Contractor is producing the mix and another is responsible for the laydown, the Quality Control Manager, from either party, who is ultimately responsible for the Quality Control should be identified in the Quality Control Addendum.

B. Quality Control Personnel

The QC Manager will assign duties in accordance with the "QC Personnel Responsibilities and Duties Checklist". The QC Manager will assure the listed duties are performed and documented. Additional duties, when necessary, will be assigned and monitored by the QC Manager. Sufficient QC personnel will be provided to comply with the QC Plan. Additional QC personnel will be added when necessary.

Quality Control Manager Name:
Phone Number:
e-mail Address:
Mailing Address (if different than above):

Backup Quality Control Manager Name:
Phone Number:
e-mail Address:

Owner or Individual Supervising QC Personnel Listed Above:

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Phone Number:
e-mail Address:

Additional contract-specific personnel will be included on the QC Addendum.

C. Plant(s)

IDOT Producer Number: ______________________________

Manufacturer: ______________________________

Model Number: ______________________________

Serial Number: ______________________________

Approved Batch Size or TPH as applicable:________________

Plant Survey Re/Approval Date:_________________________

(If more than one plant at location - Repeat for the additional plant)

D. Quality Control Laboratory

Quality Control Laboratory Location:
Quality Control Laboratory Approval Date:
Qualified for Method 2 Dispute Testing Complete (Y/N):
Use of Central Lab AC (Y/N):
Laboratory Manager:
Laboratory Phone Number:

Backup Quality Control Laboratory Location:
Backup Quality Control Laboratory Approval Date:
Qualified for Method 2 Dispute Testing Complete (Y/N):
Laboratory Manager:
Laboratory Phone Number:

Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
Appendix B.1

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Effective Date: May 1, 1993
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E. Materials

All materials proposed for use are from approved sources. Material sources are identified below for coarse aggregate, fine aggregate, mineral filler, RAP/FRAP/RAS, asphalt binder, tack coat, longitudinal joint sealant, anti-strip additive, and asphalt release agent.

1. Coarse Aggregates

Coarse aggregate materials are shown in the following table:

Material Code	Producer/Supplier Number	Producer Name	Location	Delivery Method [1/]

Note: 1/ Truck / Rail / On-Site Quarry

Coarse aggregate stockpile method: (Conveyor Cone, Conveyor Elongated Cone, Single Layer Truck, Multi-Layer Truck):

Procedures utilized to replenish and test stockpiles:

Procedures utilized to prevent intermingling of stockpiles:

List and attach any approved mix plant gradation adjustments according to Appendix A.1 of the Manual of Test Procedures.

2. Fine Aggregates

Fine aggregate materials are shown in the following table:

Material Code	Producer/Supplier Number	Producer Name	Location	Delivery Method [1/]

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Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production

Appendix B.1

(continued)

Effective Date: May 1, 1993

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Note: 1/ Truck / Rail / On-Site Quarry

Procedures utilized to replenish and test stockpiles:

Procedures utilized to prevent intermingling of stockpiles:

List and attach any approved mix plant gradation adjustments according to Appendix A.1 of the Manual of Test Procedures.

3. RAP/FRAP/RAS Materials

RAS materials incorporated into mixtures are shown in the following table:

Material Code	Producer Supplier Number	Producer Name	Producer Location

RAS stockpiling method

RAP/FRAP materials incorporated into mixtures will be described in the project QC Addendum.

RAP/FRAP Procedures:

- Delivery and stockpiling method:
- Method of Processing (Crushing / Screening / Fractionation method):
- Maintaining source and/or quality stockpile seal:

4. Liquid Asphalt

Liquid asphalt grades and sources are shown in the following table:

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Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
Appendix B.1
(continued)
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PG Grade	Producer/Supplier Number	Producer Name	Producer Location

Procedures for preventing mixing liquid asphalt grades:

5. Mineral Filler, Anti-Strip, WMA and SMA Stabilizing Additives, Asphalt Release Agents, Longitudinal Joint Sealant & Tack Coat Materials

Material	Producer Supplier Number	Producer Name	Producer Location

F. Aggregate Stockpile Procedures

All aggregate stockpiles will be built using procedures that will minimize segregation and degradation.

G. Incoming Aggregate Gradation Samples

A washed gradation test will be performed for each 500 tons (450 metric tons) for the first 1,000 tons (900 metric tons) for each aggregate received. Additional gradation tests (every third test will be a washed gradation test) will be run on the frequency of one test per 2,000 tons (1,800 metric tons) for each aggregate received while the stockpiles are being built or aggregate is being shipped in. Gradation correction factors will be developed from washed gradation test results and applied to all dry gradation results. All aggregate (correction factors applied) will meet the mix plant gradation bands as developed according to the current Department policy, "Development of Gradation Bands on Incoming Aggregate at Mix Plants", before being used in mix production at the mix plant. All incoming aggregate gradation results shall be recorded in the plant diary. If a failing sample is encountered, the following resample procedure will be followed:

1. Immediately resample the aggregate represented by the failing test.

2. If the first resample passes, the required frequency will be continued.

3. If the first resample fails, shipment of the aggregate will be halted, and corrective action will be taken. Corrective action may be rejection of the material, remixing or addition of material by feeder/conveyor system, or any other action approved by the Engineer. The aggregate producer will be notified of the problem. A second resample will be taken immediately after corrective action.

4. If the second resample passes, the aggregate represented will be used, and aggregate shipment into the plant will be resumed.

5. If the second resample fails, the aggregate represented will not be used in HMA mixtures. The material will be removed from the certified aggregate stockpile.

H. Required Gradation Sample

After mix production has started, all aggregate stockpiles will be checked with a required washed gradation sample on a weekly basis. This testing will be waived if the mixture is classified as a small tonnage item. The test results shall be compared to the mix plant gradation bands for compliance. These gradation results will be noted in the Plant Diary, and a copy will be provided to the Engineer.

If a weekly required stockpile sample fails, the following resample procedure will be followed:

1. Immediately resample and test the new stockpile sample.

2. If the first resample passes, mix production may continue. Several additional check samples will be taken to monitor the stockpile.

3. If the first resample fails, mix production will be halted, and corrective action will be taken on the stockpile. Corrective action may include rejection of the material, remixing or addition of material by feeder/conveyor system before use in the plant. The Aggregate Producer will be notified of the problem. A second resample will be obtained immediately after corrective action.

4. If the second resample passes, mix production will begin. Several additional check samples will be taken to monitor the stockpile.

5. If the second resample fails, the stockpile will not be used in HMA mixtures.

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Appendix B.1

(continued)
Effective Date: May 1, 1993
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Aggregate not meeting the mix plant gradation bands shall not be used in HMA mixtures.

I. Reporting of Test Results

All test results will be reported daily either electronically using the Department QMP Package, or by submission of the following forms to the Resident Engineer and other designated personnel as requested by the Department.

MI 504M	Field/Lab Gradations (stockpile gradations)
MI 305	Bituminous Daily Plant Report (front) Plant Settings and Scale Checks (back)
MI 303C	Bituminous Core Density Testing QC/QA
MI 303N	Nuclear Density Report QC/QA
MI 308	Asphalt Content and Volumetric Testing
LM-6	Sample Identification (for liquid asphalt)

The completed forms will be forwarded to the Engineer within three days of test completion.

J. Control Charts

In addition, when control charts are required as part of the Quality Management Program they will either be posted at the laboratory or readily available electronically upon request in accordance with the Department's current document "Hot-Mix Asphalt QC/QA Control Charts".

Primary QC Manager Signature ______________________ Date ___________________

(Please type or print name) ________________________________ Title _____________

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Model Quality Control (QC) Addendum for Hot-Mix Asphalt Production
Appendix B.2

Effective Date: July 1, 1995
Revised Date: December 1, 2021

Contract No.: ______________________________
Marked Route: ______________________________
County: ______________________________
Prime Contractor: ______________________________
HMA Producer: ______________________________
Contractor Performing Laydown: ______________________________

This Quality Control (QC) Addendum provides contract specific information to supplement the Hot-Mix Asphalt (HMA) Annual QC Plan. If multiple HMA producers will be utilized for specific items of work on a single contract (Example: one for mainline and another for shoulder), a separate QC Addendum shall be submitted for each producer.

A. HMA Production Location

	Producer Name	Location	IDOT P/S Number
Primary			
Backup			

B. Mix Designs

The following mix designs will be utilized:

Pay Item	Material Code	Lift (if applicable)	Mix Description	Department Mix Design Number	Annual Verification Completed (Y/N)

The table may include a primary and a secondary mixture for each item.

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Model Quality Control (QC) Addendum for Hot-Mix Asphalt (HMA) Production
Appendix B.2

(continued)
Effective Date: July 1, 1995
Revised Date: December 1, 2021

C. Reclaimed Asphalt Pavement (RAP/FRAP)

RAP/FRAP material incorporated into mixtures originated from the following sources:

Material Code	Material Description	Quality	Source (Marked Route, Location & Lift)	Mix Design # Utilizing the Material

D. Quality Control Personnel

Overall (Production & Laydown) Project Quality Control Manager Name:
Company:
Phone Number:

The QC personnel are shown in the table below:

Name	Task(s) Performed	Employed By	Training Level

E. Project Specific Issues:

HMA Producer Signature: ____________________________________

Title: ____

(Type or print name): ________________________________ Date: ____________

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Hot-Mix Asphalt Mixture Design Verification Procedure
Appendix B.9

Effective Date: January 1, 2002
Revised Date: December 1, 2023

1.1 GENERAL

Contractors shall provide all hot-mix asphalt (HMA) mix designs for use on Department contracts. Mix designs shall be the proprietary property of the Contractor. Mix designs must result in mixtures meeting Department criteria. The Department will provide current aggregate bulk specific gravities.

Note. The values stated in SI units are to be regarded as the standard. The English units are shown in parentheses and may not be exact equivalents.

2.1 PURPOSE

To establish a verification procedure to evaluate Contractor mix designs for use on Department contracts. This procedure also allows for comparison of test accuracy and precision between laboratories.

3.1 REQUIRED DESIGN DATA/MATERIAL SAMPLES

3.2 The Contractor shall provide a mix design prepared by a Hot-Mix Asphalt Level III Technician in accordance with the Department's "Hot-Mix Asphalt Design Procedure" in the current *Hot-Mix Asphalt Level III Technician Course* manual. All testing shall be performed by Hot-Mix Asphalt Level I, II, or III Technicians . An approved mix design that will be used as WMA through the use of foaming technology alone (without WMA additives) will not require a new submittal. Mix designs shall be submitted with the following design data:

A. The average mix plant stockpile gradations and aggregate blend percentages used to design the mix. Each of the individual aggregate gradations used in the Contractor design shall be an average of a minimum of five stockpile gradations from existing stockpiles at the plant. Adjusted average aggregate source gradations (stockpile gradations preferred) may be substituted if aggregate has not been shipped to the mix plant. The adjustment shall be based on the amount of aggregate degradation anticipated during shipment to, and handling at, the mix plant. A design using gradation information not comparing to mix plant or aggregate source gradations shall be considered unacceptable.

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Hot-Mix Asphalt Mixture Design Verification Procedure
Appendix B.9

Effective Date: January 1, 2002
Revised Date: December 1, 2023

B. The Contractor shall provide the following information utilizing a design package with the same output format as the Department's Quality Management Program (QMP) Package software.

(1) Design sheet. The design shall contain a minimum of four design points, two of which shall bracket the optimum design asphalt binder (AB) content by at least ± 0.5%. Under remarks include: short-term aging time, dust correction factor, compaction temperature, and mixing temperature.

(2) Design summary data sheet (in the QMP Package format).

(3) G_{mm} lab worksheets.

(4) Batching worksheet.

(5) Dust correction worksheet (example shown in the *Hot-Mix Asphalt Technician Course Level III* manual).

(6) Batching sources sheet.

(7) Mix design graphs (full page).

  (a) Gradation (0.45 power curve).

  (b) Asphalt Binder Content vs. G_{mb}/G_{mm}.

  (c) Asphalt Binder Content vs. VMA.

  (d) Asphalt Binder Content vs. Air Voids.

(8) Recalculations and/or retested points (e.g., recalculated G_{mm}'s using average G_{se}).

(9) TSR worksheet including the mixture unconditioned tensile strength, conditioned tensile strength, TSR and, if anti-strip additive is used, the conditioned tensile strength of the mixture without the anti-strip additive.

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3.3 The Contractor shall submit the following to the Department a minimum of 30 calendar days prior to production: samples of blended aggregate, asphalt binder, additives, and compacted gyratory cylinders, at the optimum asphalt content according to Section 3.3.D as specified herein, which represent the materials in the mix design. These representative samples shall be identified and submitted as follows:

A. Aggregate (including the mineral filler or collected dust) -- Dried, split into the individual sizes specified for the Batching Worksheet as stated in the current *Hot-Mix Asphalt Level III Technician Course* manual, and then blended to the chosen gradation. The amount submitted shall be two 10,000-gram samples of dry aggregate, with an additional 2,000 grams for gradation testing if requested by the District. All material shall be bagged in plastic bags or other airtight containers. Each container shall be identified with the source names, source locations, source Producer/Supplier Numbers, material codes, sample location, and sample date.

B. Asphalt Binder -- A minimum of four individual one quart cans with friction lids. Each container shall be identified with source name, source location, source Producer/Supplier Number, material code, sample location, and sample date.

C. Additive(s) (including anti-strip, WMA and fibers) -- Each container shall be identified with the source name, source location, brand name or number, material code, sample location, sample date, Safety Data Sheet (SDS), the manufacturer's recommended dosage rate, and the dosage rate used in the design. NOTE: Prior to submitting the additive(s), the Contractor shall contact the District Materials Engineer for the required sample size.

D. Compacted Gyratory Cylinders – The Contractor shall provide compacted 150 mm (5.91 in.) diameter gyratory cylinders meeting the air void requirements of the respective tests shown in the following table. The number of gyratory cylinders and the height of the gyratory cylinders per test is also specified in the following table.

	TSR	**Hamburg Wheel**	**I-FIT**	**I-FIT Long-Term Aging**
IL Modified AASHTO Procedure	T 283	T 324	T 393	T 393
No. of Gyratory Cylinders*	6	2/4	1/2	1/2
Height of Gyratory Cylinders mm (in.)*	95 (3.74)	160/115 (6.30/4.53)	160/115 (6.30/4.53)	160/115 (6.30/4.53)

* If a Contractor does not possess the equipment to prepare 160 mm (6.30 in.) tall gyratory cylinders, twice the number of 115 mm (4.53 in.) tall gyratory cylinders per test will be acceptable.

Hot-Mix Asphalt Mixture Design Verification Procedure
Appendix B.9

Effective Date: January 1, 2002
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3.4 All design data and material samples shall be submitted to the Department a minimum of 30 calendar days prior to production.

3.5 By submitting a mix design and the constituent materials for verification, the Contractor certifies that they meet Department requirements and represent the materials to be used during mix production.

4.1 DEPARTMENT VERIFICATION

4.2 At the option of the Department, new mix designs will be verified using Method A or Method B listed below. Previously approved mix designs adjusted per Section 5.2.A will be verified using Method A or Method B. Mix designs adjusted per Sections 5.2.B, 5.2.C, 5.2.D, or Section 5.3 will be verified using Method C.

Method A (Contractor Four Point Mix Design). Department verification for mix designs will include review of all mix design data (including all aggregate field gradations) submitted by the Contractor, mixing the component materials submitted by the Contractor, and verification testing of the asphalt mixture. The verification testing; which includes volumetric (VMA, VFA, G_{mb}, G_{mm}, air voids), tensile strength, TSR, Hamburg Wheel, and I-FIT; shall meet the mix design criteria at the optimum asphalt content. A mixture made from the individual materials will be tested for volumetric properties. The Contractor shall provide compacted gyratory cylinders as per Section 3.3.D herein.

Method B (Contractor Four Point Mix Design). Department verification for mix designs will be based on 1) a review of all mix design data (including all aggregate field gradations) submitted by the Contractor and 2) Department verification testing for G_{mm}, tensile strength, TSR, Hamburg Wheel, and I-FIT. The Contractor shall provide compacted gyratory cylinders as per Section 3.3.D herein. The Contractor shall also provide the Department with component materials according to Section 3.3 herein to verify G_{mm}. The mixture at the optimum design asphalt binder content shall meet the mix design criteria for the following: VMA, VFA, G_{mb}, G_{mm}, air voids, tensile strength, TSR values, Hamburg Wheel, and I-FIT.

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Method C (Contractor One Point Mix Design). Department verification for mix designs will include review of all mix design data (including all aggregate field gradations) submitted by the Contractor, mixing the component materials submitted by the Contractor, and verification testing of the asphalt mixture. The verification testing; which includes volumetric (VMA, VFA, G_{mb}, G_{mm}, air voids), tensile strength, TSR, Hamburg Wheel, and I-FIT; shall meet the mix design criteria at the optimum asphalt content. A mixture made from the individual materials will be tested for volumetric properties. The Contractor shall provide compacted gyratory cylinders as per Section 3.3.D herein.

Verification Method	Department Tests/Calculations Performed on[1/]:									
	Mixture Prepared by the Department					Gyratory Cylinders Prepared by Contractor				
	VMA	VFA	G_{mb}	G_{mm}	Air Voids	Unconditioned Tensile strength	Conditioned Tensile strength	Tensile strength Ratio	Hamburg Wheel	I-FIT
A[2/]	X	X	X	X	X	X	X	X	X	X
B[2/]				X		X	X	X	X	X
C[3/]	X	X	X	X	X	X	X	X	X	X

1/ At the optimum asphalt binder content using materials provided by the Contractor.

2/ Contractor Four Point Mix Design.

3/ Contractor One Point Mix Design at Optimum Asphalt Content.

In all cases the Department will review test data, including aggregate field gradations, provided by the Contractor for compliance with the specifications. All mixtures shall meet specifications at the optimum asphalt content for approval.

4.3 The Contractor mix design data and Department verification testing shall meet the mix design criteria in the Standard Specifications, any Special Provision in the Contract, and the following tolerances (where applicable):

Volumetric Testing	**Tolerance**
G_{se} (effective SG of combined aggregates)	± 0.014
G_{mb}	± 0.020
G_{mm}	± 0.014
Air Voids	± 0.5 %

Gradation	**Tolerance**
12.5 mm (1/2 in)	± 3.0
4.75 mm (No. 4)	± 2.0
2.36 mm (No. 8)	± 2.0
600 µm (No. 30)	± 1.0
75 µm (No. 200)	± 0.5
Pb (Asphalt Binder Content)	± 0.15

All aggregate field gradations submitted by the Contractor will be compared to previous mix plant and/or Aggregate Gradation Control System gradations for validity.

4.4 If a mix fails any of the Department's volumetric or verification tests, the Contractor shall make necessary changes to the mix and provide passing tensile strength, TSR, Hamburg Wheel, and I-FIT test results, as required, from a private lab before resubmittal. The Department will verify the passing results.

4.5 The Department will notify the Contractor in writing within 30 calendar days of receiving the design data/materials as to the acceptability of the submitted Contractor mix design. If the mixture volumetrics or verification tests fail, the 30-calendar-day time for the Department to notify the Contractor starts over.

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Effective Date: January 1, 2002
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5.1 MIX DESIGN APPROVAL STATUS

5.2 All mix designs verified as specified herein are approved indefinitely provided that the current contract documents have been met, no changes are made to mixture ingredients and the aggregate bulk specific gravities are updated annually using the current Department published values. The resulting combined aggregate bulk specific gravity shall be used for volumetric calculations during production that year. The following actions will occur to maintain verified mix designs due to changes at Aggregate Producers.

A. If the combined aggregate bulk specific gravity of the mix changes by more than ±0.020 from the original mix design, the mix design shall be resubmitted for verification as per Section 4.2.
B. If the aggregate producer changes ledges prior to the construction season, the Department will require Method C verification of a previously approved mix design as per Section 4.2.
C. If the aggregate producer changes ledges during the construction season, the Department will require the Contractor to submit compacted gyratory cylinders of plant-produced mix as per Section 3.3.D herein to verify tensile strength, TSR values, Hamburg Wheel, and I-FIT criteria. The Department will require Method C verification as per Section 4.2 after the current construction season is completed.
D. If the aggregate producer changes production practices (including, but not limited to changing crushers, stockpiling practices, or production rate), the Contractor shall submit material for Method C verification as per Section 4.2.
E. The Contractor may at any time resubmit a mix design for verification as per Section 4.1.

5.3 If a mix design adjustment is needed to meet current contract requirements and is outside of the adjustment limits stated in Article 1030.10, the Department will require Method C verification as per Section 4.2.

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QC/QA PROCEDURE

Development of Gradation Bands on Incoming Aggregate at Hot-Mix Asphalt and Portland Cement Concrete Plants
Appendix A1

Effective: January 1, 1994
Revised: December 1, 2021

A. Scope

Quality Control Plans for Hot-Mix Asphalt (HMA) and Portland Cement Concrete (PCC) Contracts normally require incoming aggregate to be checked for gradation compliance before use in HMA and PCC plants. Aggregate is produced to tight gradation bands at the source but will degrade during handling and shipment.

B. Purpose

Establish a procedure to modify aggregate source gradation bands to develop mix plant gradation bands for use in checking gradation compliance on incoming aggregate at mix plants. The mix plant gradation bands will also be used in checking gradation compliance for required stockpile gradation tests at the mix plant.

C. Aggregate Source Gradation Bands

The Contractor shall obtain certified aggregate gradation bands (including master band, if required) from the aggregate source for all certified aggregates prior to any shipment of material to a mix plant. Natural sand gradation bands shall be obtained from the appropriate District Materials Engineer.

D. General Procedure

The Contractor may modify the aggregate source gradation bands according to the following procedures, if necessary, to check incoming aggregate for gradation compliance at the mix plant. If not modified, the aggregate source gradation bands shall be considered the mix plant gradation bands when checking incoming aggregate.

1. Coarse Aggregate—The Contractor may shift the aggregate source master band a maximum of three percent (3%) upwards to establish a Mix Plant Master Band for each coarse aggregate used. All other aggregate source gradation bands, except for the top sieve and bottom sieve bands in the gradation specification, may also be shifted upward a maximum of three percent (3%). The top sieve and bottom sieve bands shall not be changed, except as follows:

   At PCC plants, the Contractor may increase the specification limit for the minus No. 200 (75-µm) Illinois Modified AASHTO T 11 sieve material upwards one half percent (0.5%) if the No. 200 (75-µm) material consists of dust from fracture, or degradation from abrasion and attrition, during stockpiling and handling (reference Article 1004.01[b] of the Department's *Standard Specifications for Road and Bridge Construction*).

Illinois Department of Transportation
QC/QA PROCEDURE

Development of Gradation Bands on Incoming Aggregate at Hot-Mix Asphalt and Portland Cement Concrete Plants

Appendix A1

Effective: January 1, 1994
Revised: December 1, 2021

2. Manufactured Sand—All aggregate source gradation bands, except the top sieve and bottom sieve bands in the gradation specification, for each certified natural or manufactured sand may be shifted upwards a maximum of three percent (3%). The top sieve and bottom sieve bands shall not be changed.

3. Natural Sand—The gradation bands obtained from the Department for each natural sand shall not be changed.

E. Department Approval

All aggregate source gradation bands and mix plant gradation bands must be sent to the District Materials Engineer for approval prior to any shipment of aggregate to the mix plant. Once approved, the mix plant gradation bands shall not be changed without approval of the District Materials Engineer.

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Hot-Mix Asphalt QC/QA
QC Personnel Responsibilities and Duties Checklist
Appendix B.5

Effective Date: May 1, 1993
Revised Date: December 1, 2021

The following checklists detail the required minimum duties of Contractor Quality Control (QC) personnel. The QC Manager has overall responsibility to ensure that the listed duties are performed and documented. The QC Manager shall not perform sampling and/or testing except in emergency situations or in any other situation approved by the Engineer. Additional tasks or duties, as necessary, may be required to control the quality of production and placement of the Hot-Mix Asphalt (HMA) mixtures. An HMA Level II Technician may be used to perform any HMA Level I Technician duties.

Note: Testing frequency denoted as "P" = "Prior to Test Strip" and as "D" = "Daily".

A. Level I Technician Checklist

1. Production/Placement Tasks

   a. Perform incoming aggregate gradations before start-up time. (PD) ___

   b. Ensure lab equipment is on hand and in working order. (PD) ___

   c. Run moisture samples daily (drum only). (PD) ___

   d. Determine random sampling times one day in advance and inform the QC Manager and the Engineer of the sampling times. (D) ___

   e. Take required samples when required using proper procedures. (D) ___

   f. Run required tests as soon as possible using proper procedures. (D) ___

   g. Take resamples as required. (D) ___

   h. Plot all random and resample results on control charts as soon as test results are available. (D) ___

   i. Take check samples when necessary. (D) ___

   j. Contact QC Manager immediately when tests fail or any time problems occur. (D) ___

   k. Test cores for Nuclear/Core Correlation when applicable (After Test Strip). ___

2. Required Tests. The minimum test frequency shall be according to Section 1030 of the Standard Specifications. However, additional tests may be required by the Engineer.

Illinois Department of Transportation

Hot-Mix Asphalt QC/QA
QC Personnel Responsibilities and Duties Checklist
Appendix B.5

(continued)
Effective Date: May 1, 1993
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a. Stockpiles
(washed gradations minimum one per week for each material used) ___

b. Moisture samples (drum only) ___

c. Washed Gradations ___

d. Asphalt Content

e. G_{mb} ___

f. G_{mm} ___

B. QC Manager and/or Level II Technician Checklist

Complete and submit Annual QC Plan prior to construction season. ___

1. Preliminary Inspection Tasks

a. Check for the approved sources of the materials:
   (1) Aggregates — ensure it is from Certified Source ___
   (2) Mineral filler ___
   (3) Asphalt binder (See d. below.) ___
   (4) Other additives
   (5) Truck Bed Release Agent – ensure it is on the QPL ___

b. Check the aggregate stockpiling and handling procedures:
   (1) Observe stockpiling procedures to ensure they are built correctly. ___
   (2) Discuss loadout and sampling procedures with endloader operator. ___
   (3) Sample aggregate stockpiles, in conjunction with District inspectors, and submit for Mix Designs. ___

c. Check the gradation of the aggregates:
   (1) Obtain average gradation of each aggregate (including Master Bands) from the aggregate source. ___

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Hot-Mix Asphalt QC/QA
QC Personnel Responsibilities and Duties Checklist
Appendix B.5

(continued)
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(2) Compare aggregate source information to stockpile samples at the mix plant and with the design gradation. ___

(3) Test the gradation of each aggregate stockpile.

d. Check asphalt binder:

(1) Source ___
(2) Grade ___
(3) Incoming temperatures ___
(4) Specific Gravity (drum only) ___

e. Verify that the laboratory and laboratory equipment have been inspected and approved by the Department and are in good working order. ___

f. Review Hot-Mix Asphalt Level I and Level II Technician Course manuals. ___

2. <u>Production/Placement Tasks</u>

a. Complete and submit Quality Control Addendum (P) ___

b. Check the mix plant for the following:

(1) Approval and calibration (P) ___
(2) Asphalt binder storage temperature (PD) ___
(3) Stockpiles (PD)
    (a) Correct loadout ___
    (b) Place in proper cold-feed bins

(4) Cold-feed bins or bulkheads and feeders (PD) ___
(5) Dust collecting systems (D) ___
(6) Screens and screening requirements (P) ___
(7) Hot-bin sampler (P) and hot-bin overflow (PD) ___
(8) Weigh belt 6-minute check (drum only) (D) ___
(9) Temperature recorders and thermometers (PD) ___
(10) Mixing timers (batch plant only) (PD) ___

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Hot-Mix Asphalt QC/QA
QC Personnel Responsibilities and Duties Checklist
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(continued)
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(11) Surge and storage bins (PD) ___
(12) Platform scales or suspended weigh hopper (PD) ___
(13) Additive system(s) (when required) (PD) ___
(14) Ticket printer (P) ___
(15) Computer and control systems (PD) ___

c. RAP/FRAP/RAS from appropriate approved sealed stockpile (PD) ___

d. Check trucks for the following (QC Manager may assign these duties to a Level I Technician):

(1) Truck bed release agents (PD) ___
(2) Insulation (D) ___
(3) Tarps (D) ___
(4) Clean beds (D) ___

e. Coordinate any test strip per Department guidelines (QC Manager only). ___

f. Monitor sampling and testing procedures, density test, and laydown operations. (D) ___

g. Check the mixtures for the following:

(1) Gradation test performed and bin percentages determined before start-up (P) ___
(2) Correct Job Mix Formula is being used (P) ___
(3) Moisture check (PD) ___
(4) Temperature (D) ___
(5) Coating and segregation (D) ___
(6) Additives (D) ___
(7) Draindown (D) ___

h. Laydown operation (QC Manager only)

Monitor the following field checks:
(1) Check for obvious defects in truck (segregation, uncoated, temperature, etc.) (D) ___

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Hot-Mix Asphalt QC/QA
QC Personnel Responsibilities and Duties Checklist
Appendix B.5
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(2) Monitor paver operations (equipment, laydown procedures, etc) (PD) ___

(3) Rollers and operations (equipment, pattern, procedure, etc.) (PD) ___

(4) Mix characteristics on road (appearance, mat temperature, etc.) (D) ___

(5) Monitor densities as required (D) ___

i. Monitor all test results and make any adjustments necessary (QC Manager only) (D). ___

j. Perform scale checks (minimum one per week per scale). Follow procedure in Construction Manual Documentation Section. ___

k. Ensure following records are kept and reports are submitted in a timely manner as required (QC Manager only):

(1) Daily plant output (D) ___

(2) Field gradation (D) ___

(3) Density (D) ___

(4) Control charts (D) ___

(5) Additives (D) ___

(6) Scale checks (D) ___

(7) Plant diary (D) ___

C. <u>HMA Level I Technician, HMA Level II Technician, and Quality Control Manager Duties</u>

1. <u>Material Source</u>

It is necessary to identify the source of the ingredients to ensure that they have been inspected and the correct quality of aggregate, grade of asphalt binder, and anti-strip additive are being used in the specified mix. Sources shall be verified.

2. <u>Aggregate Quality</u>

The HMA Level II Technician may confirm the quality of the aggregate by requesting current quality information from the District Materials office.

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3. Stockpiling

Sites for stockpiles shall be grubbed and cleaned prior to storing the aggregates.

Separate stockpiles shall be provided for the various sources and kinds of aggregates. Stockpiles shall be separated to prevent intermingling at the base (width of endloader bucket). If partitions are used, they shall be of sufficient heights to prevent intermingling. Aggregates for HMA mixtures shall be handled, in and out of the stockpiles, in such a manner that will prevent contamination and degradation.

Coarse aggregate stockpiles shall be built in layers not exceeding 1.5 m (5 ft) in height and each layer shall be completely in-place before the next layer is started. A stockpile may be expanded by again starting the expansion from the ground and building layers as before. End-dumping over the sides will not be permitted. Use of steel track equipment on Class B Quality, Class C Quality and all blast furnace slag aggregate stockpiles shall not be permitted where degradation is detected. When loading out of stockpiles, vertical faces shall be limited to reasonable heights to eliminate segregation due to tumbling. Segregation or degradation due to improper stockpiling or loading out of stockpiles shall be just cause for rejecting the material.

RAP/FRAP stockpiles shall be according to Article 1031.02(a).

RAS stockpiles shall be according to Article 1031.02(b).

4. Gradations

The HMA Level II Technician shall obtain the average gradations as well as the Master Bands from the aggregate source. The HMA Level II Technician shall run the required gradation's test frequency on incoming aggregate as required in Section 1030 of the Standard Specifications.

5. Asphalt Binder

   a. Incoming Asphalt Binder: The HMA Level II Technician shall periodically check the grade and temperature of asphalt binder as received at the plant. If the asphalt binder is shipped by truck, the driver should have in their possession a numbered ticket showing the name and location of the refinery, the name of the material, date shipped, loading temperature, quantity, specific gravity or weight/L (weight/gal), and the number of the tank from which the asphalt was loaded. It is the responsibility of the refinery to load trucks only from tanks that have been tested and approved by the Department. If shipment is made by rail, a tag usually will be found on the top of the dome of the tank car indicating that it has been sampled at the refinery.

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b. Asphalt Binder Storage: The HMA Level II Technician shall check the temperature of the asphalt binder in storage. The temperatures shall be maintained in accordance with the Standard Specifications. The HMA Level II Technician should be aware of the grade of asphalt binder in each storage tank. Asphalt binders of different sources and grades shall not be intermixed in storage, and the tanks shall be identified.

6. Testing Equipment

Care of the laboratory testing equipment is the responsibility of the HMA Level I Technician. Equipment shall be furnished by the Contractor or Consultant, kept clean, and kept in good working condition. The furnished equipment shall meet the minimum private laboratory requirements stated in the Central Bureau of Materials Policy Memorandum Number 6-08.4. At the start of the project, the HMA Level I technician shall check that all equipment required to be furnished is available and in good condition. Acceptance and, ultimately, performance of a mixture may be dependent on the accuracy of the tests. Defective equipment could result in erroneous, as well as untimely, results.

7. Hot-Mix Asphalt Plant

a. Plant Approval: Plant must be approved and calibrated prior to production each construction season. The QC Manager shall review this information. If it is not available or current, the District Hot-Mix Asphalt Supervisor shall be notified.

b. Cold Aggregate Bins: The cold aggregate bins or bulkheads shall be checked for aggregate intermingling. Each bin or compartment in a bin shall contain only one source and type of aggregate. The bins should be checked each day to ensure the charging of the compartments remains the same as it was for previous operations for the same mix. The QC Manager shall notify the state inspector of changes in aggregate source and gradation and/or gate settings.

c. Batch Plant Dust Collector: The Level II Technician shall check that the dust from the primary collector is returned to the boot of the hot elevator by a metering system as required by Article 1102.01(b)(3) of the Standard Specifications. This metering system should be such as to require a few adjustments in maintaining a uniform rate of collected dust returned to the hot elevator. The primary dust-feed shall occur only when aggregate is being discharged from the drier.

Plants having dry secondary collectors shall return this material to a storage silo or the mineral filler bin if it will meet the requirements of the mineral filler specifications (Section 1011 of the Standard Specifications).

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QC Personnel Responsibilities and Duties Checklist
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d. Screens: Samples from the hot-bins shall be inspected for contamination. An excess of coarse aggregate in the sand bin or sand in the coarse aggregate bins may indicate broken or clogged screens and/or a hole between the bins. The screens shall separate aggregate into sizes to produce a uniform gradation. If fluctuations in gradation occur, a change in screen size and/or aggregate flow rate may be required. Article 1102.01(b)(10) of the Standard Specifications shall be applied.

e. Hot-Bins: The HMA Level II Technician is to ensure that each hot-bin overflow pipe is working to prevent back-up of material into other compartments or bins. An overflow or sudden shortage of material in a bin may indicate a broken or clogged screen, a change in feeding rate, or a change in gradation of the aggregate being used. Overflow pipes shall not be discharged into the hot elevator.

f. Temperature Recording Device: The temperature recording devices shall be checked for compliance with Article 1102.01 of the Standard Specifications. A new chart shall be used each day.

g. Timers: The timers used for recycling the wet and dry mixing times for a batch plant shall be checked and set at the required mixing times. The required times are in the appropriate articles of the Standard Specifications.

h. Batching: The HMA Level II Technician shall observe the batching operation to ensure the approved batch weights are being met. Manually operated batch plants shall have markers on the scales to indicate the approved batch weight of each ingredient material. Automatic batching plants shall have posted near the scales the approved weights per bin. It is recommended that batch counters and/or ton counters be set at "zero" or initial and final readings be taken and recorded each day.

i. Surge and Storage Bins: When a surge and storage bin are used, approval and scale calibration information should be available. They shall be inspected for compliance with Article 1102.01(a)(5) of the Standard Specifications. Trucks shall be loaded in such a manner as to minimize segregation.

j. The platform and/or suspended weigh hopper scale shall be checked for proper zero. The scales shall be cleaned off before starting each day.

k. The additive system(s) calibration shall be checked and the proper flow rate determined.

l. The weigh ticket printer shall be checked for information required by the appropriate articles of the Standard Specifications.

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Appendix B.5

(continued)
Effective Date: May 1, 1993
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m. The computer and/or control system shall be checked to see if the correct percentages of materials have been entered. The automatic printer for the computer of the drier drum should be turned on and working.

8. Trucks

A HMA Level I Technician, under the direct supervision of the QC Manager, or the HMA Level II Technician shall inspect the trucks used to transport the HMA mix. The technician shall see that each truck is provided with a cover and is properly insulated, if specified, before it is permitted to be used in the transportation of the mixture from the plant to the job. The truck bed shall be observed for foreign material before the bed is lubricated. The HMA Level II Technician shall observe the spraying of the inside of the trucks with a release agent and shall see that no pools of release agent remain in the truck beds before loading.

9. Mixture Inspection

The HMA Level II Technician shall inspect the mixture at the plant, which includes observing the weighing of the materials; checking the temperature of the mixture; and visually inspecting for coating of the aggregates, segregation, and moisture in the mixture. The HMA Level I Technician shall sample and determine the gradation of the hot-bins and/or cold-feeds and the proper amount of asphalt binder being used to ensure conformity to the mix formula. The HMA Level II Technician shall also verify and document the addition rates of the anti-strip additives.

In addition, the HMA Level I Technician shall perform the required core density tests and, when required, extraction tests at the field laboratory.

The QC Manager shall furnish the Contractor with the mixing formulas which have been established for a specific combination of sources of ingredients. The formulas shall state the percentage of aggregate for each sieve fraction and the percentage of asphalt binder. These formulas are to be used in proportioning the ingredient materials for HMA mixtures within the specified tolerances. Changes in the mix formulas are to be made only by the QC Manager.

It is important that the QC Manager observe the laying and compaction of the mixture.

Mixture variations are noticeable in the completed work, and variations that are not apparent in the mixture at the plant sometimes show up as defects in the texture and uniformity of the surface. Flushing of the mixture is a defect that can be detected only on the road.

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It is the duty of both the HMA Level I and HMA Level II Technicians to establish and maintain an open line of communications.

Timely and appropriate actions can be instituted by early detection of defects or mixture variations.

10. Scale Checks

When measurement of mixtures is on the basis of weights obtained from batch weights or platform scales, occasional scale checks shall be made by weighing full truckloads of the mixture on an approved platform scale at the plant site or on a commercial scale approved by the Engineer. The procedure is described in the Department’s Documentation of Contract Quantities Manual. The tests will be performed by the Level II Technician and reported on form BIC 2367, as needed, and the "Daily Plant Report".

11. Samples

The HMA Level I Technician shall take check samples of the mixture in addition to the required samples. Section 1030 of the Standard Specifications discusses sampling procedures and sampling frequency.

12. Reports

The Quality Control Manager is responsible for completion of a "Daily Plant Report" for each day of production for each type of mix. Other reports, when required, are "Sample Identification" (LM-6), and Scale Checks.

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Illinois Department of Transportation

Procedure for Correlating Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt

Appendix B.3

Effective Date: May 1, 2001
Revised Date: December 1, 2021

A. Scope

1. This method covers the proper procedures for correlating nuclear gauge densities to core densities.

2. The procedure shall be used on all projects containing 3000 tons (2750 metric tons) or more of any hot-mix asphalt mixture. It may also be used on any other project where feasible.

B. Applicable Documents

1. Illinois Department of Transportation Standard Test Methods

   Illinois Modified AASHTO T 166, "Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens"

   Illinois Modified AASHTO T 275, "Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Paraffin-Coated Specimens"

2. The density test procedure shall be in accordance with the Department's "Illinois Modified ASTM D2950, Density of Bituminous Concrete in Place by Nuclear Methods".

C. Definitions

Test Location: The station location for the density testing.

Test Site: Area where a single nuclear density and a core are collected. Five (5) test sites are positioned across the mat at each test location for the correlation process.

Nuclear Density: The average of two (2) or possibly three (3) nuclear density readings at a given test site.

Core Density: The core density result at a given test site.

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Procedure for Correlating Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt

Appendix B.3

(continued)
Effective Date: May 1, 2001
Revised Date: December 1, 2021

D. Significance and Use

1. Density results from a nuclear gauge are relative. If an approximation of core density results is desired, a correlation must be developed to convert the nuclear density to core density.

2. A correlation developed in accordance with these procedures is applicable only to the specific gauge being correlated, the specific mixture, each specific thickness, and the specific project upon which it was correlated. A new correlation should be determined within a specific project if there is a significant change in the underlying materials.

E. Site Selection

1. The nuclear density tests and cores necessary for nuclear/core correlation shall be obtained during the test strip for each specific mixture for which a density specification is applicable.

2. Three test locations shall be selected. One test location shall be on each of the two growth curves from the first acceptable test strip. The third test location shall be chosen after an acceptable rolling pattern has been established and within the last 100 tons (90 metric tons) of material placed during the test strip. The material from the third test location shall correspond to the same material from which the second mixture sample was taken.

3. If a test strip is not required, two of the three test locations shall be in an area containing a growth curve.

F. Procedures for Obtaining Nuclear Readings and Cores – Backscatter Mode

1. At each of the three test locations, five individual test sites shall be chosen and identified as shown in Figure 1.

2. Two nuclear readings shall initially be taken at each of the 15 individual test sites. (See Figure 1.) The gauge shall be rotated 180 degrees between readings at each test site. The two uncorrected readings taken at a specific individual test site shall be within 1.5 lb/ft^3 (23 kg/m^3). If the two readings do not meet this criterion, one additional reading shall be taken in either direction. The nuclear readings are to be recorded on the Nuclear / Core Correlation Field Worksheet.

3. All correlation locations should be cooled with ice, dry ice, or nitrogen so that cores can be taken as soon as possible. One 4 in. diameter core in good condition shall be obtained from each of the 15 individual test sites (Figure 1). Care should be exercised

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Procedure for Correlating Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt

Appendix B.3

(continued)
Effective Date: May 1, 2001
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that no additional compaction occurs between the nuclear testing and the coring operation. The cores shall be tested for density in accordance with Illinois Modified AASHTO T 166 or T 275. The core densities are to be entered on the Nuclear / Core Correlation Field Worksheet.

4. Extreme care shall be taken in identifying which test location and test site each of the density readings represents. The data points have to be paired accurately or the correlation process will be invalid.

G. Mathematical Correlation -- Linear Regression

1. The two (or possibly three) nuclear readings at each test site shall be entered on the Nuclear / Core Correlation Field Worksheet and then averaged. The core density from each test site shall be entered on the worksheet. After the averaging, there will be 15 paired data points, each pair containing the average nuclear reading and core density for each of the 15 test sites.

2. The paired data points shall be correlated using the Department's linear regression program from the Central Bureau of Materials QMP Package or an approved and equivalent calculating method.

3. For the purpose of this procedure, standard statistical methods for measuring the "best fit" of a line through a series of 15 paired data points consisting of core density and corresponding average nuclear reading shall be used.

4. It should be recognized that correlations obtained by this or similar procedures may or may not be valid; each attempt should be judged on its merit. In general, a correlation coefficient for each correlation linear regression should be calculated.

5. Correlation coefficients (r) may range from minus 1.0 to plus 1.0. Only an r-value greater than 0.715 is considered acceptable.

6. The correlation shall be stated and used in the form:

$$y = mx + b$$

where:
y = core density
x = average nuclear reading
b = intercept
m = slope of linear regression "best fit" line

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Procedure for Correlating Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt

Appendix B.3

(continued)
Effective Date: May 1, 2001
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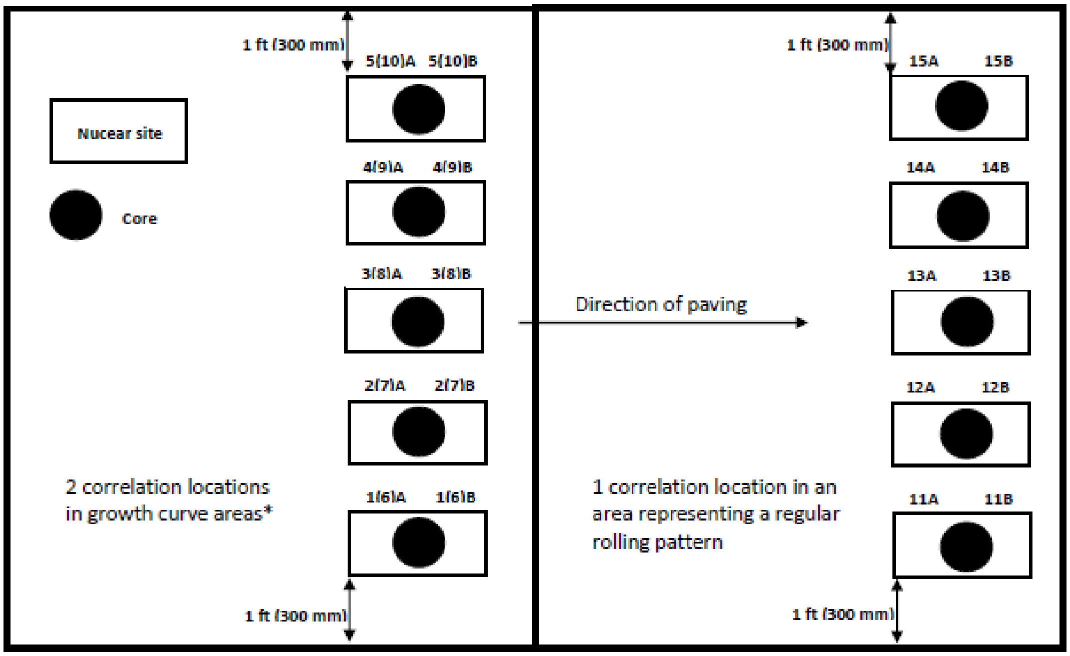
BACKSCATTER MODE



2 of 3 locations **1 of 3 locations**

* First growth curve is between 225 and 250 tons (200 and 225 metric tons). The second growth curve is between 275 and 300 tons (250 and 275 metric tons).

NUCLEAR /CORE CORRELATION TEST LOCATION LAYOUT

Figure 1

Illinois Department of Transportation

Nuclear / Core Correlation Field Worksheet

Date: ______________________
Contract: ______________________ Gauge No.: ______________
Job No.: ______________________ Layer Thickness: ______________
Route: ______________________ Gmm: ______________
Base Material: ☐ Milled ☐ Binder ☐ Aggregate Other: ______________________
Mix No.: ______________________
Mix Code: ______________________
Use: ______________________ (surface, 1st lift binder, etc.)

Reading 1	**Reading 2**	1.5 lb/ft³ (23.5 kgs/m³) tol. **Reading 3** (if applicable)	**Average Nuc.**	**Core Density**

STATION: ______________

1A)	1B)	1A) 1B)	1)	1)
2A)	2B)	2A) 2B)	2)	2)
3A)	3B)	3A) 3B)	3)	3)
4A)	4B)	4A) 4B)	4)	4)
5A)	5B)	5A) 5B)	5)	5)

STATION: ______________

6A)	6B)	6A) 6B)	6)	6)
7A)	7B)	7A) 7B)	7)	7)
8A)	8B)	8A) 8B)	8)	8)
9A)	9B)	9A) 9B)	9)	9)
10A)	10B)	10A) 10B)	10)	10)

STATION: ______________

11A)	11B)	11A) 11B)	11)	11)
12A)	12B)	12A) 12B)	12)	12)
13A)	13B)	13A) 13B)	13)	13)
14A)	14B)	14A) 14B)	14)	14)
15A)	15B)	15A) 15B)	15)	15)

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Hot-Mix Asphalt Test Strip Procedures
Appendix B.4

Effective Date: May 1, 1993
Revised Date: December 1, 2023

When the quantity of a mixture exceeds 3000 tons (2750 metric tons) on a contract, the Contractor and the Department shall make an evaluation of the mixture using a 300 ton (275 metric ton) test strip at the beginning of HMA production. The Contractor shall adhere to the following procedures for constructing a test strip.

A. Contractor/Department Test Strip Team

As the test strip is constructed, a team of both Contractor and Department personnel will evaluate the mix.

The test strip team may consist of the following:

1. Resident Engineer
2. District Construction Supervising Field Engineer, or representative
3. District Materials Mixtures Control Engineer, or representative
4. District Nuclear Density Gauge Tester
5. Contractor's QC Manager, required
6. Contractor’s Paving Superintendent
7. Contractor's Density Tester

Optional:

8. Central Bureau of Construction representative
9. Central Bureau of Materials representative
10. Asphalt Binder Supplier representative

B. Communications

The Contractor shall advise the team members 48 hours in advance of the anticipated start date/time of production of the test strip mix. The QC Manager shall direct the activities of the test strip team. A Department appointed representative from the test strip team will act as spokesperson for the Department.

C. Test Strip Method

The mix design shall have been approved by the Department prior to the test strip. Target values shall be provided by the Contractor and will be approved by the Department prior to constructing the test strip.

The Contractor shall produce 300 tons (275 metric tons) of mix for the test strip.

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Hot-Mix Asphalt Test Strip Procedures
Appendix B.4

Effective Date: May 1, 1993
Revised Date: December 1, 2023

The procedures listed below shall be followed to construct a test strip.

1. Location of Test Strip - The test strip shall be located on a relatively flat portion of the roadway. Descending/ascending grades or ramps should be avoided.

2. Constructing the Test Strip - After the Contractor has produced and placed approximately 225 to 250 tons (200 to 225 metric tons) of mix, paving shall cease and a growth curve shall be constructed. After completion of the first growth curve, paving shall resume for the remaining 50 to 75 tons (45 to 70 metric tons), and the second growth curve shall be constructed within this area. The Contractor shall use normal rolling procedures for all portions of the test strip except for the growth curve areas which shall be compacted as directed by the QC Manager.

3. Mixture Sampling - Mixture samples shall be taken by the Contractor in the field at such a time as to represent the mixture in-between the two growth curves. The Contractor has the option to sample mixture for Department Hamburg Wheel, I-FIT, Tensile Strength, and TSR testing on the first production day after completion of an acceptable test strip. The sampling procedure shall follow the method of field sampling described in the document "Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples" Section D. Department Random Verification Mixture Sample Determination and Collection.

   In addition to the quantity of mix the Contractor collects for their volumetric tests per Standard Specification Article 1030.09(a), the Contractor shall also collect a sufficient quantity of mix for Department tests. This shall include 50 lb (23 kg) for volumetric testing, a minimum of 150 lb (70 kg) for the Contractor to fabricate Hamburg Wheel and I-FIT gyratory cylinders, and if this test strip is the first of the year for the mix design, an additional 100 lb (45 kg) for the Contractor to fabricate gyratory cylinders for Tensile Strength and TSR testing.

D. <u>Compaction Requirements</u>

1. Compaction Equipment - The Contractor shall provide a roller meeting the requirements of Article 1101.01(g) for dense graded mixtures and 1101.01(e) for SMA and IL-4.75 mixtures. It shall be the responsibility of the QC manager to verify roller compliance before commencement of growth curve construction.

   a. Dense Graded Mixtures – A vibratory roller shall be used with an appropriate amplitude determined based on the roller weight and mat thickness to achieve maximum density. The vibratory roller speed shall be balanced with frequency so as to provide compaction at a rate of not less than 10 impacts per 1 ft (300 mm).

Illinois Department of Transportation

Hot-Mix Asphalt Test Strip Procedures
Appendix B.4

(continued)
Effective Date: May 1, 1993
Revised Date: December 1, 2023

b. SMA and IL-4.75 Mixtures – A static roller shall be used with the weight determined by the mixture composition, mat thickness, and ability to achieve maximum density.

2. Compaction Temperature - In order to make an accurate analysis of the density potential of the mixture, the initial compaction temperature of the mixture on the pavement at the beginning of the growth curve shall be no more than 10°F (5°C) lower than the minimum mixture placement temperature specified in Article 406.06.

3. Compaction and Testing - The Contractor shall direct the roller speed and number of passes required to obtain a completed growth curve. The nuclear gauge shall be placed near the center of the hot mat and the position marked for future reference. With the bottom of the nuclear gauge and source rod clean, a 1-minute nuclear reading (without mineral filler) shall be taken after each pass of the roller. Rolling shall continue until a growth curve can be plotted, the maximum density determined, and three consecutive passes show no appreciable increase in density or evident destruction of the mat.

4. Final Testing - A core shall be taken and will be secured by the Department from each growth curve to represent the density of the in-place mixture. Additional random cores may be required as determined by the Engineer.

E .<u>Evaluation of Growth Curves</u>

Mixtures which exhibit density potential less than or greater than the density ranges specified in 1030.09(c) shall be considered to have a potential density problem which is sufficient cause for mix adjustment.

If an adjustment is made at the plant, the Engineer may require an additional test strip to be constructed and evaluated. This information shall then be compared to the AJMF and required design criteria for acceptance.

F .<u>Nuclear/Core Correlation</u>

When required, a correlation of core and nuclear gauge test results shall be performed on-site as defined in the document “Procedure for Correlating Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt”. This correlation shall be completed by the Contractor prior to the next day's production. Smoothness of the test strip shall be to the satisfaction of the Engineer.

Illinois Department of Transportation

Hot-Mix Asphalt Test Strip Procedures
Appendix B.4

(continued)
Effective Date: May 1, 1993
Revised Date: December 1, 2023

G. Documentation

All test strip volumetric test results, rolling pattern information (including growth curves), and nuclear readings and core test results for correlating the nuclear gauge shall be tabulated by the Contractor with a copy provided to each team member and the original retained in the project files.

State of Illinois
Department of Transportation
Bureau of Materials
Springfield

POLICY MEMORANDUM

Revised: July 27, 2023	6-08.8
This Policy Memorandum supersedes number 6-08.7 dated February 7, 2023	

TO: REGIONAL ENGINEERS AND HIGHWAY BUREAU CHIEFS
AGGREGATE, HOT-MIX ASPHALT (HMA), AND
PORTLAND CEMENT CONCRETE (PCC) PRODUCERS

SUBJECT: MINIMUM PRIVATE LABORATORY REQUIREMENTS FOR CONSTRUCTION MATERIALS TESTING OR MIX DESIGN

1.0 SCOPE

This policy governs the minimum qualifications for materials **Private Quality Control (QC)** and **Quality Assurance (QA) Laboratories** operated by **Contractors**, **Producers** and **Consultants**.

It applies to three categories of materials testing:

1. Aggregate (Agg)
2. Hot-mix asphalt (HMA)
3. Portland cement concrete (PCC)

Private Quality Control Laboratories shall be approved as one or more of the following laboratory types:

1. Agg QC
2. HMA/Agg QC
3. HMA Design/Agg QC
4. PCC/Agg QC
5. Jobsite PCC QC

Private Quality Assurance Laboratories shall be approved as one or more of the following laboratory types:

1. HMA /Agg QA
2. PCC/Agg QA

Qualified Private Laboratories are permitted to conduct **Acceptance Program** testing for localities such as counties, cities and municipalities. Note, however, that **Qualified Private Laboratories** are not permitted to perform **QC** (including mix design) and acceptance testing on the same project.

2.0 PURPOSE

1. To ensure that **Private QC and QA Laboratories** are equipped and maintained at a uniform and high level of quality.
2. To establish uniform procedures for evaluating and approving **Private QC and QA Laboratories**.
3. To maintain a uniform standard for inspecting test equipment and test procedures.

3.0 AUTHORITY AND REFERENCES

3.1 **Authority.** Federal regulations (23 CFR Part 637) require the **Department** to establish an **Acceptance Program** for qualifying construction testing laboratories.

3.2 **References.**

1. IDOT Standard Specifications for Road and Bridge Construction.
2. IDOT Manual of Test Procedures for Materials.
3. IDOT Bureau of Design and Environment Special Provisions for Hot-Mix Asphalt and Portland Cement Concrete.
4. AASHTO, ASTM, and IDOT Test Procedures.
5. Code of Federal Regulations (23 CFR Part 637).
6. Department Policy MAT-15, “Quality Assurance Procedures for Construction.”
7. IDOT Bureau of Local Roads and Streets Manual

4.0 DEFINITIONS

AASHTO - American Association of State Highway and Transportation Officials.

AASHTO R 18 - The **AASHTO** Standard for "Establishing and Implementing a Quality System for Construction Materials Laboratories." The principles and/or requirements of **AASHTO R 18** are used by the **Bureau** to administer the **Qualified Laboratory** program for **District** and **Private Laboratories**.

AASHTO RE:SOURCE - Administrator of the Accreditation, Laboratory Assessment, and Proficiency Sample Programs for **AASHTO** (formerly the American Materials Reference Laboratory or AMRL). Re:source is part of the Engineering and Technical Services Division of **AASHTO**.

ACCEPTANCE PROGRAM – All factors that comprise the Department’s determination of the quality of the product as specified in the contract requirements. These factors include verification (**QA**) sampling, testing, and inspection and may include results of **QC** sampling and testing.

ACCREDITED LAB - A laboratory that is currently accredited by the **AASHTO** Accreditation Program (AAP) or other accrediting body recognized by **FHWA**.

ASTM - American Society for Testing Materials.

ASTM C 1077 - The **ASTM** “Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation"

The principles and/or requirements of **ASTM C 1077** are used by the **Bureau** to administer the **Qualified Laboratory** program for **District** and **Private Laboratories**.

BUREAU - Central Bureau of Materials (CBM), Illinois **Department** of Transportation.

BUREAU LABORATORY - The **Department's** central laboratory maintained and operated by the **Bureau**. The **Bureau Laboratory** administers the **Qualified Laboratory** program for **District** and **Private Laboratories**.

CCRL – Cement and Concrete Reference Laboratory.

CONSULTANT - A private firm which performs construction materials testing for the **Department**, **Producer**, or **Contractor**. **Department** prequalification and **AASHTO** accreditation requirements apply where **Department** construction testing is performed directly for the **Department** under a **Department** contract or subcontract.

CONTRACTOR - The individual, firm, partnership, joint venture, or corporation contracting with the **Department** for performance of prescribed work.

DEPARTMENT - Illinois Department of Transportation (IDOT), including its **Districts** and Central Bureau offices.

DISTRICT - District office, Illinois **Department** of Transportation.

DISTRICT LABORATORY - A **Department** laboratory that is operated by a **District**.

FHWA - Federal Highway Administration.

FIELD TESTS - Tests that may be performed outside of a laboratory. For example, a portland cement concrete (PCC) or hot-mix asphalt (HMA) test performed at the jobsite.

INDEPENDENT ASSURANCE – Activities that are an unbiased and independent evaluation of all the sampling and testing (or inspection) procedures used in the quality assurance program. [*IA* provides an independent verification of the reliability of the acceptance (or verification) data obtained by the agency and the data obtained by the contractor. The results of *IA* testing or inspection are not to be used as a basis of acceptance. *IA* provides information for quality system management.] Policies and procedures contained in this memorandum are also an aspect of independent assurance.

LOCAL AGENCY - Governmental agency such as a county, city, or municipality.

NIST - National Institute for Standards and Technology.

PRIVATE LABORATORY - Any construction materials testing or design laboratory not operated by the **Department** or a **Local Agency**. This includes **Contractor**, **Producer**, or **Consultant** laboratories performing **Quality Control**, **Quality Assurance**, acceptance, **Independent Assurance**, or any other required or contracted testing on a **Department** project.

PRODUCER - An individual or business entity providing materials and/or products for performance of prescribed work.

QUALIFIED LABORATORY - A laboratory that is inspected and approved by the **Department**. FHWA's regulations (23 CFR 637.203) define these as *Laboratories that are capable as defined by appropriate programs established by each state transportation department. As a minimum, the qualification program shall include provisions for checking test equipment, and the laboratory shall keep records of calibration checks.*

QUALIFIED PERSONNEL - Personnel with demonstrated and documented capability to perform the applicable inspection and testing. The minimum requirement for aggregate, hot-mix asphalt or portland cement concrete testing is successful completion of the prescribed **Department** Quality Management Training Program classes. (Note: Additional personnel or experience requirements may apply to labs performing professional service work for the **Department**, e.g. Professional Engineer (P.E.) registrations, resumes, documented experience. When required, such notice will be provided in the prequalification process or solicitation notice.)

QUALITY ASSURANCE (QA) - All those planned and systematic actions necessary to provide adequate **Department** confidence that materials; manufactured, fabricated or constructed items; processes; products; designs; conducted test procedures; etc. will satisfy the requirements of the **Specifications**, **Quality Control Plan**, etc., as applicable.

QUALITY CONTROL (QC) - The sum total of activities performed by a **Producer**, **Contractor**, **Consultant**, **Manufacturer**, etc. to make sure materials; manufactured, fabricated or constructed items; processes; products; designs; conducted test procedures; etc. will satisfy the requirements of the **Specifications**, **Quality Control Plan**, etc., as applicable.

QUALITY ASSURANCE TESTING CONSULTANT – A Professional Engineering firm that is prequalified by the **Department** to perform field and/or laboratory tests for the **Department**. Required tests for **Quality Assurance Testing Consultants** are listed in Attachment A Table 2.

QUALITY ASSURANCE LABORATORY - Any laboratory used for **Quality Assurance** testing (**Department** tests) required by the **Department**. Required tests for **Quality Assurance Laboratories** are listed in Attachment A Table 2.

QUALITY CONTROL LABORATORY - Any laboratory used for **Quality Control** testing (**Contractor** or **Producer** tests) required by the **Department**. Required tests for **Quality Control Laboratories** are listed in Attachment A Table 1.

QUALITY CONTROL MANAGER - A **Consultant** or an employee of a **Contractor**, **Producer**, **Manufacturer**, etc. who is responsible for compliance with the **QC** requirements in a **Department** contract or policy.

STATE - The state of Illinois.

SPECIFICATIONS - Specifications for materials; manufactured, fabricated or constructed items; processes; products; designs; conducted test procedures, etc. which includes the **Standard Specifications**, supplemental specifications and recurring special provisions, highway standards, shop drawings, contract plans, project special provisions, **AASHTO Specifications**, **ASTM Specifications**, etc., as applicable.

STANDARD SPECIFICATIONS - The **Department's** Standard Specifications for Road and Bridge Construction.

TECHNICAL MANAGER - The individual with responsibility for the overall operations, condition, and maintenance of the **Private Laboratory**. The **Technical Manager** shall be identified in writing. The **Technical Manager** is not required to be the **QC Manager** defined in the contract. However, the **Technical Manager** shall be familiar with the **Quality Control** testing requirements and the specified equipment.

5.0 PRIVATE LABORATORY REQUIREMENTS

5.1 Personnel Qualifications/Responsibilities.

5.1.1 All testing for **Department** contracts shall be performed by **Qualified Personnel** as specified in the contract. This includes any testing related to **Quality Assurance**, **Quality Control** and **Independent Assurance**.

5.1.2 The **Department** will maintain a computer database of **Qualified Personnel** who have successfully passed the appropriate Quality Management Training Program classes.

5.2 Facilities and Equipment.

5.2.1 The **Department** will approve all **Private Laboratories** used on **Department** projects.

5.2.2 Each **Private Laboratory** shall maintain the equipment and facilities necessary to perform the tests required for each laboratory type it is approved for. Lists of required **Private Laboratory** test capabilities for each **Qualified Laboratory** type are provided in Tables 1 and 2 located in Attachment A.

5.2.3 Each **Private Laboratory** shall have adequate floor space to efficiently conduct the required tests for each laboratory type it is approved for. Minimum floor space requirements are provided under "Model Quality Control Plans" in Appendices B and C of the Manual of Test Procedures for Materials.

5.2.4 Each **Private Laboratory** shall have HVAC equipment capable of maintaining a room temperature of 20 to 30º C (68-86º F). A **Private Laboratory** that performs only aggregate gradation and/or aggregate moisture testing is exempt from this requirement.

5.2.5 Each **Private Laboratory** shall maintain, at a minimum, the required equipment for each laboratory type it is approved for as outlined in the appropriate appendix to the Manual of Test Procedures for Materials. Appendix D.3 applies to aggregate equipment, Appendix C.3 applies to portland cement concrete equipment, and Appendix D.4 applies to hot-mix asphalt equipment.

6.0 QUALITY SYSTEM CRITERIA

6.1 **AASHTO R 18 and ASTM C 1077.** Each **Private Quality Assurance Laboratory** shall maintain **AASHTO** accreditation for the required tests outlined in Attachment A Table 2 for each laboratory type it is approved for. The implemented quality system shall be according to **AASHTO R 18** for HMA/Agg labs, and **AASHTO R 18** and **ASTM C 1077** for PCC/Agg labs.

6.2 **Technical Manager.** Each **Private Laboratory** shall have a **Technical Manager** (however titled) who has overall responsibility for the technical operations of the **Private Laboratory**. The **Technical Manager** shall be responsible for equipment maintenance, calibration, standardization, verification and checks; maintaining records; and ensuring that current test procedures are utilized. If the **Private Laboratory** is prequalified in a Professional **Consultant** service category, a licensed Illinois Professional Engineer shall have direct supervision of the laboratory.

6.3 **Equipment Calibration, Standardization, Verification and Checks (C/S/V/C).** The **Private Quality Control Laboratory** shall calibrate, standardize, verify or check all testing equipment associated with tests performed for each laboratory type it is approved for according to Attachment A Table 3. The table also provides descriptive notes and links to forms that may be used to document lab equipment C/S/V/Cs. Heavy use or specific test requirements may require more frequent intervals than those given in Attachment A Table 3. **Department** verification of **Private Quality Control Laboratory** equipment shall not be construed as part of, or substitute for, equipment calibration, standardization, verification or check requirements, except for **Department** verification of the gyratory compactor using the DAV-2 and **Department** verification of the gyratory molds using the bore gauge.

The **Private Quality Assurance Laboratory** shall meet the requirements listed above for the **Private Quality Control Laboratory** for each laboratory type it is approved for. In addition, the **Private Quality Assurance Laboratory** shall calibrate, standardize, verify or check all equipment associated with the tests for which the **Private Quality Assurance Laboratory** is accredited according to **AASHTO R 18** and **ASTM C 1077**, as applicable.

6.4 **Department Proficiency Testing.** **Private Laboratory** qualifications may include round-robin proficiency testing conducted by the **Department**. Results of proficiency testing may be considered in the overall evaluation of the **Private Laboratory** to conduct specific tests.

6.5 **Records.**

6.5.1 Test Records. Each **Private Laboratory** shall maintain test records which contain sufficient information to permit verification of any test report.

6.5.2 Laboratory Quality Records. Each **Private Laboratory** shall maintain documentation of internal quality controls. At a minimum, the records shall include:

1. Documentation of assignment of personnel responsible for internal quality controls.
2. Documentation of equipment calibration, standardization, verification and checks.
3. All documentation shall be maintained and available for **Department** inspection for a period of three years.

6.5.2.1 Equipment Calibration, Standardization, Verification and Check Records. Calibration, standardization, verification and check records shall include the minimum information listed below. **AASHTO R 18** and **ASTM C 1077** provide additional guidance for recording calibration, standardization, verification and check records for testing equipment.

1. Description.
2. Model & Serial Number.
3. Name of person calibrating, standardizing, verifying or checking.
4. Equipment used for calibration, standardization, verification or checks (e.g., standard weights, proving rings, thermometers).
5. Date calibrated, standardized, verified, or checked & next due date.
6. Reference procedure used.
7. Results of calibration, standardization, verification or checks.

6.5.3 Proficiency Sample Records. Each **Private Laboratory** shall retain results of participation in any proficiency sample program, including the documentation of steps taken to determine the cause of poor results and corrective action taken.

6.6 **Publications.** Each **Private Laboratory** shall maintain current copies or electronic access to the required test procedures for each laboratory type it is approved for. Each **Private Laboratory** shall maintain a current copy or electronic access to the Manual of Test Procedures for Materials.

7.0 LABORATORY INSPECTIONS

7.1 **General.** The **Department** will approve **Private Quality Control** and **Quality Assurance Laboratories** by inspection and other requirements, as applicable.

7.1.1 Aggregate and Jobsite PCC **Private QC Laboratories**. Initial inspections and re-inspections will be performed by the District.

7.1.2 All Other **Private Laboratories**. Initial inspections are performed by the Bureau. Re-inspections are performed by the District.

7.1.3 Documentation review of a **Private Laboratory's** equipment calibration, standardization, verification and check records by the **Bureau** and resolution of any nonconformities is required prior to the initial **Bureau** inspection according to Subsection 7.4.4 for **Private Laboratories** seeking to become a **Quality Control Laboratory** or **Quality Assurance Testing Consultant**.

7.1.4 Initiation of the prequalification process with the Bureau of Design and Environment is required prior to initial **District** pre-inspection according to Subsection 7.4.3 and initial **Bureau** inspection according to Subsection 7.4.4 for **Private Laboratories** seeking to become a **Quality Assurance Testing Consultant.**

7.2 **AASHTO Accredited Private Quality Assurance Laboratories.**

7.2.1 Current **AASHTO** accreditation as well as providing **Departmental** access to the results of participation in the **AASHTO** Proficiency Sample Program is a prerequisite for beginning the prequalification process for a **Private Laboratory** to become a **Quality Assurance Testing Consultant**. Other prerequisites may be found in the prequalification instructions and forms. **AASHTO re:source** shall provide accreditation assessment for HMA/Agg **QA Laboratories**. **CCRL** shall provide accreditation assessment for PCC/Agg **QA Laboratories**. Instructions for providing the **Department** access to a **Private Laboratory's** Proficiency Sample Program results can be found in Attachment B.

7.2.2 **AASHTO** accreditation does not waive the right of the **Department** to conduct inspections and/or re-inspections.

7.3 **Initial Private Laboratory Inspection Scope.**

1. Facilities - Physical and environmental conditions.
2. Equipment - Test apparatus for specification compliance.
3. Documentation - Calibration, standardization, verification and check records.
4. Personnel - A review of **Qualified Personnel** credentials.
5. Observation - The **Private Laboratory** may be required to demonstrate required tests. Some test procedures, such as **Field Tests**, may be evaluated through discussion with laboratory personnel.
6. Report - The **Private Laboratory** will be provided with a report listing those tests for which it is approved. The report will note deficiencies.

7.4 **Initial Private Laboratory Inspection Procedure.**

7.4.1 The **Private Laboratory** shall submit a written request for an inspection to the **District**. The request shall indicate the following:

1. The location of the **Private Laboratory**.
2. The type of **Private Laboratory**, i.e., Agg QC, PCC/Agg QC, HMA /Agg QA, etc.
3. The name of the **Technical Manager** who will be present for the inspection.
4. The date the **Private Laboratory** will be ready for inspection.

7.4.2 The **District** will notify the **Bureau** of the inspection request and coordinate with the **Private Laboratory** to submit equipment calibration, standardization, verification, and check records to the **Bureau**. Once all record nonconformities are resolved, **Bureau** personnel will establish a tentative date to perform the inspection (see also Subsection 7.1.3).

7.4.3 The **District** will perform a pre-inspection approximately seven calendar days before the **Bureau** inspection. The **District** will verify that the **Private Laboratory** is ready for inspection and notify the **Bureau**.

7.4.4 **Bureau** personnel will perform the inspection and prepare a preliminary report. Standard inspection forms and a preliminary report, developed and maintained by the **Bureau Laboratory**, will be used.

7.4.5 **Bureau** personnel will assign identification numbers to all test equipment. Unless a **District** has an established numbering system, the following sequences will be used:

<u>Sieves</u>
e.g., IL07 -1418-01

where: IL = State

07 = inspection year
1418-01 = Producer/Supplier Number

Sieves are engraved on the inside of the bottom lip directly beneath the label. If a laboratory does not have a producer/supplier number, all sieves will be engraved with one number that follows the numbering system for HMA or PCC lab equipment, as appropriate.

HMA Equipment
e.g., IL07B1 - 123

where: IL = State
07 = inspection year
B = hot mix asphalt (bituminous)
1 = district number
123 = sequential numbers

PCC Equipment
e.g., IL07C1 - 123

where: IL = State
07 = inspection year
C = concrete
1 = district number
123 = sequential numbers

Note: The numbering system prior to 2007 was IL07-123 for HMA and IL07CND1-123 for PCC. The change was made to make the numbering system more uniform.

7.4.6 **Bureau** personnel will perform a close-out with the **Technical Manager** and the **District** representative. The **Technical Manager** and the **District** will be given a copy of the preliminary report.

7.4.7 If a review of the preliminary report indicates there are no deficiencies, the **Bureau** will provide written notification to the **Private Laboratory** indicating the **Private Laboratory** is now an approved **Quality Control** or **Quality Assurance Laboratory**. The notification will include an equipment list. A copy of the notification will be provided to the **District**.

7.4.8 If the preliminary report indicates there are deficiencies, the **Bureau** will provide written notification to the **Private Laboratory**, indicating the deficiencies and that corrective action is required. A copy of the written notification will be provided to the **District**.

7.4.9 After correction of all cited deficiencies, the **Private Laboratory** shall notify the **District**. The **District** will inspect the **Private Laboratory** to verify the deficiencies have been corrected and will notify the **Bureau** in writing.

7.4.10 The **Bureau** will provide written notification to the **Private Laboratory**, indicating the **Private Laboratory** is now an approved **Quality Control** or **Quality Assurance Laboratory**. The notification will include an equipment list. A copy of the written notification will be provided to the **District**.

7.4.11 Uncorrected deficiencies will not be waived. Equivalent equipment specifications may be approved only with the written approval of the **Bureau's** Engineer of Concrete, Soils, and Metals.

7.5 Initial Private Aggregate Quality Control Laboratory Inspection. For aggregate and Jobsite PCC **Private Quality Control Laboratories**, the procedures outlined in 7.4 shall be followed, except **District** personnel will perform the inspection instead of personnel from the **Bureau**.

7.6 Re-Approval of Approved Private Laboratories.

7.6.1 The re-inspection of **Private Laboratories** shall be conducted at intervals deemed appropriate by the **District**. The interval between inspections shall not exceed two calendar years. The **District's** evaluation may include the following:

1. Physical inspection of the laboratory facility and equipment.
2. Review of the **Private Laboratory's** internal quality plan and documentation in accordance with this policy and those parts of **AASHTO R 18** and **ASTM C 1077** incorporated by this policy.
3. Observations of tests performed by **Qualified Personnel**.
4. Results of split sample testing between the **Private Laboratory** and the **District**.
5. Results of proficiency sample testing programs conducted by the **Department**.
6. Overall past performance and experience.

7.6.2 The **District** may not waive any requirements for **Private Laboratories** or test equipment for required tests.

7.6.3 The **District** shall issue a letter of re-approval to the **Private Laboratory**, or provide a written and itemized deficiency list. The **Private Laboratory** shall notify the **District** when deficiencies are corrected and ready for re-inspection.

7.6.4 At any time, if the **District** identifies deficiencies in the facility, equipment, or test procedures that could affect the results of any **QC** or **QA** tests, the **District** will require the **Private Laboratory** to take immediate action to correct the deficiency.

8.0 EXEMPTIONS – AASHTO ACCREDITATION PROGRAM

If a **Private Laboratory** maintains current accreditation through the **AASHTO** Accreditation Program (AAP) for the appropriate test procedures, the **District** may waive the re-inspection requirements of this policy. To enact the waiver, the **Private Laboratory** shall provide copies of inspection reports and proficiency sample results to the **District**. This waiver does not apply to the initial inspection requirements, including the required equipment list.

9.0 LABORATORY DATABASE

The **Bureau** is responsible for maintaining a database that monitors the approval status of **Department and Private Laboratories**. Online queries and reports are available to the **Districts** to assist them in tracking **Qualified Laboratories**. The **Bureau** is responsible for updating the database with the approval status of **District Laboratories** and for entering the initial approval of **Private Laboratories**. The **District** shall be responsible for updating the approval status of **Private Laboratories** based on subsequent re-inspections. The **District** shall also be responsible for initial recording and updating the approval status of **Local Agency Laboratories**, Aggregate Only **Private Laboratories** and PCC Jobsite **Private Laboratories**. The database will include the following information:

1. Laboratory Codes (**Department**, **Producer**, etc.)
2. Responsible **District**
3. Type Laboratory (Agg QC, HMA/Agg QC, HMA Design/Agg QC, PCC/Agg QC, Jobsite PCC QC, HMA/Agg QA, or PCC/Agg QA)
4. Demographics (Address, etc.)
5. Date Inspected
6. Approval Status

10.0 CLOSING NOTICE

Archived versions of this policy memorandum may be examined by contacting the **Bureau**.

The current **Bureau** Chief of Materials has approved this policy memorandum. Signed documents are on file with the **Bureau**.

TABLE 1
PRIVATE QUALITY CONTROL LABORATORY TESTS

	PROCEDURE	PRIVATE QC LAB TYPE					
	Illinois Modified AASHTO (IL Mod.)	AGG	HMA QC	HMA DESIGN	PCC QC	Jobsite PCC QC	TITLE
AGGREGATE TESTS	**IL Mod. R 90**	✓	✓	✓	✓		**Sampling of Aggregates**
	IL Mod. T 11	✓	✓	✓	✓		**Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing**
	IL Mod. T 19	✓[1]					**Bulk Density ("Unit Weight") and Voids in Aggregate**
	IL Mod. T 27	✓	✓	✓	✓		**Sieve Analysis of Fine and Coarse Aggregate**
	IL Mod. T 84	✓[2]					**Specific Gravity and Absorption of Fine Aggregate**
	IL Mod. T 85	✓[2]					**Specific Gravity and Absorption of Coarse Aggregate**
	IL Mod. R 76	✓	✓	✓	✓		**Reducing Samples of Aggregate to Testing Size**
	IL Mod. T 255	✓	✓	✓	✓		**Total Evaporable Moisture Content of Aggregate by Drying**

Note 1: Required for laboratories that test Air Cooled Blast Furnace Slag.

Note 2: Required for laboratories that run the Department's Slag Producers' Self-Testing Program

TABLE 1 (CONT'D)
PRIVATE QUALITY CONTROL LABORATORY TESTS

	PROCEDURE		PRIVATE QC LAB TYPE		
	Illinois Modified AASHTO (IL Mod.)	Illinois Modified ASTM (IL Mod.)	HMA QC	HMA DESIGN	TITLE
HOT-MIX ASPHALT TESTS	IL Mod. T 30	-	✓	✓	Mechanical Analysis of Extracted Aggregate
	IL Mod. T 164	-	✓[3] or IL Mod. T 287 or IL Mod. T 308[4]	✓[3]	Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)
	IL Mod. T 166	-	✓	✓	Bulk Specific Gravity (Gmb) of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens
	IL Mod. T 209	-	✓	✓	Theoretical Maximum Specific Gravity (Gmm) and Density of Hot Mix Asphalt Paving Mixtures
	IL Mod. T 283	-		✓	Resistance of Compacted Hot Mix Asphalt (HMA) to Moisture-Induced Damage
	IL Mod. T 287	-	✓ or IL Mod. T 164 or IL Mod. T 308[4]		Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method
	IL Mod. T 308	-	✓ or IL Mod. T 164 or IL Mod. T 287[4]		Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
	IL Mod. T 312	-	✓	✓	Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
	-	IL Mod. D 2950	✓		Determination of Density of Bituminous Concrete in Place by Nuclear Methods – Field Test; not observed during Lab Inspection

Note 3: Method A or B shall be used for quantitative extraction. Method A or E shall be used to recover binder for qualitative analysis. If a QC HMA Mix Design laboratory does not have the ability to perform AASHTO T 164 (IL), outsourcing the test to a qualified QC or QA laboratory will be permitted.

Note 4: Determined by which piece of equipment is more appropriate for the lab to determine asphalt content.

TABLE 1 (CONT'D)
PRIVATE QUALITY CONTROL LABORATORY TESTS

	PROCEDURE		PRIVATE QC LAB TYPE		TITLE
	Illinois Modified AASHTO (IL Mod.)	Illinois Modified ASTM (IL Mod.)	PCC QC	Jobsite PCC QC	
PORTLAND CEMENT CONCRETE TESTS	IL Mod. R 39	-	Required if developing mix designs.		Making and Curing Concrete Test Specimens in the Laboratory
	IL Mod. R 60	-	✓	✓	Sampling Freshly Mixed Concrete
	IL Mod. R 100	-	✓	✓	Making and Curing Concrete Test Specimens in the Field
	IL Mod. T 22	-	✓[5] or IL Mod. T 177		Compressive Strength of Cylindrical Concrete Specimens
	IL Mod. T 119	-	✓	✓	Slump of Hydraulic Cement Concrete
	IL Mod. T 121	-			Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
	IL Mod. T 152	-	✓	✓	Air Content of Freshly Mixed Concrete by the Pressure Method - Type A or B Air Meter
	IL Mod. T 177	-	✓[5] or IL Mod. T 22		Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading)
	IL Mod. T 196	-			Air Content of Freshly Mixed Concrete by the Volumetric Method
	IL Mod. T 231	-	✓ or IL Mod. C 1231		Capping Cylindrical Concrete Specimens
	-	IL Mod. C 1064	✓	✓	Temperature of Freshly Mixed Hydraulic Cement Concrete
	-	IL Mod. C 1231	✓ or IL Mod. T 231		Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders

Note 5: For an exception to the strength testing requirement of performing compressive or flexural testing (Example: Labs at Concrete Producer Plants), refer to the Department's "Required Sampling and Testing Equipment for Concrete" document and check with District for approval of exception.

TABLE 2
REQUIRED TESTS – QUALITY ASSURANCE TESTING CONSULTANTS [1,2]

PROCEDURE			REQUIRED FOR PREQUALIFICATION			TITLE
			Private QA Lab Type: HMA/Agg and PCC/Agg			
	Illinois Modified AASHTO/ AASHTO	ASTM	IDOT QA	AAP On-Site Assessment	AAP Proficiency Sample Program	
AGGREGATE	Mod. R 90 R 90	-	✓			Sampling of Aggregates
	Mod. T 11	-	✓			Materials Finer Than 75-µm (No. 200)Sieve in Mineral Aggregates by Washing
	T 11	-		✓	✓	
	Mod. T 19	-	✓			Bulk Density ("Unit Weight") and Voids in Aggregate
	T 19	-		✓		
	Mod. T 27	-	✓			Sieve Analysis of Fine and Coarse Aggregates
	T 27	-		✓	✓	
	Mod. T 84[3]	-	✓			Specific Gravity and Absorption of Fine Aggregate
	T 84[3]	-		✓	✓	
	Mod. T 85[3]	-	✓			Specific Gravity and Absorption of Coarse Aggregate
	T 85[3]	-		✓	✓	
	Mod. R 76	-	✓			Reducing Samples of Aggregate to Testing Size
	R76	-		✓		
	Mod. T 255	-	✓			Total Evaporable Moisture Content of Aggregate by Drying
	T 255	-		✓		

Note 1: Compliance with IDOT test methods will be required for IDOT QA lab inspections. However, AASHTO re:source or CCRL lab inspections shall require compliance with the corresponding AASHTO or ASTM test methods.

Note 2: QA labs have the option to be HMA/Agg, PCC/Agg or HMA/PCC/Agg approved.

Note 3: Required for laboratories that run the Department's Slag Producers' Self-Testing Program.

TABLE 2 (CONT'D)
REQUIRED TESTS – QUALITY ASSURANCE TESTING CONSULTANTS [1, 2]

	PROCEDURE		REQUIRED FOR PREQUALIFICATION Private QA Lab Type: HMA/Agg			TITLE
	Illinois Modified AASHTO/ AASHTO	Illinois Modified ASTM	IDOT QA	AAP On-Site Assessment	AAP Proficiency Sample Program	
HOT-MIX ASPHALT	Mod. T 30	-	✓	✓		Mechanical Analysis of Extracted Aggregate
	T 30	-		✓	✓	
	Mod. T 164	-	✓			Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)
	T 164	-		✓	✓	
	Mod. T 166	-	✓			Bulk Specific Gravity (Gmb) of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens
	T 166	-		✓	✓	
	Mod. T 209	-	✓			Theoretical Maximum Specific Gravity (Gmm) and Density of Hot Mix Asphalt Paving Mixtures
	T 209	-		✓	✓	
	Mod. T 283	-	✓			Resistance of Compacted Hot Mix Asphalt (HMA) to Moisture-Induced Damage
	T 283	-		✓		
	Mod. T 287	-	✓^{4}			Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method
	Mod. T 308	-	✓^{4}			Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
	T 308	-		✓^{4}	✓	
	Mod. T 312	-	✓			Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
	T 312	-		✓	✓	
	-	IL Mod. D 2950	✓			Density of Bituminous Concrete in Place by Nuclear Method – Field Test

Note 1: Compliance with IDOT test methods will be required for IDOT QA lab inspections. However, AASHTO re:source or CCRL lab inspections shall require compliance with the corresponding AASHTO or ASTM test methods.

Note 2: QA labs have the option to be HMA/Agg, PCC/Agg or HMA/PCC/Agg approved.

Note 4: Requirement determined on case-by-case basis by District in which lab is located.

TABLE 2 (CONT'D)
REQUIRED TESTS – QUALITY ASSURANCE TESTING CONSULTANTS [1, 2]

	PROCEDURE		REQUIRED FOR PREQUALIFICATION			TITLE
			Private QA Lab Type: PCC/Agg			
	Illinois Modified AASHTO/ AASHTO/ Illinois Test Procedure (ITP)	Illinois Modified ASTM/ ASTM	IDOT QA	AAP On-Site Assessment	AAP Proficiency Sample Program	
PORTLAND CEMENT CONCRETE	-	C 192			✓	Making and Curing Concrete Test Specimens in the Laboratory
	Mod. R 60	-	✓			Sampling Freshly Mixed Concrete
	-	C 172		✓		
	Mod. R 100	-	✓			Making and Curing Concrete Test Specimens in the Field
	-	C 31		✓		
	Mod. T 22	-	✓			Compressive Strength of-Cylindrical Concrete Specimens
	-	C 39		✓	✓	
	Mod. T 119	-	✓			Slump of Hydraulic Cement Concrete
	-	C 143		✓	✓	
	Mod. T 121	-	✓			Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
	-	C 138		✓	✓	
	Mod. T 152	-	✓			Air Content of Freshly Mixed Concrete by the Pressure Method-Type A or B Air Meters
	-	C 231		✓	✓	
	Mod. T 177	-	✓			Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading)
	-	C 293		✓[5]		
	Mod. T 196	-	[6]			Air Content of Freshly Mixed Concrete by the Volumetric Method
	-	C 173		[6]	[7]	
	Mod. T 231	-	[6]			Capping Cylindrical Concrete Specimens
	-	C 617		[6]		
	-	Mod. C 1064	✓			Temperature of Freshly Mixed Hydraulic Cement Concrete
		C 1064		✓		
	-	Mod. C 1231	✓			Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders
		C 1231		✓		
	ITP 301		[6]			Fine Aggregate Moisture Content by the Flask Method
	ITP 302		[6]			Aggregate Specific Gravity and Moisture Content by the Dunagan Method
	ITP 303		[6]			Fine or Coarse Aggregate Moisture Content by Pycnometer Jar Method

Note 1: Compliance with IDOT test methods will be required for IDOT QA lab inspections. However, AASHTO re:source or CCRL lab inspections shall require compliance with the corresponding AASHTO or ASTM test methods.

Note 2: QA labs have the option to be HMA/Agg, PCC/Agg or HMA/PCC/Agg approved.

Note 5: The AAP on-site assessment is not required for Illinois type portable beam breakers but is required for all other types of beam breakers. Additional information regarding use of portable PCC labs and their approval is provided in Department Policy MAT-15, "Quality Assurance Procedures for Construction".

Note 6: Test equipment shall be presented during an inspection if the consultant lab has the ability to perform the test.

Note 7: Test shall be performed if consultant lab has the ability to perform the test.

TABLE 3
EQUIPMENT CALIBRATION, STANDARDIZATION, VERIFICATION AND CHECK SCHEDULE[1]

EQUIPMENT	REQUIREMENT	MAX. INTERVAL (MONTHS)	FORM AND/OR PROCEDURE
GENERAL			
General Purpose Balance and Scale	Commercial Service or Verification using Standardized NIST Traceable Masses	12	BMPR QCD01
Standard Masses	Standardize	60	Outside Calibration
Caliper	Standardize	12	BMPR QCD02
Micrometer	Standardize	12	BMPR QCD03
Oven	Standardize Thermometric Device	12	BMPR QCD04
Working Thermometer	Standardize with Calibrated NIST Traceable Reference Thermometer	12	BMPR QCD05
Reference Thermometer	Calibrate	60	Outside Calibration
Timer	Check Accuracy	12	BMPR QCD06
Caliper Checker or Gauge Blocks	Calibrate	60	Outside Calibration
AGGREGATE			
Mechanical Shaker	Check Sieving Thoroughness	12	BMPR QCD07
Agg. Unit Weight Measure	Standardize	12	BMPR QCD08
Conical Mold and Tamper	Check Critical Dimensions	24	BMPR QCD09
Coarse Sieves (Openings ≥ 4.75 mm)	Check Overall Physical Condition and Dimensions of Openings	12	BMPR QCD10 Calipers BMPR QCD11 Go/No-Go Gauges
Fine Sieves (Openings < 4.75 mm)	Check Overall Physical Condition	12	BMPR QCD12

EQUIPMENT	REQUIREMENT	MAX. INTERVAL (MONTHS)	FORM AND/OR PROCEDURE
HOT MIX ASPHALT			
Gyratory Compactor	Verify Angle[2], Pressure, and Height	Once a Month During Use	Manufacturer's Instructions[2]
	Verify Angle using a DAV-2	12	MTP Appendix B.19
Molds, Base Plates, and Ram Face	Check Critical Dimensions	12	BMPR QCD13
Tensile Strength Machine	Verification	12	ASTM E4
Ignition Furnace Balance	Commercial Service or Verification using Standardized NIST Traceable Masses	12	BMPR QCD01
Manometer and Vacuum Pump	Standardize and Check Pressure	12	BMPR QCD14
TSR Breaking Head	Check Critical Dimensions	12	BMPR QCD15
Pycnometer	Standardize Volume	12	CBM QCD16
Water Baths	Standardize	12	BMPR QCD17
Bore Gauge	Standardize	Each Use	IL Mod AASHTO T312
Master Ring	Calibrate	60	Outside Calibration
Hamburg Wheel Tracking Machine:			BMPR QCD18
Water Temperature	Verification	6	
Speed	Verification	12	
Wheel Weight	Verification	24	
LVDT'S	Verification	12	
I-FIT	Verify with Validator (Servo-hydraulic Machines only)	Once a Month During Use	See I-FIT Validator Lab Worksheet

EQUIPMENT	REQUIREMENT	MAX. INTERVAL (MONTHS)	FORM AND/OR PROCEDURE
PORTLAND CEMENT CONCRETE			
PCC Unit Weight Measure	Standardize	12	BMPR QCD34 Unit Weight Bucket BMPR QCD35 Air Meter Bowl
Air Meter (Pressure Type)	Standardize	12 (Type A)	BMPR QCD36
	Standardize	3 (Type B)	BMPR QCD37
Air Meter (Volumetric Type)	Standardize	12	BMPR QCD38
Compression & Flexural Testing Machine	Verification	12	ASTM E4
Capping Material	Check Strength	3 or New Shipment	BMPR QCD39
Slump Cone	Check Critical Dimensions	12	BMPR QCD40
Beam Molds	Check Critical Dimensions	12	BMPR QCD41
Plastic Cylinder Mold 4 x 8	Check Dimensions	Each Shipment	BMPR QCD42
Plastic Cylinder Mold 6 x 12	Check Dimensions	Each Shipment	BMPR QCD43
Retaining Rings and Neoprene Pads	Check Critical Dimensions and Neoprene Pad Usage	12	BMPR QCD44
Metal Stem Thermometer	Standardize with Calibrated NIST Traceable Reference Thermometer	12	BMPR QCD45
Moist Room/Storage Tank Recording Thermometer or Max/Min Thermometer	Standardize with Calibrated NIST Traceable Reference Thermometer	12	BMPR QCD46

Note 1: See AASHTO R 18 for equipment calibration, standardization, verification and check terminology definitions.
Note 2: See Manual of Test Procedures Appendix B.19 for permissible verification procedures.

Instructions for Providing Departmental Access to Results of Participation in the AASHTO Proficiency Sample Program for Quality Assurance Testing Consultants

Consultants seeking to become prequalified as a **Quality Assurance Testing Consultant** shall be accredited by **AASHTO**. Participation in the **AASHTO** Proficiency Sample Program is one of the requirements for accreditation. **Consultants** who are accredited by **AASHTO** shall also allow the **Department** access to their Proficiency Sample Ratings as part of the prequalification process.

To allow the **Department** access to these data from **AASHTO re:source** provided proficiency samples, **Consultants** should go to the **AASHTO re:source** website (http://www.aashtoresource.org) and follow the instructions given below:

1. Log into your account and navigate to your home page.
2. Using the green vertical menu on the left side of the page, click “My Specifiers”
3. Click “Search for Specifiers” at the top of the page
4. Using the drop-down menu, select “Illinois” as the State, or type in “Illinois Dept. of Transportation”. A list of results should populate including the ILDOT option. It is important to type in the specifier name EXACTLY as shown or it won’t find the Illinois Department of Transportation.
5. Click the green “Request” button. Confirm that you want to send a request.
6. The samples to be made available to the **Department** (with unlimited time periods) for evaluation shall be taken from Attachment A Table 2 and need only correspond to the QA Lab Type(s) a **Consultant** is seeking prequalification for.

To allow the **Department** access to these data from **CCRL** provided proficiency samples, **Consultants** should contact **CCRL** directly for assistance.

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Illinois Department of Transportation

Ignition Oven Aggregate Mass Loss Procedure
Appendix B18

Effective: May 1, 2005
Revised: May 1, 2007

A. Purpose

Dolomite aggregates that contain significant amounts of Magnesium Carbonate, when used in Hot-Mix Asphalt, have been found to undergo mass loss during ignition oven testing, which causes highly variable results in asphalt binder content. This procedure utilizes the ignition oven to identify these types of aggregates.

B. Procedure

1. Obtain a 3000 gram sample of the aggregate to be tested and oven dry to a constant mass in an oven set at 110° C ± 5° (230° F ± 9°). Constant mass is achieved by drying sample until further drying does not alter the mass by more than 0.5 g in one hour as stated in IL Modified AASHTO T-30.

2. Split sample into 3 separate 1000 gram samples.

3. Place one of the 1000 gram samples into the ignition oven catch pan.

4. Record the initial weight of the sample and catch pan at room temperature to the nearest 0.1 gram.

5. Place the sample and catch pan into an ignition oven preheated to 625 °C. ***Do not push the start button on the oven.*** Allow sample to remain in ignition oven for one hour.

6. After one hour, remove the sample and catch pan, allow it to cool to room temperature and record the weight to the nearest 0.1 gram.

7. Repeat steps 3 through 10 for the two remaining 1000 gram samples.

8. Calculate the aggregate mass loss for each run according to the following:

$$\Delta W = \left(\frac{Wi - Wf}{Wi} \right) \times 100$$

Where: ΔW = Aggregate mass loss in percent
Wi = Initial weight of the aggregate sample in grams
Wf = Final weight of the aggregate sample in grams after exposure to 625 °C

9. Calculate the average of the three mass loss results.

10. Aggregates exhibiting average mass loss in excess of 4% are likely to contain significant amounts of Magnesium Carbonate and will likely cause high variability in ignition oven test results for asphalt content.

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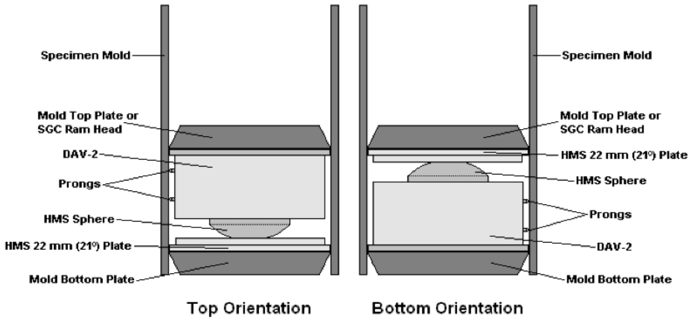
Procedure for Internal Angle Calibration of Superpave Gyratory Compactors (SGCs) using the Dynamic Angle Validator (DAV-2)

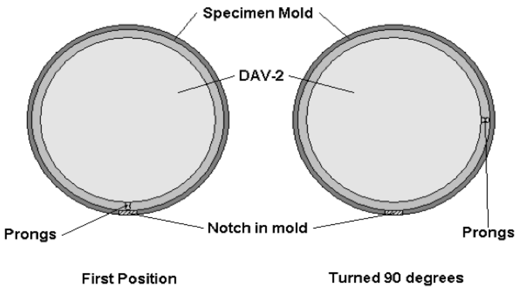
Internal Angle Testing with HMS

Nomenclature and DAV-2 orientation in the specimen mold

In the following sections, the terms "top" and "bottom" angles, "first position", and "turned 90 degrees" will be used. This refers to the position where the DAV-2 will be collecting angle data. The following diagrams will display how the DAV-2 will be oriented in the gyratory specimen mold and will help avoid confusion in the midst of testing:



Top Orientation Bottom Orientation

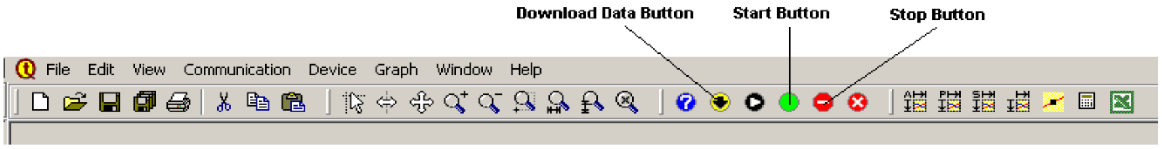


First Position Turned 90 degrees

Basic method for all compactors (additional instructions included for early model Troxler 4140s)

1. Attach the HMS sphere to the top of the DAV-2 using the supplied bolt. Tighten the bolt enough so that the sphere will not turn, but do not over tighten as this could strip out the bolt. The HMS plates are referred to by their eccentricity, or how far (in mm) from the center of the sphere the load is applied. The 22 mm plate (the one labeled "21", referring to the angle in degrees ground into the bottom of the plate) will be the only plate used in this calibration. Apply lubricant to the top of the sphere and to the angled surface on the bottom of the plate, as this will help to reduce wear from metal on metal contact. Petroleum jelly is the best lubricant to use with the DAV-2 and HMS.

2. Prior to testing, select two good, clean specimen molds to use for calibration. Make sure these molds are not too worn, are within specifications, and are used for production testing. The molds will be referred to as mold "A" and mold "B". Place molds "A" and "B" into an oven set at 305° F / 154° C for a minimum of 30 minutes. Connect the DAV-2 to a CPU using the supplied interface cable. If the CPU doesn't have a serial port, a serial to USB adapter may be used; these adapters, however, need software in order to function and this software must be installed before they will operate. There are three buttons in the Test Quip software that will be used. They are as follows:

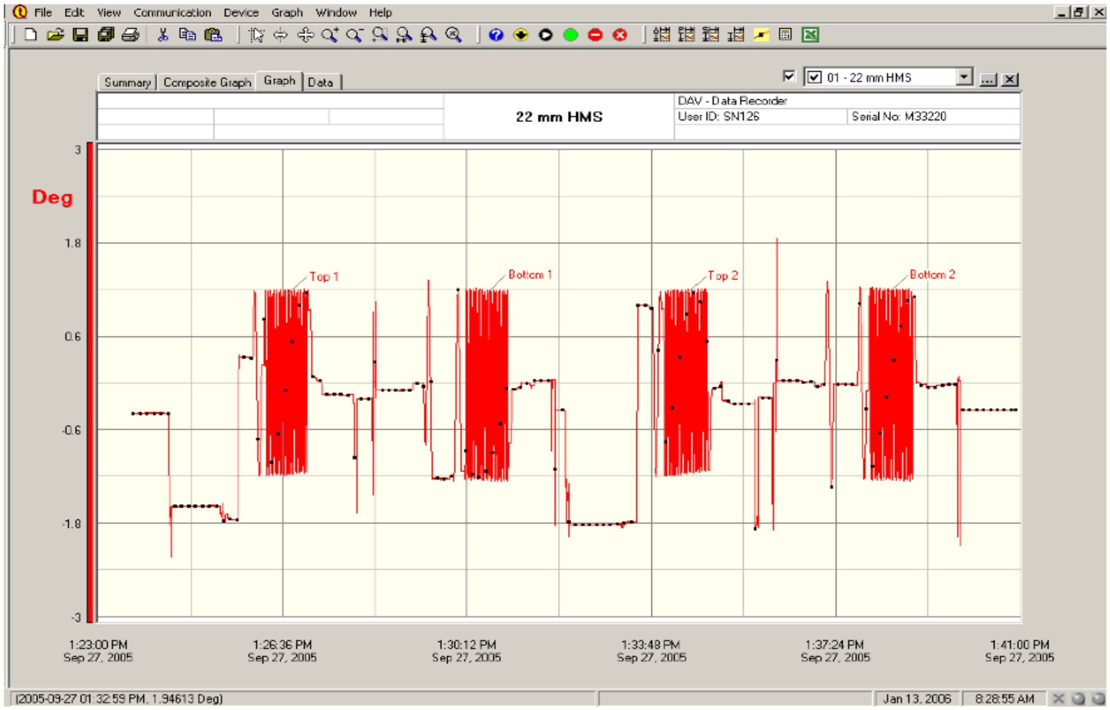


3. Open the Test Quip DAV-2 software and start data collection in the DAV-2 ("Start Button" in the illustration above). When data collection has been successfully initialized, disconnect the cable from the DAV-2. The DAV-2 has ~26 minutes of memory for data collection, so begin testing quickly so all test points will be collected within that time frame. Before placing the DAV-2 into a mold, apply lubricant to the bottom of the DAV-2. As the DAV-2 will spin during gyration, the lubricant will allow for free movement and help to reduce wear from metal on metal contact.

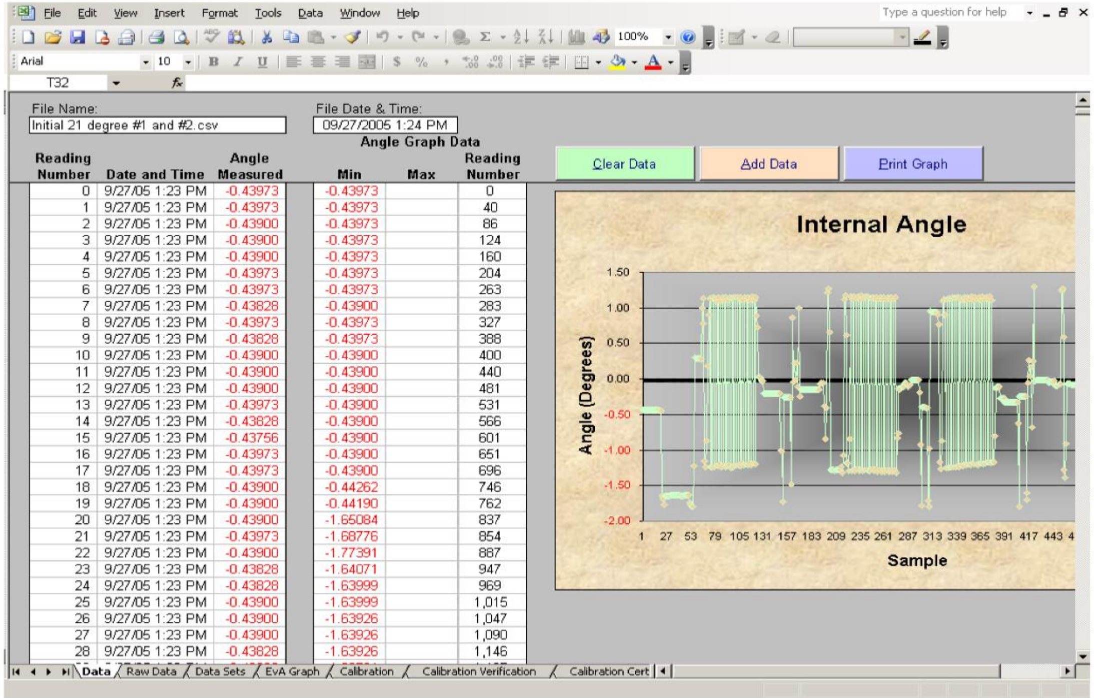
4. Take mold “A” out of the oven and begin testing. For the first bottom angle, place the DAV-2 and HMS plate into the mold, illustrated on the previous page as “bottom orientation”. Choose a reference point on the mold (for example, the notch on the top of the Troxler 4140 molds makes a handy reference point) and line the DAV-2’s prongs up with that point, as in the “first position” illustration on the previous page, before lowering it all the way into the mold. Place the mold in the SGC and gyrate for 25 gyrations. After this, extrude the DAV-2, flip the DAV-2 and HMS plate upside-down, and place the HMS plate and DAV-2 back into the mold, illustrated on the previous page as “top orientation”. Gyrate the first top angle using the “first position”, as was done with the first bottom angle, to line up the prongs. Extrude the DAV-2 and put mold “A” back in the oven to reheat for possible further testing.

5. Remove mold “B” from the oven. Repeat the same process as with mold “A” for the second bottom and top angles; but for both these angles, line the prongs up with a point 90 degrees counter-clockwise from the “first position”, as in the “turned 90 degrees” illustration on the previous page. After running the second bottom and top angles, extrude the DAV-2 and put mold “B” back into the oven to reheat for possible further testing. These internal angles will yield a total of four test points for one “run”.

6. Connect the DAV-2 to the CPU with the interface cable and stop the data collection in the DAV-2 (“Stop Button” in the illustration on the previous page). Download the data to the CPU (“Download Data Button” in the illustration on the previous page). Label the data sheet as needed and save it to a pre-labeled file that has been set up for internal angle data. The data will look something like this:



7. Open the DAV-2 Excel spreadsheet. Be sure to choose “Enable Macros” when prompted so the integrated buttons will function. A prompt should pop up asking to open a file. Choose the desired saved file and click “OK”. If the prompt doesn’t come up or an error occurs, simply click on the “Add Data” button. After the data imports to the spreadsheet, the initial page will look something like this:

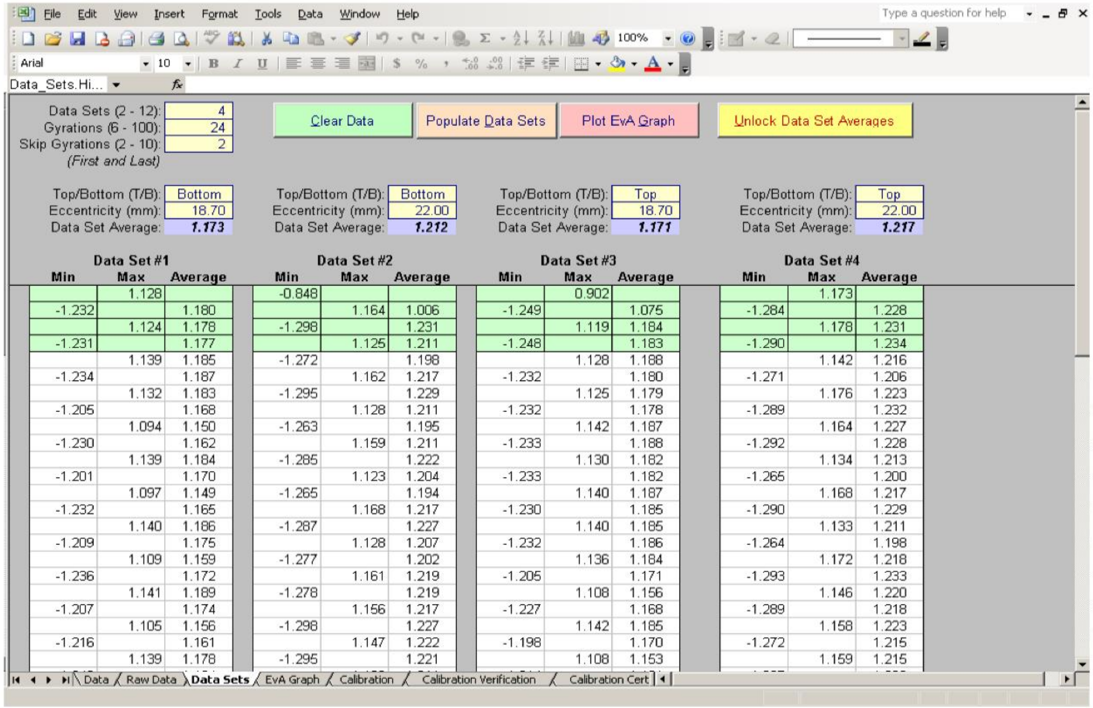


File Name: Initial 21 degree #1 and #2.csv

File Date & Time: 09/27/2005 1:24 PM

Reading Number	Date and Time	Angle Measured	Angle Graph Data Min	Max	Reading Number
0	9/27/05 1:23 PM	-0.43973	-0.43973		0
1	9/27/05 1:23 PM	-0.43973	-0.43973		40
2	9/27/05 1:23 PM	-0.43900	-0.43973		86
3	9/27/05 1:23 PM	-0.43900	-0.43973		124
4	9/27/05 1:23 PM	-0.43900	-0.43973		160
5	9/27/05 1:23 PM	-0.43973	-0.43973		204
6	9/27/05 1:23 PM	-0.43973	-0.43973		263
7	9/27/05 1:23 PM	-0.43828	-0.43900		283
8	9/27/05 1:23 PM	-0.43973	-0.43973		327
9	9/27/05 1:23 PM	-0.43828	-0.43973		388
10	9/27/05 1:23 PM	-0.43900	-0.43900		400
11	9/27/05 1:23 PM	-0.43900	-0.43900		440
12	9/27/05 1:23 PM	-0.43900	-0.43900		481
13	9/27/05 1:23 PM	-0.43973	-0.43900		531
14	9/27/05 1:23 PM	-0.43828	-0.43900		566
15	9/27/05 1:23 PM	-0.43756	-0.43900		601
16	9/27/05 1:23 PM	-0.43973	-0.43900		651
17	9/27/05 1:23 PM	-0.43973	-0.43900		696
18	9/27/05 1:23 PM	-0.43900	-0.44262		746
19	9/27/05 1:23 PM	-0.43900	-0.44190		762
20	9/27/05 1:23 PM	-0.43900	-1.65084		837
21	9/27/05 1:23 PM	-0.43973	-1.68776		854
22	9/27/05 1:23 PM	-0.43900	-1.77391		887
23	9/27/05 1:23 PM	-0.43828	-1.64071		947
24	9/27/05 1:23 PM	-0.43828	-1.63999		969
25	9/27/05 1:23 PM	-0.43900	-1.63999		1,015
26	9/27/05 1:23 PM	-0.43900	-1.63926		1,047
27	9/27/05 1:23 PM	-0.43900	-1.63926		1,090
28	9/27/05 1:23 PM	-0.43828	-1.63926		1,146

8. Click on the “Data Sets” tab. In the “Data Sets” field, type in “4”; four individual angle measurements (or data sets) were run. In the “Gyrations” field, type in “24”; since the SGC and the DAV-2 may record the first gyration at different points, using a number one less than the number of gyrations entered into the SGC will ensure that the data will populate correctly. In the “Skip Gyrations” field, type in “2”; this is sufficient when running with the HMS. Click on the “Populate Data Sets” button and the internal angle data will be displayed in the blue boxes; the page will look something like this:



Data Sets (2 - 12): 4
Gyrations (6 - 100): 24
Skip Gyrations (2 - 10): 2
(First and Last)

	Data Set #1			Data Set #2			Data Set #3			Data Set #4	
Top/Bottom (T/B):	Bottom		Top/Bottom (T/B):	Bottom		Top/Bottom (T/B):	Top		Top/Bottom (T/B):	Top	
Eccentricity (mm):	18.70		Eccentricity (mm):	22.00		Eccentricity (mm):	18.70		Eccentricity (mm):	22.00	
Data Set Average:	***1.173***		Data Set Average:	***1.212***		Data Set Average:	***1.171***		Data Set Average:	***1.217***	
Min	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**
	1.128		-0.848				0.902			1.173	
-1.232		1.180		1.164	1.006	-1.249		1.075	-1.284		1.228
	1.124	1.178	-1.298		1.231		1.119	1.184		1.178	1.231
-1.231		1.177		1.125	1.211	-1.248		1.183	-1.290		1.234
	1.139	1.185	-1.272		1.198		1.128	1.188		1.142	1.216
-1.234		1.187		1.162	1.217	-1.232		1.180	-1.271		1.206
	1.132	1.183	-1.295		1.229		1.125	1.179		1.176	1.223
-1.205		1.168		1.128	1.211	-1.232		1.178	-1.289		1.232
	1.094	1.150	-1.263		1.195		1.142	1.187		1.164	1.227
-1.230		1.162		1.159	1.211	-1.233		1.188	-1.292		1.228
	1.139	1.184	-1.285		1.222		1.130	1.182		1.134	1.213
-1.201		1.170		1.123	1.204	-1.233		1.182	-1.265		1.200
	1.097	1.149	-1.265		1.194		1.140	1.187		1.168	1.217
-1.232		1.165		1.168	1.217	-1.230		1.185	-1.290		1.229
	1.140	1.186	-1.287		1.227		1.140	1.185		1.133	1.211
-1.209		1.175		1.128	1.207	-1.232		1.186	-1.264		1.198
	1.109	1.159	-1.277		1.202		1.136	1.184		1.172	1.218
-1.236		1.172		1.161	1.219	-1.205		1.171	-1.293		1.233
	1.141	1.189	-1.278		1.219		1.108	1.156		1.146	1.220
-1.207		1.174		1.156	1.217	-1.227		1.168	-1.289		1.218
	1.105	1.156	-1.298		1.227		1.142	1.185		1.158	1.223
-1.216		1.161		1.147	1.222	-1.198		1.170	-1.272		1.215
	1.139	1.178	-1.295		1.221		1.108	1.153		1.159	1.215

9. Manually calculate the average of the four internal angles. This average represents the current internal angle of the SGC. In the example above, the internal angle of this SGC is about 1.19° and is out of the specified range of 1.16° +/- 0.02°.

10. If the average internal angle is not within the specified 1.16° +/- 0.02° range, the SGC's angle must be physically adjusted accordingly using the manufacturer's specified method. This adjustment often has to be done on a trial and error basis; some manufacturers have detailed documentation on changing the angle, so be sure to refer to that when possible. *State personnel* ***<u>will not</u>*** *perform the physical angle adjustment to contractor or consultant SGCs under any circumstances.*

11. When the angle is physically adjusted, repeat steps #2 – #10 after both molds have had a minimum of 30 minutes to reheat in the oven. This may take more than one additional attempt to get to the desired internal angle. Adjust the SGC's angle until the average of the four internal angles from the 22 mm HMS plate is at 1.16° +/- 0.02°. The SGC is now within internal angle specifications.

Gyratory Angle Calibration Frequency

The DAV-2 and HMS must be used a minimum of once every 12 months for gyratory angle calibration. Routine monthly angle calibration verification of SGCs may be performed one of two ways:

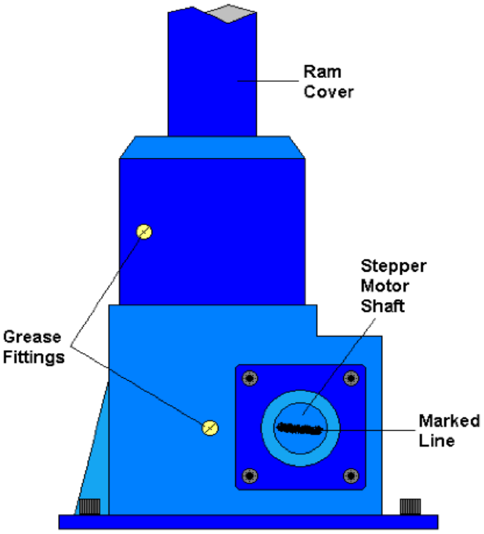
1. Using the DAV-2 and HMS.

2. After the final angle is set and calibrated with the DAV-2 and HMS, an external angle verification procedure may be run according to the SGC manufacturer's specifications. If HMA is needed for this procedure, an N90 surface mix commonly used in the testing lab's area should be utilized. The external angle measurement from this procedure will become the reference angle for verification purposes. For example: the DAV-2 and HMS gives an internal angle of 1.16° and the external angle procedure gives an external angle of 1.23°. When verifying using the external angle from then on, the external angle should measure 1.23° +/- 0.02°. This method addresses concerns of possible mold wear due to the use of the DAV-2 and HMS as well as giving labs that do not own a DAV-2 an accepted method of routine gyratory angle verification.

Additional Instructions for Early Model Troxler 4140 Compactors

When mixless testing was first introduced, intermittent problems with consistency and reproducibility were noted during testing with some older Troxler 4140 compactors. It was later discovered that some early model 4140s (those with the sample chamber door that moves up and down) act in an unfriendly way when the DAV-2 and the HMS are used. It seems the load cell cannot react fast enough to reduce pressure when the ram head initially contacts the DAV-2 and HMS. This triggers an error in the load cell which essentially causes the compactor to apply excessive pressure; values as high as 1300 kPa have been recorded. This excessive pressure causes the internal angles drop significantly, often below 1.00°, making them unusable for calibration. Fortunately, this effect can be bypassed by using the alternate manual start procedure that follows:

1. Start data collection in the DAV-2. Load the DAV-2 and HMS into the mold, and place in the SGC sample chamber.
2. Hit the “MENU” button on the keypad. Hit “2” to adjust the maximum pressure setting. Type “200”, then hit the “ENTER” key to input the value. Hit the “ESC” key to exit the menu.
3. Hit the manual “RAM DOWN” key on the keypad.
4. When the ram reaches ~130 mm, hit the “ESC” key to stop the ram. Make sure the ram head and collar are seated squarely in the top of the mold, with the pin on the collar fully down into the notch on the top of the mold.
5. Hit the “ANGLE ON” key to induce the angle. Be sure that the angle stop block (inside the compactor) fully engages. Hit the “ESC” key after the tray stops rotating.
6. Hit the “RAM DOWN” key. The ram will travel down and contact the DAV-2 and HMS. Hit the “ESC” key when the ram has stopped completely.
7. Hit the “MENU” button on the keypad. Hit “2” to adjust maximum pressure setting. Type “600”, then hit the “ENTER” key to input the value. Hit the “ESC” key to exit the menu.
8. Hit the “START” button to use automatic compaction to complete the rest of the internal angle measurement.
9. Confirm that this procedure was effective by watching the end of the stepper motor shaft (illustration to the left) just above the sample chamber. When the compactor is gyrating, the end of the shaft should move clockwise and counterclockwise as much as one quarter of a turn as the pressure increases and decreases to adjust for the simulated loading that the HMS induces. Drawing a line on the end of the stepper motor shaft with a marker makes observing this motion easier. Enabling the pressure data collection feature on the compactor will also verify that the pressure is correct and will give a printout of pressure per gyration.
10. Repeat this procedure for each subsequent internal angle measurement.



Troxler 4140 External Ram Assemby (On top of the sample chamber)

Annual DAV-2 Calibration Verification

Calibration verification on the DAV-2 units will be performed by BMPR annually. The units are to be sent to the Central Bureau HMA Lab in the late fall or early winter after the construction season ends. The calibration verification will be performed and the units will be returned to the districts in time for winter mix design verifications and lab inspections.

Hints and Tips

1. Keep the DAV-2, the ram head, and the molds being used as clean as possible. Any debris on the bottom (or top) plate of the mold or on the ram head will have an effect on the angle when the bottom of the DAV-2 contacts it. A quick spray of WD-40 and a wipe down with a rag on the inside of the mold, the plate(s), and the ram head will ensure good angle data.

2. According to the DAV-2 manufacturer, mold temperature is important to collecting useful angle data. After two runs with the DAV-2 and HMS at 25 gyrations (i.e. one bottom and one top), the mold will have cooled enough that it could affect angle data. This is the reason for using two molds for calibration as outlined in previous pages.

3. While the standard hydraulic jack set up may be used for extruding the DAV-2 and other contents from the mold after testing, there is a more efficient way using Marshall molds. Start with a base plate, followed by a collar, then a mold, then another collar; then place your gyratory mold (with base plate) over the stack. This will give you enough height on most SGC molds to bring the gyratory mold base plate to the upper lip of the gyratory mold without coming out. Another Marshall base plate may be added to the top of the stack to give a little more height for taller gyratory molds (Troxler 4141, Pine compactors). This stack is also helpful in loading the DAV-2 into the mold without having to drop it down into the mold. Experiment to find the best setup to work with different models of SGCs.

4. Some early model Troxler 4140s have been noted to release the angle when the HMS is used. This is attributed to a worn main bearing in the compactor. This causes the angle stop block inside the compactor to start moving away from the fixed angle screw block that is supposed to be "pushing" it to keep the angle "on". As the angle stop block moves farther away from the fixed angle screw block, the angle is reduced. This is seen mostly when using the 25.8 mm HMS plate or when the SGC exhibits excessive pressure. This issue shouldn't be a problem when calibrating with the 22 mm HMS plate at 600 kPa (using the alternate manual start procedure), but it is good to be aware of the potential for this problem. A symptom of a worn main bearing can be observed during compaction of hot mix when the angle stop block inside the compactor "chatters" (causing a rapping noise) and can physically be seen moving a little bit during gyration. It seems to not be a problem when compacting hot mix as the angle will stay engaged despite the "chattering", but this can pose a problem with HMS testing. While not recommended, the following technique has been used as a way to continue testing until the main bearing could be replaced. To physically keep the angle block engaged, a shop rag was first folded in half twice. When the compactor induced the angle, the protruding collar inside the compactor was gripped with the rag. Pressure was then applied in the opposite direction of gyration. This held the angle block in place and kept the angle "on".

5. When calibrating the angle on a contractor or consultant's SGC, be sure to let their personnel perform the physical angle adjustments when they are needed. This way the state is not held liable for any mechanical problems that may occur afterwards.

Illinois Department of Transportation

Segregation Control of Hot-Mix Asphalt
Appendix B.20

Effective Date: May 1, 2007
Revised Date: December 1, 2021

1.0 SCOPE

1.1 This work shall consist of the visual identification and corrective action to prevent and/or correct segregation of hot-mix asphalt.

2.0 DEFINITIONS

2.1 Segregation. Areas with a non-uniform distribution of coarse and fine aggregate particles in a hot-mix asphalt pavement.

2.2 End-of-Load Segregation. A systematic form of segregation typically identified by chevron-shaped areas of segregation at either side of a lane of pavement, corresponding with the beginning and end of truck loads.

2.3 Longitudinal Segregation. A linear pattern of segregation that usually corresponds to a specific area of the paver.

2.4 Severity of Segregation.

2.4.1 Low. A pattern of segregation where the mastic is in place between the aggregate particles; however, there is slightly more coarse aggregate in comparison with the surrounding acceptable mat.

2.4.2 Medium. A pattern of segregation that has significantly more coarse aggregate in comparison with the surrounding acceptable mat and which exhibits some lack of mastic.

2.4.3 High. A pattern of segregation that has significantly more coarse aggregate in comparison with the surrounding acceptable mat and which contains little mastic.

3.0 PROCEDURE

3.1 When medium or high segregation of the mixture is identified by the Contractor, the Engineer, or the daily evaluation, the following specific corrective actions shall be taken as soon as possible. The corrective actions shall be reported to the Engineer before the next day’s paving proceeds.

3.1.1 End of Load Segregation. When medium or high end of load segregation is identified, the following actions as a minimum shall be taken.

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Segregation Control of Hot-Mix Asphalt
Appendix B.20
(continued)

Effective Date: May 1, 2007
Revised Date: December 1, 2021

3.1.1.1 Trucks transporting the mixture shall be loaded in multiple dumps. The first against the front wall of the truck bed and the second against the tailgate in a manner which prevents the coarse aggregate from migrating to those locations.

3.1.1.2 The paver shall be operated so the hopper is never below 30 percent capacity between truck exchanges.

3.1.1.3 The “Head of Material” in the auger area shall be controlled to keep a constant level, with a 1 inch (25 mm) tolerance.

3.1.2 Longitudinal Segregation. When medium or high longitudinal segregation is identified, the Contractor shall make the necessary adjustment to the slats, augers or screeds to eliminate the segregation.

3.2 When the corrective actions initiated by the Contractor are insufficient in controlling medium or high segregation, the Contractor and Engineer will investigate to determine the cause of the segregation.

When an investigation indicates additional corrective action is warranted, the Contractor shall implement operational changes necessary to correct the segregation problems.

Any verification testing necessary for the investigation will be performed by the Department according to the applicable project test procedures and specification limits.

3.3 The District Construction Engineer will represent the Department in any dispute regarding the application of this procedure.

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Off-Site Preliminary Test Strip and Modified Start-Up Procedures
Appendix B.23

Effective Date: April 1, 2010
Revised Date: December 1, 2021

The purpose of an off-site preliminary test strip is to verify a plant can produce a new mixture within volumetric tolerances, to verify a mixture can be compacted within specification, and possibly to develop a rolling pattern on a similar pavement. If an off-site preliminary test strip is used in lieu of an on-site test strip, the process shall additionally follow the document "Hot-Mix Asphalt Test Strip Procedures".

A. Contractor/Department Off-Site Preliminary Test Strip Team Members

As the test strip is constructed, a team of both Contractor and Department personnel will evaluate the mix.

The test strip team may consist of the following:

1. Resident Engineer
2. District Construction Supervising Field Engineer, or representative
3. District Materials Mixtures Control Engineer, or representative
4. District Nuclear Density Gauge Tester
5. Contractor's QC Manager, required
6. Contractor's Paving Superintendent
7. Contractor's Density Tester

Optional:

8. Central Bureau of Construction representative
9. Central Bureau of Materials representative
10. Asphalt Binder Supplier representative

B. Communications

The Contractor shall advise the team members 48 hours in advance of the anticipated start date/time of production of the off-site preliminary test strip mix. The QC Manager shall direct the activities of the test strip team. A Department appointed representative from the test strip team will act as spokesperson for the Department.

C. Off-Site Preliminary Test Strip Method

The off-site preliminary test strip shall consist of 300 tons (275 metric tons) of mix. It shall contain two growth curves which shall be tested as outlined herein.

1. Location of Off-Site Preliminary Test Strip. The off-site preliminary test strip shall be located on a pavement type similar to the contract pavement and acceptable to the Engineer. It shall be on a relatively flat portion of the roadway.

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Off-Site Preliminary Test Strip and Modified Start-Up Procedures
Appendix B.23

Effective Date: April 1, 2010
Revised Date: December 1, 2021

2. Compaction Equipment. It shall be the responsibility of the QC manager to verify roller compliance before commencement of growth curve construction.

   All rolling equipment intended for use on a project shall be utilized on the off-site preliminary test strip.

3. Compaction Temperature. In order to make an accurate analysis of the density potential of the mixture, the initial compaction temperature of the mixture on the pavement at the beginning of the growth curve shall be no more than 10°F (5°C) lower than the minimum mixture placement temperature specified in Section 406.06. The mat temperature shall be monitored throughout the construction of each growth curve.

4. Mixture Volumetric Samples. The first and second sets of mixture volumetric samples shall be taken by the Contractor at such times as to represent the mixture of the two growth curves, respectively. All off-site preliminary test strip samples shall be processed by the Contractor for determination of mixture composition and air voids. This shall include washed extraction gradation and asphalt content test results. This information shall then be compared to the job mix formula (JMF) and required design criteria.

5. Growth Curve. The QC manager shall specify the roller(s) speed and number of passes required to obtain a completed growth curve. The nuclear gauge shall be placed near the center of the hot mat and the position marked for future reference. With the bottom of the nuclear gauge and the source rod clean, a one-minute nuclear reading (without mineral filler) shall be taken after each pass of the roller. Rolling shall continue until the maximum density is achieved and three consecutive passes show no appreciable increase in density or no evidence of destruction of the mat. The growth curve shall be plotted. No testing of initial passes shall be taken until the third roller pass is completed.

6. Constructing the Off-Site Preliminary Test Strip. After the Contractor has placed approximately 225 to 250 tons (200 to 225 metric tons) of mix, placement of the mix shall stop, and a growth curve shall be constructed. After completion of the first growth curve, paving shall resume for remaining 50 to 75 tons (45 to 70 metric tons) of mix, placement shall again stop, and the second growth curve shall be constructed within this area. Additional growth curves may be required if an adjustment/plant change is made during the off-site preliminary test strip. The Contractor shall use the specified rolling procedures for all portions of the test strip except for the growth curve areas which shall be compacted as directed by the QC Manager.

   If the off-site preliminary test strip is to be used as the final test strip, mixture sampling and testing as specified in the document “Hot-Mix Asphalt Test Strip Procedures” shall be followed.

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Off-Site Preliminary Test Strip and Modified Start-Up Procedures
Appendix B.23

Effective Date: April 1, 2010
Revised Date: December 1, 2021

7. Evaluation of Growth Curves. Mixtures which exhibit density potential outside of the specified density range shall be considered as sufficient cause for mix adjustment. If a mix adjustment is made, an additional test strip may be constructed, and associated tests shall be performed. This information shall then be compared to the adjusted job mix formula (AJMF) and required design criteria.

   If the density potential of the mixture does not meet the minimum specified, the operation shall cease until adjustments are made to the AJMF or a new mix design is produced.

   In addition, other aspects of the mixture, such as appearance, segregation, texture, or other evidence of mix problems, should be noted and corrective action taken at this time.

8. Final Density Testing. After the growth curve information is obtained, a final nuclear reading, using mineral filler to eliminate surface voids, shall be taken at the marked position. This reading is used to adjust the maximum density reading obtained during the growth curve.

D. <u>Acceptance Criteria</u>

If the off-site preliminary test strip is to be used as the final test strip, acceptance will be as specified in the document “Hot-Mix Asphalt Test Strip Procedures”.

E. <u>Documentation</u>

All off-site preliminary test strip mixture volumetrics and rolling pattern information (including growth curves) will be tabulated by the QC manager with copies provided to each team member, and the original retained in the project files.

If the off-site preliminary test strip is to be used as the final test strip, documentation shall also include mixture tests, and nuclear readings and core test results if a nuclear gauge correlation was completed.

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Procedure for Field Permeability Testing of Hot-Mix Asphalt Pavements

Appendix B.25

Effective Date: January 1, 2016
Revised Date: December 1, 2021

1. Scope

1.1. This test method covers the in-place estimation of the water permeability of a compacted hot-mix asphalt (HMA) pavement. The estimate provides an indication of water permeability of a pavement location as compared to those of other pavement locations.
1.2. The values stated in metric (SI) units are regarded as standard. Values given in parenthesis are for information and reference purposes only.
1.3. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Summary of Test Method

2.1. This test method is based on National Center for Asphalt Technology (NCAT) Report No. 99-1, Permeability of Superpave Mixtures – Evaluation of Field Permeameters by J. Allen Cooley, Jr.
2.2. A falling head permeability test is used to estimate the rate at which water flows into a compacted HMA pavement. Water from a graduated standpipe is allowed to flow into a compacted HMA pavement and the interval of time taken to reach a known change in head loss is recorded. The coefficient of permeability of a compacted HMA pavement is then estimated based on Darcy's Law.

3. Significance and Use

3.1. This test method provides a means of estimating water permeability of compacted HMA pavements. The estimation of water permeability is based upon assumptions that the sample thickness is equal to the immediately underlying HMA pavement course thickness; the area of the tested sample is equal to the area of the permeameter from which water is allowed to penetrate the HMA pavement; one-dimensional flow; and laminar flow of the water. It is assumed that Darcy's law is valid.

4. Apparatus

4.1. *Hand Broom* – A broom of sufficient stiffness to sweep a test location free of debris.
4.2. *Timing Device* – A stopwatch or other timing device graduated in divisions of at least 0.1 seconds.
4.3. *Sealant* – A silicone-rubber caulk to seal the permeameter to the pavement surface.

Procedure for
Field Permeability Testing of Hot-Mix Asphalt Pavements

Appendix B.25

Effective Date: January 1, 2016
Revised Date: December 1, 2021

4.4. *Field Permeameter* – A field permeameter made to the determined dimensions and specifications.

5. Preparation of Pavement Surface

5.1. Prior to conducting the test, a broom should be used to remove all debris from the pavement surface. Debris left on the pavement surface can hinder the sealing of the permeameter to the pavement surface.

6. Test Procedure

6.1. Permeameter Setup
- 6.1.1. Ensure that both sides of the square rubber base and the bottom of the square plastic base plate of the permeameter are free of debris.
- 6.1.2. Apply sealant to one side of the square, rubber base.
- 6.1.3. Place the side of the square, rubber base containing the sealant onto the pavement surface. Evenly apply light hand pressure to the top of the square, rubber base to force the sealant into the surface voids.
- 6.1.4. Place the middle, medium sized standpipe and stopper into the bottom, large standpipe of the permeameter base and seat securely in the top of the large standpipe.
- 6.1.5. Place the base of the permeameter onto the square, rubber base ensuring that the hole within the square, plastic base plate of the permeameter lines up with the hole in the square, rubber base.
- 6.1.6. Carefully place the weight over the standpipes onto the square, plastic base plate of the permeameter.

6.2. Test
- 6.2.1. To start the test, pour water into the medium standpipe until the water level is well above the initial head (top marked line).
- 6.2.2. Notice how quickly the water level drops. When the water level is at the desired initial head, start the timing device. (See Note 1) Stop the timing device when the water level within the standpipe reaches the desired final head (bottom marked line) (See Note 2). Record the time interval between the initial and final head (top and bottom marked lines).

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Note 1: For relatively impermeable pavements, the water level will drop very slowly within the top tier standpipe. Therefore, the initial head should be taken within the top tier standpipe. For pavements of “medium” permeability, the water level will drop quickly through the top tier standpipe. Therefore, the initial head should be taken within the middle tier standpipe. For very permeable pavements the water level will drop very quickly through the top and middle tier standpipes but slow down when it reaches the bottom tier standpipe. Therefore, the initial head should be taken in the bottom tier standpipe.

Note 2: The initial and final head determinations should be made within the same standpipe tier.

Note 3: At some point, after several layers of silicone caulk have been allowed to build up on the square rubber base, removing the layers of silicone will be necessary. This is best done after the silicone has been allowed to “set up” somewhat but before the silicone layer becomes permanently attached to the square rubber base. This is normally around six layers.

7. Calculation

7.1. The coefficient of permeability, k, is estimated using the following equation:

$$k = \frac{aL}{At} \ln \left(\frac{h1}{h2}\right)$$

Where:

k = coefficient of permeability, cm/sec
a = inside cross-sectioned area of standpipe used for that test, sq cm
L = thickness of underlying HMA course, cm
A = cross-sectioned area of pavement through which water can penetrate, sq cm (generally the same area as the bottom tier standpipe and area of hole in the square rubber base)
t = elapsed time between h_1 and h_2, sec
h_1 = initial head in the pavement location, cm
h_2 = final head on the pavement location, cm

7.2. Report the results for k to the nearest tenth of a unit x 10^{-5} cm/sec.

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Illinois Department of Transportation

Hot-Mix Asphalt Production Inspection Checklist
Appendix B.27

Effective Date: December 1, 2019
Revised Date: December 1, 2021

A. Scope

This checklist is intended for use as a guide by Department materials inspectors engaged in reviewing hot-mix asphalt (HMA) plant and field operations.

B. Purpose

This checklist provides a standardized format for documenting HMA materials inspection activities.

C. General Information

This checklist is based upon the previous successful completion of all applicable plant surveys, truck certifications, scale (or volumetric mixer) calibrations, plant Annual Quality Control (QC) Plan for Hot-Mix Asphalt Production, and QC laboratory inspections.

The inspector will familiarize themselves with Standard Specifications Sections 1030 and 1102, and applicable portions of the Manual of Test Procedures for Materials.

If applicable, the inspector will review the current Model Quality Control Plan and Quality Control Plan Addendum for the plant.

If applicable, the inspector will review project special provisions and plans relating to project specific HMA mixture property, sampling, and testing requirements.

The inspector will maintain a record of each visit to a production facility and typically include the following information:

- Date, arrival time, weather conditions, & departure time.
- Producer Name and Plant Location.
- Producer Number and Plant Description if more than one plant at location.
- Mix Design being produced.
- Address for mixture delivery.
- Item mixture incorporated into.
- Plant QC personnel present.
- Results of any QC, QA, INV, or Verification testing performed.
- Component material samples taken.
- Substantive conversations with QC personnel relating to production or plant operations.
- Items described in the following sections that are not acceptable.

Note: The inspector is to inform plant personnel of any unacceptable items and document if they are corrected while present.

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Revised Date: December 1, 2021

D. Plant Operations

QC Laboratory and Equipment (if applicable)

Is testing equipment present and in good working order?

Does equipment calibration documentation indicate required calibration activities have been performed?

Aggregates

Are aggregate stockpiles clearly marked?

Are aggregate stockpiles separated with no adjacent stockpiles intermingling?

Are aggregate stockpiles free from clay or other contamination?

Are aggregate stockpiles free from segregation or degradation?

Is an Investigative Sample warranted for quality or gradation check?

Are aggregate stockpiles constructed with steel-track equipment?

Are stockpiles being handled properly?

Do aggregate shipping tickets clearly represent the material being stockpiled?

Does the aggregate source match the approved source from the Quality Control Plan or indicated on the approved mix design?

Is stockpile sampling being performed properly?

Are aggregate gradation results up-to-date and available?

If required, are aggregate split samples labeled and available?

Do QC and QA gradations compare?

Are correct RAP/RAS stockpiles being used and producer has RAP/RAS approval letter?

Perform Investigative gradation and quality sampling as directed.

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Mineral Filler, Asphalt Binder, Additives

Do material delivery tickets indicate materials are on the qualified products list?

Do materials match those shown in the Quality Control Plan or indicated on the approved mix design?

Is an asphalt binder sample required?

Mixture Production

Is the mix design appropriate for the item?

Do the Batch Plant batch weights or Drum Plant cold feed percentages and component materials correlate to the mix design?

Are stockpile moistures being done daily for recycled materials, coarse, & fine aggregates?

Has the correct aggregate moisture been input?

At a drum plant, verify the 6-minute checks are being performed and information is within tolerance.

Is the moving average for critical gradation sieve within job mixture formula parameters?

Is the mixture temperature within specifications?

Does the mixture delivery ticket include the required information?

Is the truck loading time-stamp on the delivery ticket accurate?

E. Trucks

Are the truck beds clean?

Have the truck beds been sprayed with release agents? Is there a diesel fuel smell?

Does release agent delivery ticket indicate a product on the qualified product list?

Is a release agent sample required?

Are the truck tarps and insulation in place?

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Effective Date: December 1, 2019
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F. Plant Mixture Testing

Are plant QC personnel documenting actions?

Do plant QC personnel performing testing match the approved QC Plan?

Is equipment utilized for plant testing calibrated and in good working condition?

Is sufficient QC testing being performed to control production?

Split samples are saved and labeled correctly?

Does QC testing comply with the approved QC Plan?

Are plant QC personnel performing tests according to proper procedures?

Are control charts available upon request?

Are all criteria with volumetrics moving averages being checked and calculated?

Are adjustments and re-testing results documented?

Do test results indicate mixture will arrive at the project site within specification limits?

Are Daily Plant Reports being completed?

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Effective Date: December 1, 2019
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G. Project Site

Maintain a diary record of each visit to a project site where HMA is being placed. Include the following information.

- Date, arrival time, weather conditions, & departure time.
- Contract and project location.
- Producer Name and Plant Location.
- Producer Number and Plant Description if more than one plant at location.
- Mix Design being produced.
- The item the mixture is incorporated into.
- Jobsite QC personnel present. Jobsite QA personnel present if applicable.
- Document results of any QC, QA, INV, or Verification testing performed.
- Document any substantive conversations with contractor or IDOT field personnel relating to the mixture.
- Document any of the items described in the following section applicable to field operations that are not acceptable. Inform field personnel of any unacceptable items, and note if they are corrected while you are present.

Do jobsite QC personnel performing testing match the approved QC plan?

Do individuals performing testing on behalf of the agency have proper certification (HMA Level I or Nuclear Density)?

Is equipment utilized for jobsite testing calibrated and in good working condition?

Does testing frequency meet applicable requirements?

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Use of Correction Factors for Adjusting the Gradation of Cores to Estimate the Gradation of the In-Place Pavement

Appendix B22

Effective January 31, 2008
Revised December 1, 2023

GENERAL

When cores are removed from a pavement, and a solvent extraction or ignition oven burn is conducted on the cored material, the gradation of the resulting aggregate is finer than the original pavement because the perimeter of the core was cut by the core barrel. Also, breakdown may occur as a result of the aggregate being subjected to the high temperatures in the ignition oven. The following Core Correction Factors are used to estimate the gradation of the in-place pavement from the gradation of the core after a solvent extraction or an ignition oven burn has been conducted. The Core Correction Factors were determined from four-inch diameter cores cut from 150 mm gyratory compacted lab specimens. The six-inch Factors were estimated from the four-inch Factors.

APPLICABLE DOCUMENTS

- Illinois-modified AASHTO T 30, Mechanical Analysis of Extracted Aggregates
- Illinois-modified AASHTO T 164, Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)
- Illinois-modified AASHTO T 308, Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method

FOUR-INCH AND SIX-INCH CORE CORRECTION FACTORS EXAMPLES

CORE CORRECTION FACTORS

	Percent Passing							
	EXTRACTION							
Sieve	BINDER		SURFACE		9.5 SMA		12.5 SMA	
	4-inch	6-inch	4-inch	6-inch	4-inch	6-inch	4-inch	6-inch
1" / 25.0mm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3/4" / 19.0mm	1.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0
1/2" / 12.5mm	1.5	1.0	0.0	0.0	0.5	0.3	0.4	0.3
3/8" / 9.5mm	1.4	0.9	0.0	0.0	0.8	0.6	2.1	1.4
#4 / 4.75mm	0.9	0.6	2.2	1.5	1.0	0.7	1.4	1.0
#8 / 2.36mm	0.7	0.5	1.0	0.7	0.7	0.4	0.8	0.5
#16 / 1.18mm	0.6	0.4	0.6	0.4	0.5	0.3	0.2	0.1
#30 / 0.600mm	0.4	0.3	0.4	0.3	0.2	0.1	0.0	0.0
#50 / 0.300mm	0.4	0.3	0.4	0.3	0.5	0.3	0.0	0.0
#100 / 0.150mm	0.3	0.2	0.2	0.1	0.0	0.0	0.0	0.0
#200 / 0.075mm	0.17	0.11	0.16	0.11	0.18	0.12	0.00	0.00

	Percent Passing							
	IGNITION OVEN *							
Sieve	BINDER		SURFACE		9.5 SMA		12.5 SMA	
	4-inch	6-inch	4-inch	6-inch	4-inch	6-inch	4-inch	6-inch
1" / 25.0mm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3/4" / 19.0mm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1/2" / 12.5mm	2.3	1.5	0.0	0.0	0.3	0.2	0.1	0.1
3/8" / 9.5mm	2.5	1.7	0.1	0.1	1.3	0.9	1.4	1.0
#4 / 4.75mm	1.9	1.3	2.1	1.4	1.0	0.7	0.6	0.4
#8 / 2.36mm	1.0	0.7	0.9	0.6	0.7	0.4	0.0	0.0
#16 / 1.18mm	0.7	0.5	0.6	0.4	0.2	0.1	0.0	0.0
#30 / 0.600mm	0.5	0.3	0.5	0.3	0.2	0.1	0.0	0.0
#50 / 0.300mm	0.4	0.3	0.3	0.2	0.2	0.1	0.2	0.1
#100 / 0.150mm	0.3	0.2	0.3	0.2	0.0	0.0	0.0	0.0
#200 / 0.075mm	0.20	0.13	0.20	0.13	0.15	0.10	0.00	0.00

The gradation of the aggregate from the extraction or ignition oven burn of the core is finer than the gradation of the original in-place pavement. Therefore, subtract the designated amount in this table from the measured percent passing of the core to estimate the in-place gradation prior to coring.

This testing was conducted on a limited number of aggregate sources. The actual correction factor from another specific mixture or aggregate may vary slightly from the factors listed in this table.

Factors for 4-inch diameter cores are from tests. Factors for 6-inch cores are estimated by multiplying 4-inch factors by 0.667.

* A larger amount of degradation in the ignition oven is possible from aggregates from other sources.

Given: 4-inch SURFACE mix cores where a SOLVENT EXTRACTION has been conducted.

	Percent Passing			
	EXTRACTION			
Sieve	Extracted Gradation	Surface Correction Factor	Subtract Correction Factor from Extracted Gradation	Estimated In-place Pavement Gradation
1" / 25.0mm	100.0	0.0	100.0 - 0.0	100.0
3/4" / 19.0mm	100.0	0.0	100.0 - 0.0	100.0
1/2" / 12.5mm	100.0	0.0	100.0 - 0.0	100.0
3/8" / 9.5mm	95.6	0.0	95.6 - 0.0	95.6
#4 / 4.75mm	60.6	2.2	60.6 - 2.2	58.4
#8 / 2.36mm	35.3	1.0	35.3 - 1.0	34.3
#16 / 1.18mm	23.8	0.6	23.8 - 0.6	23.2
#30 / 0.600mm	17.8	0.4	17.8 - 0.4	17.4
#50 / 0.300mm	12.8	0.4	12.8 - 0.4	12.4
#100 / 0.150mm	9.2	0.2	9.2 - 0.2	9.0
#200 / 0.075mm	7.10	0.16	7.10 - 0.16	6.94

Given: 4-inch BINDER mix cores where an IGNITION OVEN Burn has been conducted.

	Percent Passing			
	IGNITION OVEN			
Sieve	Ignition Oven Gradation	Binder Correction Factor	Subtract Correction Factor from Ignition Oven Gradation	Estimated In-place Pavement Gradation
1" / 25.0mm	100.0	0.0	100.0 - 0.0	100.0
3/4" / 19.0mm	97.9	0.0	97.9 - 0.0	97.9
1/2" / 12.5mm	77.2	2.3	77.2 - 2.3	74.9
3/8" / 9.5mm	63.6	2.5	63.6 - 2.5	61.1
#4 / 4.75mm	38.5	1.9	38.5 - 1.9	36.6
#8 / 2.36mm	25.0	1.0	25.0 - 1.0	24.0
#16 / 1.18mm	18.1	0.7	18.1 - 0.7	17.4
#30 / 0.600mm	14.0	0.5	14.0 - 0.5	13.5
#50 / 0.300mm	10.1	0.4	10.1 - 0.4	9.7
#100 / 0.150mm	6.9	0.3	6.9 - 0.3	6.6
#200 / 0.075mm	5.60	0.20	5.60 - 0.20	5.40

Given: 6-inch SURFACE mix cores where a SOLVENT EXTRACTION has been conducted.

	Percent Passing			
	EXTRACTION			
Sieve	Extracted Gradation	Surface Correction Factor	Subtract Correction Factor from Extracted Gradation	Estimated In-place Pavement Gradation
1" / 25.0mm	100.0	0.0	100.0 - 0.0	100.0
3/4" / 19.0mm	100.0	0.0	100.0 - 0.0	100.0
1/2" / 12.5mm	100.0	0.0	100.0 - 0.0	100.0
3/8" / 9.5mm	95.6	0.0	95.6 - 0.0	95.6
#4 / 4.75mm	60.6	1.5	60.6 - 1.5	59.1
#8 / 2.36mm	35.3	0.7	35.3 - 0.7	34.6
#16 / 1.18mm	23.8	0.4	23.8 - 0.4	23.4
#30 / 0.600mm	17.8	0.3	17.8 - 0.3	17.5
#50 / 0.300mm	12.8	0.3	12.8 - 0.3	12.5
#100 / 0.150mm	9.2	0.1	9.2 - 0.1	9.1
#200 / 0.075mm	7.10	0.11	7.10 - 0.11	6.99

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PFP Quality Level Analysis
Appendix E.1

Effective: December 12, 2003
Revised: December 1, 2021

This document explains the statistical analysis and procedures used to determine pay adjustments for a hot-mix asphalt (HMA) mixture and a HMA full-depth pavement when Pay for Performance (PFP) is specified as the Quality Management Program (QMP).

Pay parameters are evaluated using percent within limits (PWL) analyzed collectively and statistically by the Quality Level Analysis method to determine the total estimated percent of the lot that is within specification limits. Quality Level Analysis is a statistical procedure for estimating the percent compliance to a specification and is affected by shifts in the arithmetic mean and the sample standard deviation.

Additionally, for a full-depth pavement the adjusted pay and pay adjustment will be calculated using the combined composite pay factors for mixtures used in its construction.

Note: Monetary deductions will be applied separately for both dust/AB ratio using the Dust/AB Ratio Deduction Table and unconfined edge density using the Unconfined Edge Density Deduction Table found in the Standard Specifications Article 406.14.

(a) PAY ADJUSTMENT PROCEDURES

Items 1 through 8 of the following procedure will be repeated for each of the pay parameters (air voids, field VMA and core density) for each lot.

(1) Determine the arithmetic mean ($\bar{x}$) of the test results:

$$\bar{x} = \frac{\sum x}{n}$$

Where:

$\sum$ = summation of
x = individual test value
n = total number of test values

PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
Revised: December 1, 2021

(2) Calculate the sample standard deviation (s):

$$s = \sqrt{\frac{n \cdot \Sigma (x)^2 - (\Sigma x)^2}{n(n-1)}}$$

Where:

$\sum(x^2)$ = summation of the squares of individual test values

$(\sum x)^2$ = summation of the individual test values squared

(3) Calculate the upper quality index (Q_U):

$$Q_U = \frac{UL - \bar{x}}{s}$$

Where:

UL = upper specification limit (target value (*TV*) plus allowable deviation)

(4) Calculate the lower quality index (Q_L):

$$Q_L = \frac{\bar{x} - LL}{s}$$

Where:

LL = lower specification limit (target value (*TV*) minus allowable deviation)

(5) Determine P_U (percent within the upper specification limit which corresponds to a given Q_U) from Table 2. (Note: Round up to nearest Q_U in Table 2.)

Note: If a *UL* is not specified, P_U will be 100.

(6) Determine P_L (percent within the lower specification limit which corresponds to a given Q_L) from Table 2. (Note: Round up to nearest Q_L in Table 2.)

Note: If a *LL* is not specified, P_L will be 100.

(7) Determine the Quality Level or *PWL* (the total percent within specification limits).

$PWL = (P_U + P_L) - 100$

PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
Revised: December 1, 2021

(8) To determine the pay factor for each individual parameter lot:

$$Pay\ Factor\ (PF) = 55 + 0.5\ (PWL)$$

(9) Once the project is complete determine the Total Pay Factor (*TPF*) for each parameter by using a weighted lot average by tons (mix) or distance (density) of all lots for a given parameter.

$$TPF = W1PFlot1 + W2PFlot(n+1) + etc.$$

Where:
W1,W2… = weighted percentage of material evaluated
PF = Pay factor for the various lots
TPF = Total pay factor for the given parameter

(10) Determine the Composite Pay Factor (*CPF*) for each mixture. The *CPF* shall be rounded to 3 decimal places.

$$CPF = [f_{\text{Voids}}(\text{TPF}_{\text{Voids}}) + f_{\text{VMA}}(\text{TPF}_{\text{VMA}}) + f_{\text{Density}}(\text{TPF}_{\text{Density}})] / 100$$

Substituting from Table 1:

$$CPF = [0.3(\text{TPF}_{\text{Voids}}) + 0.3(\text{TPF}_{\text{VMA}}) + 0.4(\text{TPF}_{\text{Density}})] / 100$$

Where:
f_{Voids}, f_{VMA}, *and* $f_{Density}$ = Parameter Weights listed in Table 1

TPF_{Voids}, TPF_{VMA}, *and* $TPF_{Density}$ = *Total Pay Factor for the designated measured attribute from (9)*

(11) Determine the adjusted pay and pay adjustment for a given mixture.

Plan Unit Pay = Mixture Unit Price x Quantity

Adjusted Pay = Plan Unit Pay x CPF

Pay Adjustment = Adjusted Pay – Plan Unit Pay

Illinois Department of Transportation

PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
Revised: December 1, 2021

(12) To determine the adjusted pay and pay adjustment for a full-depth pavement, first combine the composite pay factors for all mixtures to arrive at the combined composite pay factor. Each mixture composite pay factor will be weighted equally. Mixtures placed having the same gyration values but with and without polymer will be treated as two separate mixtures. For example, one surface mix and one binder mix will be weighted 50/50 regardless of tonnage. Additionally, one surface mix, one polymer binder mix and one non-polymer binder mix will be treated as three equally (1/3) weighted mixtures even if the polymer binder is the only difference between binder lifts. The full-depth adjusted pay is determined by multiplying the plan unit pay by the combined composite pay factor. The pay adjustment is then determined by subtracting the plan unit pay from the adjusted pay.

Illinois Department of Transportation

PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
Revised: December 1, 2021

Table 1

Pay Parameters, Parameter Weights “f” and Quality Levels				
Pay Parameter		Parameter Weight *“f”*	*UL*	*LL*
Air Voids		0.3	Design Voids + 1.35	Design Voids – 1.35
Field VMA		0.3	MDR/1 + 3.0	MDR/1 – 0.7
In-Place Density	IL-4.75	0.4	97.5	92.5
	IL-9.5, IL-9.5FG		97.5	91.5
	IL-19.0		97.5	92.2
	SMA		98.0	93.0

1. MDR = Minimum Design Requirement (VMA)

Illinois Department of Transportation

PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
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TABLE 2: QUALITY LEVELS
QUALITY LEVEL ANALYSIS BY STANDARD DEVIATION METHOD

P_U OR P_L PERCENT WITHIN LIMITS FOR POSITIVE VALUES OF Q_U OR Q_L	UPPER QUALITY INDEX Q_U OR LOWER QUALITY INDEX Q_L														
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=18	n=19 to n=25	n=26 to n=37	n=38 to n=69	n=70 to n=200	n=201 to infinity
100	1.16	1.50	1.79	2.03	2.23	2.39	2.53	2.65	2.83	3.03	3.20	3.38	3.54	3.70	3.83
99		1.47	1.67	1.80	1.89	1.95	2.00	2.04	2.09	2.14	2.18	2.22	2.26	2.29	2.31
98	1.15	1.44	1.60	1.70	1.76	1.81	1.84	1.86	1.91	1.93	1.96	1.99	2.01	2.03	2.05
97		1.41	1.54	1.62	1.67	1.70	1.72	1.74	1.77	1.79	1.81	1.83	1.85	1.86	1.87
96	1.14	1.38	1.49	1.55	1.59	1.61	1.63	1.65	1.67	1.68	1.70	1.71	1.73	1.74	1.75
95		1.35	1.44	1.49	1.52	1.54	1.55	1.56	1.58	1.59	1.61	1.62	1.63	1.63	1.64
94	1.13	1.32	1.39	1.43	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.55
93		1.29	1.35	1.38	1.40	1.41	1.42	1.43	1.44	1.44	1.45	1.46	1.46	1.47	1.47
92	1.12	1.26	1.31	1.33	1.35	1.36	1.36	1.37	1.37	1.38	1.39	1.39	1.40	1.40	1.40
91	1.11	1.23	1.27	1.29	1.30	1.30	1.31	1.31	1.32	1.32	1.33	1.33	1.33	1.34	1.34
90	1.10	1.20	1.23	1.24	1.25	1.25	1.26	1.26	1.26	1.27	1.27	1.27	1.28	1.28	1.28
89	1.09	1.17	1.19	1.20	1.20	1.21	1.21	1.21	1.21	1.22	1.22	1.22	1.22	1.22	1.23
88	1.07	1.14	1.15	1.16	1.16	1.16	1.16	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
87	1.06	1.11	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.13	1.13
86	1.04	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
85	1.03	1.05	1.05	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
84	1.01	1.02	1.01	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99
83	1.00	0.99	0.98	0.97	0.97	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.95	0.95	0.95
82	0.97	0.96	0.95	0.94	0.93	0.93	0.93	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
81	0.96	0.93	0.91	0.90	0.90	0.89	0.89	0.89	0.89	0.88	0.88	0.88	0.88	0.88	0.88
80	0.93	0.90	0.88	0.87	0.86	0.86	0.86	0.85	0.85	0.85	0.85	0.84	0.84	0.84	0.84
79	0.91	0.87	0.85	0.84	0.83	0.82	0.82	0.82	0.82	0.81	0.81	0.81	0.81	0.81	0.81
78	0.89	0.84	0.82	0.80	0.80	0.79	0.79	0.79	0.78	0.78	0.78	0.78	0.77	0.77	0.77
77	0.87	0.81	0.78	0.77	0.76	0.76	0.76	0.75	0.75	0.75	0.75	0.74	0.74	0.74	0.74
76	0.84	0.78	0.75	0.74	0.73	0.73	0.72	0.72	0.72	0.71	0.71	0.71	0.71	0.71	0.71
75	0.82	0.75	0.72	0.71	0.70	0.70	0.69	0.69	0.69	0.68	0.68	0.68	0.68	0.68	0.67
74	0.79	0.72	0.69	0.68	0.67	0.66	0.66	0.66	0.66	0.65	0.65	0.65	0.65	0.64	0.64
73	0.76	0.69	0.66	0.65	0.64	0.63	0.63	0.63	0.62	0.62	0.62	0.62	0.62	0.61	0.61
72	0.74	0.66	0.63	0.62	0.61	0.60	0.60	0.60	0.59	0.59	0.59	0.59	0.59	0.58	0.58

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PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
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TABLE 2: QUALITY LEVELS (continued)
QUALITY LEVEL ANALYSIS BY STANDARD DEVIATION METHOD

P_U OR P_L PERCENT WITHIN LIMITS FOR POSITIVE VALUES OF Q_U OR Q_L	UPPER QUALITY INDEX Q_U OR LOWER QUALITY INDEX Q_L														
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=18	n=19 to n=25	n=26 to n=37	n=38 to n=69	n=70 to n=200	n=201 to infinity
71	0.71	0.63	0.60	0.59	0.58	0.57	0.57	0.57	0.57	0.56	0.56	0.56	0.56	0.55	0.55
70	0.68	0.60	0.57	0.56	0.55	0.55	0.54	0.54	0.54	0.53	0.53	0.53	0.53	0.53	0.53
69	0.65	0.57	0.54	0.53	0.52	0.52	0.51	0.51	0.51	0.50	0.50	0.50	0.50	0.50	0.50
68	0.62	0.54	0.51	0.50	0.49	0.49	0.48	0.48	0.48	0.48	0.47	0.47	0.47	0.47	0.47
67	0.59	0.51	0.47	0.47	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.44	0.44	0.44	0.44
66	0.56	0.48	0.45	0.44	0.44	0.43	0.43	0.43	0.42	0.42	0.42	0.42	0.41	0.41	0.41
65	0.52	0.45	0.43	0.41	0.41	0.40	0.40	0.40	0.40	0.39	0.39	0.39	0.39	0.39	0.39
64	0.49	0.42	0.40	0.39	0.38	0.38	0.37	0.37	0.37	0.37	0.36	0.36	0.36	0.36	0.36
63	0.46	0.39	0.37	0.36	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.33
62	0.43	0.36	0.34	0.33	0.32	0.32	0.32	0.32	0.31	0.31	0.31	0.31	0.31	0.31	0.31
61	0.39	0.33	0.31	0.30	0.30	0.29	0.29	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.28
60	0.36	0.30	0.28	0.27	0.27	0.27	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.25
59	0.32	0.27	0.25	0.25	0.24	0.24	0.24	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23
58	0.29	0.24	0.23	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.20	0.20	0.20	0.20	0.20
57	0.25	0.21	0.20	0.19	0.19	0.19	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
56	0.22	0.18	0.17	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	0.15
55	0.18	0.15	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
54	0.14	0.12	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
53	0.11	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
52	0.07	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
51	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: For negative values of Q_U or Q_L, P_U or P_L is equal to 100 minus the table P_U or P_L. If the value of Q_U or Q_L does not correspond exactly to a figure in the table, use the next higher value.

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Effective: December 12, 2003
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(b) Examples

<u>Example 1 – One Lift Overlay:</u>

Determine the adjusted pay and pay adjustment for the given lot of a N90 IL-9.5 HMA surface being placed at 1.5 inches thick as an overlay. The project consists of 27,840 tons over 16.7 miles.

Note that mix sample and density lots are independent of each other.

In this example the first mix sample lot represents 10,000 tons while the first density lot represents 6 miles (N=30). The project would have two additional mix and density lots following the same calculations as the first mix and density lots, respectively. All three lots are combined as per step (9).

Mix sample: Each sublot represents 1000 tons

Lot #	Sublot #	Air Voids TV = 4.0	Field VMA Design Min. = 15.0
1	1	4.2	15.4
	2	4.5	15.7
	3	3.3	14.9
	4	5.0	15.0
	5	5.4	15.2
	6	2.5	15.5
	7	3.8	15.2
	8	4.1	15.3
	9	4.3	15.4
	10	4.5	15.6
	Average:	4.16	15.32
	Standard Deviation:	0.825	0.253

Density: Each density test interval represents 0.2 mile (5 cores are taken per mile) along the 6 miles of paving resulting in an N=30.

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Lot #	Density Test Interval	Density
1	1	91.5
	2	93.0
	3	92.9
	4	93.5
	5	93.0
	6	94.0
	7	92.8
	8	93.5
	9	91.0
	⋮	⋮
	30	92.7
	Average:	92.79
	Standard Deviation:	0.910

Determine the pay factor for each parameter.

Air Voids:

Lot: Average = 4.16
Standard Deviation = 0.825

$$Q_U = \frac{(4.0+1.35)-4.16}{0.825} = 1.44$$

$$Q_L = \frac{4.16-(4.0-1.35)}{0.825} = 1.83$$

N = 10 sublots (from Table 2)

P_U = 94

P_L = 98

PWL = (94 + 98) - 100

PWL = 92

PF = 55 + 0.5 (92)

PF = 101.0

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Determine the pay factor for Air Voids.

$PF_{Voids} = 101.0$

Field VMA:

Lot : Average = 15.32
Standard Deviation = 0.253

$$Q_U = \frac{(15.0+3.0)-15.32}{0.253} = 10.59$$

$$Q_L = \frac{15.32-(15.0-0.7)}{0.253} = 4.03$$

N = 10 sublots (from Table 2)

$P_U = 100$

$P_L = 100$

$PWL = (100 + 100) - 100$

$PWL = 100$

$PF = 55 + 0.5\ (100)$

$PF = 105.0$

Determine the pay factor for Field VMA.

$PF_{VMA} = 105.0$

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Density:

Lot: Average = 92.79
Standard Deviation = 0.910

$$Q_U = \frac{97.0 - 92.79}{0.910} = 4.63$$

$$Q_L = \frac{92.79 - 91.5}{0.910} = 1.42$$

N = 30 Density measurements (from table)

$P_U = 100$

$P_L = 93$

$PWL = (100 + 93) - 100$

$PWL = 93$

$PF = 55 + 0.5\ (93)$

$PF = 100.5$

Determine the pay factor for Density.

$PF_{Density} = 101.5$

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Determine the total pay factors for each parameter. In this example the Air Voids PF and Field VMA PF for the second and third lots are given to be equal to the Air Voids PF and Field VMA PF for the first lot, respectively. The total pay factor for density ($TPF_{Density}$) is calculated as shown below.

Lot #	Mix Tons	Air Voids PF	Field VMA PF	Density Distance	Density PF
1	10,000	101.0	105.0	31680 ft	101.5
2	10,000	101.0	105.0	31680 ft	101.4
3	7,840	101.0	105.0	24640 ft	97.3
Total	27,840			88000 ft	
TPF		**101.0**	**105.0**		**100.3**

$$TPF_{Density} = W1PF_{lot1} + W2PF_{lot2} + W3PF_{lot3}$$

$$TPF_{Density} = (31680/88000)(101.5)+(31680/88000)(101.4)+(24640/88000)(97.3)$$

$$TPF_{Density} = 100.3$$

Combine the three Total Pay Factors to determine the Composite Pay Factor for the mix.

$$CPF = [0.3(101.0) + 0.3(105.0) + 0.4(100.3)] / 100$$

$$CPF = 1.019$$

Determine the adjusted pay for the given mixture.

Given that the mixture bid price per ton = $65.00 and 27,840 tons were placed.

Plan Unit Pay = $65.00/ton x 27,840 tons = $1,809,600.00

Adjusted Pay = $65.00/ ton x 27,840 tons x 1.019 = $1,843,982.40

The pay adjustment is the difference between the adjusted pay and the plan unit pay.

Pay Adjustment = $1,843,982.40 – $1,809,600.00 = $34,382.40

If the difference is a positive value this will be the incentive paid. If the difference is a negative value this will be the disincentive applied. In this case a $34,382.40 incentive would be paid as per Construction Memorandum #4.

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Example 2 – Full Depth:

Given: a 14,000 sq yd full-depth project bid at $40/sq yd with two mixtures whose composite pay factors were determined to be 101.5% and 99.2%. The full-depth combined composite pay factor will be calculated as follows:

101.5(1/2) + 99.2(1/2) = 100.4%

Determine the adjusted pay and pay adjustment for the full-depth pavement.

Given that the bid price per square yard = $40.00 and 14,000 sq yd were placed.

Plan Unit Pay = $40.00/ sq yd x 14,000 sq yd = $560,000

Adjusted Pay = $40.00/ sq yd x 14,000 sq yd x 1.004 = $562,240

Pay Adjustment = $562,240 – $560,000 = $2,240 (Positive value = Incentive)

Example 3 – Full Depth:

Given: a 43,000 sq yd full-depth project bid at $40/sq yd with three mixtures whose composite pay factors were determined to be 98.9%, 101.5% and 99.2%. The full-depth combined composite pay factor will be calculated as follows:

98.9(1/3) + 101.5(1/3) + 99.2(1/3) = 99.9%

Determine the adjusted pay and pay adjustment for the full-depth pavement.

Given that the bid price per square yard = $40.00 and 43,000 sq yd were placed.

Plan Unit Pay = $40.00/ sq yd x 43,000 sq yd = $1,720,000

Adjusted Pay = $40.00/ sq yd x 43,000 sq yd x 0.999 = $1,718,280

Pay Adjustment = $1,718,280 – $1,720,000 = -$1,720 (Negative value = Disincentive)

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Hot-Mix Asphalt PFP Dispute Resolution
Appendix E.5

Effective Date: April 1, 2010
Revised Date: December 1, 2023

A. Scope

This document describes the two methods for disputing Pay for Performance (PFP) test results and the requirements for each. It also provides cost information for dispute testing and instructions for submitting dispute resolution samples to the Central Bureau of Materials (CBM). All participating Contractor Labs shall meet all the requirements of an Approved QC Laboratory by the Department.

B. Dispute Resolution

Dispute resolution testing will be permitted when the Contractor submits their split sample test results prior to receiving Department split sample test results. Dispute resolution testing shall be according to Method 1 (pay parameter dispute) or Method 2 (individual parameter dispute). When dispute resolution is chosen, the Contractor shall submit a request in writing within four working days of receipt of the Department's results of the Quality Level Analysis for the lot in question. The Engineer will document receipt of the request. The request shall specify Method 1 or Method 2 dispute resolution. The CBM laboratory will be used for dispute resolution testing.

1. Method 1:

Method 1 dispute resolution will be allowed when Contractor and Department split test results exceed the precision limits shown in Table 1. Dispute resolution test results for G_{mm}, G_{mb}, and asphalt binder content will replace the original Department G_{mm}, G_{mb}, and asphalt binder content test results. Method 1 shall be used in cases where Department test results are outside the acceptable limits shown in the Standard Specifications Article 1030.07.

Table 1

Test Parameter	Limits of Precision
Voids	1.0 %
Field VMA	1.0 %
Dust/AB Ratio	0.2
Core Density	1.0 %

2. Method 2:

Method 2 dispute resolution will be allowed when both: 1) the Contractor participates and complies with the AASHTO re:source Proficiency Sample Program testing protocol as specified herein and 2) the Contractor and Department **adjusted** split test results, as described herein, exceed the precision limits shown in Table 2. The dispute resolution test/s will only be performed for the parameter/s (G_{mm}, G_{mb}, or asphalt binder content) exceeding precision limits.

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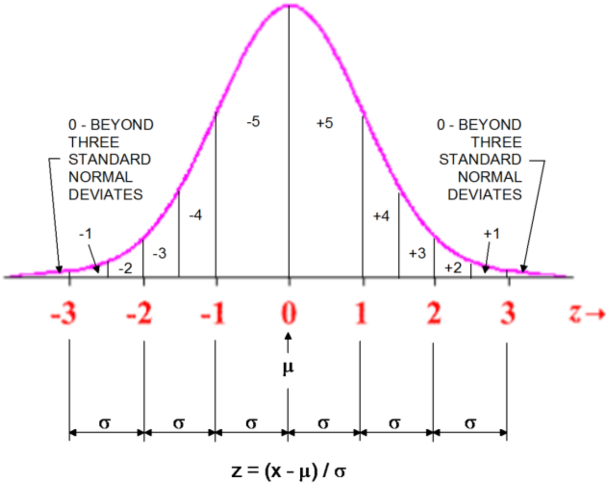
Both solvent extraction and ignition oven procedures may be used for determining asphalt binder content. The dispute resolution test result(s) will replace the original Department result(s) for the disputed parameters.

Table 2

Test Parameter	Limits of Precision
G_{mm}	0.008
G_{mb}	0.012
Asphalt Binder Content	0.2

a. Proficiency Sample Testing

To qualify for dispute resolution using Method 2, a QC laboratory must participate in the AASHTO re:source's (formerly AMRL) Proficiency Sample Program (PSP). PSP samples are distributed annually to federal, state, independent, commercial, and research testing laboratories. AASHTO re:source scores proficiency test samples by fitting a standard normal distribution to the data from all laboratories (with outliers eliminated). Laboratories whose results fall within one standard normal deviation from the mean are assigned a numerical score of "5." Laboratories whose results fall between 1 and 1½ standard normal deviations from the mean are assigned a score of "4," and the ratings are further decreased one point for each half standard normal deviate thereafter. A positive sign (+) indicates the lab result is above the population mean, and a negative sign (-) indicates the lab result is below the population mean. This system can be depicted graphically, as follows:



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For the Contractor to dispute individual test results, G_{mm}, G_{mb}, and/or asphalt binder content, all of the following shall be met:

1. The Contractor's laboratory that conducts the Quality Control testing for the project in question participates annually in the appropriate AASHTO re:source PSP.
2. The Contractor has submitted the laboratory's proficiency sample report(s) to the Department with the documentation of the data results submission to AASHTO re:source dated no later than December 31 for G_{mm} and G_{mb} and June 7 for asphalt content. The results will be evaluated as follows:
   a) If the Contractor's laboratory that conducts Quality Control testing received a proficiency score of 3 or better on all individual tests (G_{mm}, G_{mb}, and asphalt binder content), the Contractor will be approved for Method 2.

   b) If the Contractor's laboratory that conducts Quality Control testing for the project in question received a proficiency score of 2 or lower on an individual test, the Contractor shall complete the following to remain on the Method 2 approved list:
      i) Conduct an investigation and perform a root cause analysis to determine the possible reason(s) for the results;
      ii) Correct any issues that are uncovered in the investigation;
      iii) Document the investigation and corrective actions;
      iv) Submit the AASHTO Accreditation Program (AAP) proficiency sample corrective action report to CBM; and
      v) Purchase and test a blind proficiency sample from AASHTO re:source.

      Note: Blind extra proficiency samples are surplus samples that were produced for a regularly scheduled round of testing and are available for purchase by contacting AASHTO re:source. The blind extra proficiency sample should be randomly selected by AASHTO re:source.

      vi) Submit the laboratory's proficiency sample report for the blind proficiency sample to the Department with the documentation of the data results submission to AASHTO re:source dated no later than December 31 for G_{mm} and G_{mb} and June 7 for asphalt content. Failure to show that these results were submitted to AASHTO re:source by these deadlines will result in removal from the Method 2 approved list.

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vii) A proficiency score of 3 or better shall be received for the test parameter in question on the blind proficiency sample.

viii) Failure to achieve a score of 3 or better on each of the three test parameters in two attempts within each annual testing period will result in removal from the Method 2 approved list until a score of 3 or better on all test parameters is achieved through scheduled AASHTO re:source PSP testing.

c) Use of Contractor Central Lab for asphalt binder content disputes:

i) All labs shall conduct daily asphalt binder content testing for quality control.

ii) Any lab that participates in the PSP program and earns ratings of 3 or better on respective G_{mm}, G_{mb}, and asphalt binder content tests is eligible to dispute any of the three parameters according to Method 2.

iii) A Contractor's Lab that has earned PSP ratings of 3 or better in all three parameters can be used as a Central Lab to dispute asphalt binder content according to Method 2 for any of the labs operated by that Contractor. To be eligible to be a Central Lab, that specific lab must perform all the asphalt binder content testing that is reported to the Department for all of that Contractor's PFP projects for that calendar year including the asphalt binder content sample result that is being disputed. In addition, for any lab to use a Central Lab for asphalt binder content disputes according to Method 2, the originating lab where dailyquality control is conducted shall have earned ratings of 3 or better on both G_{mm} and G_{mb} testing.

3. The adjusted split test results, as defined below, for the individual test, G_{mm}, G_{mb}, or asphalt binder content, exceed the precision limits listed in Table 2. The adjusted split test results account for any offset between the Department and Contractor test results. The adjusted split test results will be determined for each lot by:

a) For each sublot, subtract the Department's result from the Contractor's result to determine the initial split;

b) For each lot, calculate the average initial split test result;

c) For each sublot, subtract the average initial split test result for the lot from the initial split result to determine the adjusted split sublot test result.

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d) Compare the adjusted split with the precision limits listed in Table 2 to determine whether the sample qualifies for dispute testing (Example is shown in Table 3).

Table 3.

EXAMPLE ADJUSTED SPLIT RESULTS CALCULATION

G_{mm}				
Sublot	Contractor	IDOT	Initial Split	Adjusted Split
1-1	2.456	2.454	0.002	-0.001
1-2	2.458	2.455	0.003	0.000
1-3	2.462	2.466	-0.004	-0.007
1-4	2.471	2.463	0.008	0.005
1-5	2.459	2.461	-0.002	-0.005
1-6	2.474	2.462	0.012	0.009
1-7	2.463	2.465	-0.002	-0.005
1-8	2.463	2.461	0.002	-0.001
1-9	2.472	2.468	0.004	0.001
1-10	2.466	2.464	0.002	-0.001
Average Initial Split			0.003	

Density cores for dispute resolution testing shall be taken at the same time as the random density core. The density core for dispute resolution testing shall be taken within 1 ft (300 mm) longitudinally of the random density core and at the same transverse offset. Density dispute resolution will replace the original density test results. For density disputes, the Contractor shall use the Department’s running average for G_{mm} when determining compliance with the limits of precision.

If three or more consecutive mixture sublots or G_{mm} results are contested, corresponding density results will be recalculated with the new G_{mm}.

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C. Dispute Testing Pay Schedule

The final pay factor for the lot under dispute resolution will be recalculated using the results from all disputed mix sublots and density intervals. If the recalculated average lot pay factor for any single disputed mix sublot or density interval is less than or equal to the original lot pay factor, the laboratory costs for that sublot (Table 4) will be borne by the Contractor.

Table 4

Test	Cost
Method 1 Mix Testing	$1000 / sublot
Core Density	$300 / core
G_{mm}	$200
G_{mb}	$500
Asphalt Binder Content	$500

1. Mix Dispute Cost Calculation Examples:

Given: This example mix is an N50 SMA with an updated G_{SB} of 2.650 and a design G_{MM} of 2.500. Examples 1 and 2 will use the data provided in Tables 5 and 6.

Table 5

Example Contractor Results					
Sublot	G_{MB}	G_{MM}	AB	Air Voids	VMA
1-1	2.369	2.501	6.1	5.3	16.1
1-2	2.367	2.498	6.0	5.2	16.0
1-3	2.372	2.502	5.9	5.2	15.8
1-4	2.371	2.503	6.2	5.3	16.1
1-5	2.368	2.503	6.0	5.4	16.0
1-6	2.369	2.497	6.1	5.1	16.1
1-7	2.368	2.501	6.0	5.3	16.0
1-8	2.384	2.498	6.0	4.6	15.4
1-9	2.375	2.495	5.9	4.8	15.7
1-10	2.368	2.496	6.0	5.1	16.0

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Table 6

Example IDOT District Results					
Sublot	G_{MB}	G_{MM}	AB	Air Voids	VMA
1-1	2.355	2.494	6.1	5.6	16.6
1-2	2.370	2.510	6.1	5.6	16.0
1-3	2.375	2.504	6.3	5.2	16.0
1-4	2.378	2.502	5.3	5.0	15.0
1-5	2.377	2.485	5.9	4.3	15.6
1-6	2.354	2.500	6.0	5.8	16.5
1-7	2.370	2.497	6.0	5.1	15.9
1-8	2.381	2.503	6.1	4.9	15.6
1-9	2.377	2.493	6.0	4.7	15.7
1-10	2.367	2.494	6.1	5.1	16.1

Example 1 – Method 1 Mix Disputes:

Sublots 1-4 and 1-5 qualify for dispute resolution based on the limits for Method 1 in Table 1. The Contractor has chosen to dispute these two mix sublots. The CBM dispute resolution results are shown Table 7. These results will replace the District results.

Table 7

Example IDOT CBM Dispute Resolution Results					
Sublot	G_{MB}	G_{MM}	AB	Air Voids	VMA
1-4	2.372	2.498	6.2	5.0	16.0
1-5	2.374	2.495	6.0	4.9	15.8

Replacing the results for the mix sublots generates the pay factor changes shown in Table 8. The effect of each sublot on the pay factor is evaluated independently of other disputed sublots when determining if the sublot lab costs are to be borne by the Contractor.

Table 8

Method 1 Pay Factors				
Sublot	Air Voids	VMA	Average	Cost Responsibility
Initial Pay Factors	89.5	100.5	97.3	
1-4 Only	89.5	105.0	95.8	IDOT
1-5 Only	89.0	101.0	95.0	Contractor
Final Pay Factors	89.0	105.0	97.0	

Sublot 1-4 caused an increase in the VMA pay factor, and no change in the air voids pay factor. The average pay factor increased, so the cost for sublot 1-4 will be borne by IDOT. Sublot 1-5 caused an increase in the VMA pay factor, but a decrease in the air voids pay factor. The average pay factor did not change, so the cost for sublot 1-5 will be borne by the Contractor.

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Example 2 – Method 2 Mix Disputes

Based on the adjusted splits, sublots 1-1 through 1-6 qualify for Method 2 dispute resolution. The adjusted splits are shown in Table 9, with the highlighted splits being outside of the precision limits from Table 2. For this example, the Contractor is qualified to use Method 2, and has chosen to dispute all the possible sublots using Method 2. The CBM results for the disputed volumetrics are shown in Table 10. Those results then replace the District results from Table 6, and the combined results are shown in Table 11 with the new values highlighted.

Table 9

Method 2 Splits						
Sublot	Initial G_{MB}	Adjusted G_{MB}	Initial G_{MM}	Adjusted G_{MM}	Initial AB	Adjusted AB
1-1	0.014	**0.013**	0.007	0.006	0.00	-0.00
1-2	-0.003	-0.004	-0.012	**-0.013**	-0.10	-0.10
1-3	-0.003	-0.004	-0.002	-0.003	-0.40	**-0.40**
1-4	-0.007	-0.008	0.001	0.000	0.90	**0.90**
1-5	-0.009	-0.010	0.018	**0.017**	0.10	0.10
1-6	0.015	**0.014**	-0.003	-0.004	0.10	0.10
1-7	-0.002	-0.003	0.004	0.003	0.00	0.00
1-8	0.003	0.003	-0.005	-0.006	-0.10	-0.10
1-9	-0.002	-0.002	0.002	0.001	-0.10	-0.10
1-10	0.001	0.000	0.002	0.001	-0.10	-0.10
Average Initial split	0.001		0.001		0.00	

Table 10

Example IDOT CBM Dispute Resolution Results			
Sublot	G_{MB}	G_{MM}	AB
1-1	2.362	X	X
1-2	X	2.505	X
1-3	X	X	6.2
1-4	X	X	6.2
1-5	X	2.495	X
1-6	2.356	X	X

Table 11

Example IDOT Combined Dispute Resolution Results					
Sublot	G_{MB}	G_{MM}	AB	Air Voids	VMA
1-1	**2.362**	2.494	6.1	**5.3**	**16.3**
1-2	2.370	**2.505**	6.1	**5.4**	**16.0**
1-3	2.375	2.504	**6.2**	**5.2**	**15.9**
1-4	2.378	2.502	**6.2**	**5.0**	**15.8**
1-5	2.377	**2.495**	5.9	**4.7**	**15.6**
1-6	**2.356**	2.500	6.0	**5.8**	**16.4**

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Replacing the results for the mix sublots generates the pay factor changes shown in Table 12. The effect of changing each sublot on the pay factor is evaluated independently of other disputed sublots when determining if the lab costs are to be borne by the Contractor.

Table 12

Method 2 Pay Factors				
Sublot	Air Voids	VMA	Average	Cost Responsibility
Initial Pay Factors	89.5	100.5	95.0	
1-1 Only	91.0	101.0	96.0	IDOT
1-2 Only	90.5	100.5	95.5	IDOT
1-3 Only	89.5	100.5	95.0	Contractor
1-4 Only	89.5	104.5	97.0	IDOT
1-5 Only	89.0	100.5	94.8	Contractor
1-6 Only	89.5	100.5	95.0	Contractor
Final Pay Factors	92.5	105.0	98.8	

Disputing sublot 1-5 caused the pay factor to decrease, resulting in the Contractor bearing the cost. Disputing sublots 1-1, 1-2, and 1-4 caused the pay factor to increase, resulting in IDOT bearing the cost. Disputing sublots 1-3 and 1-6 did not cause the pay factor to increase, resulting in the Contractor bearing the cost.

Example 3 – Method 1 Core Disputes:

Given: This example mix is an N50 SMA with an updated G_{SB} of 2.650 and a design G_{MM} of 2.500. The sublot core G_{MB} results from the Department and Contractor are shown in table 13. The Department's running average G_{MM} for this sublot is 2.487, and it has been used to calculate the Density in Table 13.

Table 13

Sublot	**Contractor Results**		**IDOT District Results**		Δ Density
	G_{MB}	Air Voids	G_{MB}	Density	
1-1	2.315	93.1	2.305	92.7	0.4
1-2	2.324	93.4	2.295	92.3	**1.1**
1-3	2.320	93.3	2.301	92.5	0.8
1-4	2.328	93.6	2.309	92.8	0.8
1-5	2.329	93.6	2.355	94.7	**1.1**
1-6	2.338	94.0	2.320	93.3	0.7
1-7	2.335	93.9	2.322	93.4	0.5
1-8	2.338	94.0	2.335	93.9	0.1
1-9	2.360	94.9	2.333	93.8	**1.1**
1-10	2.340	94.1	2.320	93.9	0.2

Sublots 1-2, 1-5, and 1-9 are outside the limits of precision from Table 1 and can be disputed using Method 1. The Contractor has decided to dispute all the sublots. The CBM G_{MM} and air void results are shown in Table 14. Table 15 shows the effect of each of the CBM results on the pay factor. The effect of each sublot is evaluated independently for determining the cost responsibility.

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Table 14

CBM Results		
Sublot	G_{MB}	Density
1-2	2.315	93.1
1-5	2.328	93.6
1-9	2.329	93.6

Table 15

Method 1 Core Pay Factors		
Sublot	Density	Cost Responsibility
Initial Pay Factor	87.0	
1-2	90.0	IDOT
1-5	85.5	Contractor
1-9	87.0	Contractor
Final Pay Factor	89.5	

Sublot 1-2 caused the pay factor to increase, so IDOT bears the cost. Sublot 1-5 caused the pay factor to decrease, so the Contractor bears the cost. Sublot 1-9 did not change the pay factor, so the Contractor bears the cost.

D. Dispute Submittal Instructions

When submitting HMA mix and/or core samples to CBM for dispute testing, the District will include the following:

1. All District and Contractor split sample test results on the attached “PFP Dispute Resolution Form”,
2. The dispute resolution HMA mix split sample with the contract number and sublot clearly marked on each sample bag,
3. Cores must be split or sawed by the Contractor to the appropriate lift thickness for testing,
4. Quality Management Program (QMP) Package template and Daily Plant Reports sent electronically for mix being tested.

Send sample and requested documentation to:

Illinois Department of Transportation
Central Bureau of Materials
Hot-Mix Asphalt Laboratory
126 E. Ash Street
Springfield, Illinois 62704-4766
Attention: HMA Lab Supervisor

Any sample sent to CBM without the above listed information will not be processed until all requested information is received

Illinois Department of Transportation

PFP DISPUTE RESOLUTION

Method 1 ☐ Parameter Disputed: VMA ☐ Voids ☐ D/AB ☐

Method 2 ☐ Parameter Disputed: G_{mb} ☐ G_{mm} ☐ AB ☐

Contract # : ____________________

Dist. Lab ID # : ____________________

Mix Design # : ____________________

Mix Code #: ____________________

Producer #: ____________________

CBM Lab #: ____________________

Wt. for G_{mb}: ____________________

Sampled From: Truck ☐ MTD ☐ Road ☐

Sample Date: ____________________

Date Received: ____________________

Mix Lot _____ Sublot _____

Sieve Size	**District** % Passing	**Contractor** % Passing	**CBM** % Passing
1 ½ in. (37.5 mm)			
1 in. (25 mm)			
¾ in. (19 mm)			
½ in. (12.5 mm)			
3/8 in. (9.5 mm)			
No. 4 (4.75 mm)			
No. 8 (2.36 mm)			
No. 16 (1.18 mm)			
No. 30 (600 µm)			
No. 50 (300 µm)			
No. 100 (150 µm)			
No. 200 (75 µm)			
Asphalt Binder %			
Dust/AB Ratio			
G_{mm}			
G_{mb}			
% Air Voids			
G_{sb}			
Field VMA			

CORES

	District	**Contractor**	**CBM**
Core #	G_{mm}†	G_{mm}	G_{mm}
Core #	G_{mb}	G_{mb}	G_{mb}
Core #	Density %	Density %	Density %

† This shall be the G_{mm} used for Density Calculation.

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QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
Revised: December 1, 2021

This document explains the procedures used to determine the pay adjustment for a hot-mix asphalt (HMA) mixture and a hot-mix asphalt full-depth pavement when Quality Control for Performance (QCP) is specified as the Quality Management Program (QMP).

The following steps are used to determine the pay adjustment for a QCP mixture:

1. Determine sublot deviation from target for each pay parameter.

   A. If intelligent compaction was successfully implemented, there will be no deviations from target for density.

   B. A density sublot will either be based upon intelligent compaction or density tests using cores. The two methods will not be mixed.

2. Determine the sublot pay factor (PF) for each sublot using Table 1 and the deviation from target.

   A. For mixtures, the 105% column only applies when the District conducts testing of all the sublots within a given lot and all the test results are within the Acceptable Limits.

   B. For density, the 105% column also applies to density sublots where no individual density test is less than 90.0% or greater than 98.0% density.

   C. If intelligent compaction was successfully implemented, the density pay factor will be 100%.

3. Determine the average sublot PF for each pay parameter. The average sublot PF for each pay parameter will be capped at 100.0%.

4. Calculate the composite pay factor (CPF) using the average sublot PFs and Equation 1.

5. Determine the plan unit pay, adjusted pay, and pay adjustment for the mixture using Equations 2, 3, and 4.

Additionally, for a full-depth pavement the adjusted pay and pay adjustment will be calculated using the combined composite pay factors for mixtures used in its construction. Each mixture composite pay factor will be weighted equally. Mixtures placed having the same gyration values but with and without polymer will be treated as two separate mixtures. For example, one surface mix and one binder mix will be weighted 50/50 regardless of tonnage. Additionally, one surface mix, one polymer binder mix and one non-polymer binder mix will be treated as three equally (1/3) weighted mixtures even if the polymer binder is the only difference between binder lifts. The full-depth adjusted pay is determined by multiplying the plan unit pay by the combined composite pay factor. The pay adjustment is then determined by subtracting the plan unit pay from the adjusted pay.

Note: Monetary deductions for dust/AB ratio will be applied separately using the Dust/AB Ratio Deduction Table found in the Standard Specifications Article 406.14.

QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
Revised: December 1, 2021

Table 1

Pay Parameter		Pay Factor			
		105%	100%	95%	90%
Air Voids$^{1/2/3/}$		± 0.5%	± 1.2%	± 1.6%	± 2.0%
Field VMA $^{1/2/}$		0% to +1.0% above minimum specified	-0.5% to +2.0%	-0.7% to +2.5%	-1.0% to +3.0%
In-Place Density$^{4/5/}$	SMA	94.0% to 95.0%	93.5% to 96.5%	92.5% to 97.0%	92.0% to 98.0%
	HMA	93.5% to 94.5%	92.5% to 96.5%	91.5% to 97.0%	90.0% to 98.0%

1/ Mixture targets specified in 1030.05(b).
2/ If mixture testing is waived for small tonnage, the Contractor will receive 100% for Air Voids and Field VMA pay factors in Equation 1.
3/ Ranges based on deviation from specified design percent Air Voids.
4/ If no density requirement applies, the Contractor will receive 100% for the Density pay factor in Equation 1.
5/ A density test where the core thickness is less than 0.75 in. will not be used in the Density pay factor calculation.

Equation 1: $CPF = 0.30(PF_{Voids}) + 0.30(PF_{VMA}) + 0.40(PF_{Density})$

Where:

CPF = Composite Pay Factor

PF_{Voids}, PF_{VMA}, and $PF_{Density}$ = Average sublot pay factors for the pay parameters

The pay adjustment for a given mixture is calculated by multiplying the Mixture Unit Price by the Quantity and the CPF, and then subtracting the Mixture Unit Price multiplied by the Unit Price according to Equations 2, 3, and 4 below.

Equation 2: Plan Unit Pay = Mixture Unit Price x Mixture Quantity

Equation 3: Adjusted Pay = (Mixture Unit Price x Mixture Quantity x CPF/100)

Equation 4: Pay Adjustment = Adjusted Pay – Plan Unit Pay

QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
Revised: December 1, 2021

Overlay Example:

Determine the adjusted pay and pay adjustment for a N70 HMA IL-9.5 surface mixture being placed at 1.5 inches thick as an overlay with QCP specified as the Quality Management Program. The project consists of 6,900 tons placed over a distance of 12 lane miles. From the mix requirements table in the contract plans and 1030.05(b) the target air voids are 4.0% and the target minimum field VMA is 15.0%, respectively.

Note: The mix sample lots and density lots are independent of one another.

In this example, the first mix lot represents 4,000 tons while the second lot represents 2,900 tons. There are 12 density sublots representing 12 lane-miles (N=12).

Mix samples: Each sublot represents 1,000 tons except for lot 2, sublot 3 which represents 900 tons. (Note: All sublots are weighted the same.)

Mixture Sample		Air Voids		Field VMA	
Lot	Sublot	Contractor	District	Contractor	District
1	1	4.1	***3.2***	14.9	***14.6***
	2	3.9		14.5	
	3	2.5		14.0	
	4	3.0		14.8	
2	1	2.3	***2.5***	14.3	***14.5***
	2	2.1	2.2	14.0	14.1
	3	3.8	3.6	14.7	14.6

Note: Bolded and italicized test results denote the sublot split that was randomly selected by the District for testing.

Density: Since this pavement is < 3 inches thick, cores are taken randomly every 0.2 miles which is 5 cores per mile (60 cores for the 12 lane-mile project). With each density sublot the average of 5 consecutive cores represents 1 mile of paving.

QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
Revised: December 1, 2021

Density Sublot	**Density Intervals (cores)**				
	1	**2**	**3**	**4**	**5**
1	**90.4**	**90.8**	**91.6**	**92.4**	**92.1**
2	**93.8**	**94.1**	**92.3**	**92.1**	**92.6**
3	**91.8**	**93.5**	**93.9**	**92.8**	**92.5**
4	**93.7**	**94.2**	**93.5**	**93.3**	**92.8**
5	**92.1**	**94.1**	**92.6**	**93.8**	**92.3**
6	**94.1**	**94.3**	**93.2**	**94.5**	**93.9**
7	**93.6**	**93.3**	**92.5**	**91.9**	**92.7**
8	**92.8**	**93.3**	**94.2**	**93.5**	**93.7**
9	**91.5**	**91.2**	**91.9**	**91.8**	**90.9**
10	**93.0**	**92.6**	**92.1**	**92.3**	**94.1**
11	**92.3**	**93.0**	**93.8**	**92.6**	**94.1**
12	**91.5**	**93.5**	**92.7**	**93.8**	**92.1**

Determine the average sublot pay factor for each parameter:

Air Voids:

Since the District randomly selected and tested the split from Sublot 2 in Lot 1, and the Air Void results were 1) within the 100% pay factor tolerance **and** 2) within Precision Limits of the Contractor's results, the District does not need to test the remaining sublots in Lot 1 and the entire lot receives a pay factor of 100%.

For the second lot, the District randomly selected and tested the split from Sublot 1. Since the District Air Void results were not within the 100% pay factor tolerance, the District had to test all of the remaining sublot splits. (see completed table below):

Calculate the Air Void deviation from the target for each of the District sublot split results.

Lot 1:
Sublot 2: Deviation = 3.2% - 4.0% = -0.8%

Lot 2:
Sublot 1: Deviation = 2.5% - 4.0% = -1.5%
Sublot 2: Deviation = 2.2% - 4.0% = -1.8%
Sublot 3: Deviation = 3.6% - 4.0% = -0.4%

QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
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Using Table 1 and the deviation from the Target, determine the corresponding Air Voids sublot pay factor for each District test result.

Lot 1:
Sublot 2: Pay Factor associated with -0.8% in Table 1 is 100%

Lot 2:
Sublot 1: Pay Factor associated with -1.5% in Table 1 is 95%
Sublot 2: Pay Factor associated with -1.8% in Table 1 is 90%
Sublot 3: Pay Factor associated with -0.4% in Table 1 is 105%

Air Voids					
Lot	Sublot	Contractor	District	Deviation	Sublot PF
1	1 2 3 4	4.1 3.9 2.8 3.0	***3.2***	***-0.8***	***100***
2	1	2.3	***2.5***	***-1.5***	***95***
	2	2.1	2.2	-1.8	90
	3	3.8	3.6	-0.4	105

Note: Bolded and italicized test results denote the sublot split that was randomly selected by the District for testing.

Calculate the average sublot pay factor for Air Voids. (Note: The 100% in Lot 1 represents four sublots and therefore is multiplied by four.)

Average sublot Pay Factor (PF_{Voids}) = ((100% x 4) + 95% + 90% + 105%) / 7 sublots = **98.6%**

Field VMA:

Since the District randomly selected and tested the split from Sublot 2 in Lot 1, and the Field VMA results were 1) within the 100% pay factor tolerance **and** 2) within Precision Limits of the Contractor's results, the District does not need to test the remaining sublots in Lot 1 and the entire lot receives a pay factor of 100%.

For the second lot, the District randomly selected and tested the split from Sublot 1. Since the District results were not within the 100% pay factor tolerance **for Air Voids**, the District had to test all of the remaining sublot splits. (see completed table below):

QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
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Calculate the Field VMA deviation from the target for each of the District sublot split results.

Lot 1:
Sublot 2: Deviation = 14.6% - 15.0% = -0.4%

Lot 2:
Sublot 1: Deviation = 14.5% - 15.0% = -0.5%
Sublot 2: Deviation = 14.1% - 15.0% = -0.9%
Sublot 3: Deviation = 14.6% - 15.0% = -0.4%

Using Table 1 and the deviation from Target, determine the corresponding Field VMA sublot pay factor for each District test result.

Lot 1:
Sublot 2: Pay Factor associated with -0.4% in Table 1 is 100%

Lot 2:
Sublot 1: Pay Factor associated with -0.5% in Table 1 is 100%
Sublot 2: Pay Factor associated with -0.9% in Table 1 is 90%
Sublot 3: Pay Factor associated with -0.4% in Table 1 is 100%

Minimum Field VMA = 15.0%					
Lot	Sublot	Contractor	District	Deviation	Sublot PF
1	1 2 3 4	14.9 14.5 14.4 14.8	***14.6***	***-0.4***	***100***
2	1	14.3	***14.5***	***-0.5***	***100***
	2	14.0	14.1	-0.9	90
	3	14.7	14.6	-0.4	100

Note: Bolded and italicized test results denote the sublot split that was randomly selected by the District for testing.

Calculate the average sublot pay factor for Field VMA. (Note: The 100% in Lot 1 represents four sublots and therefore is multiplied by four)

Average sublot Pay Factor (PF_{VMA}) = ((100% x 4) + 100% + 90% + 100%) / 7 sublots = **98.6%**

Density:

Determine the average Density for each sublot.

Determine the sublot pay factor using the average sublot Density and Table 1 (see completed table below).

Determine the Density pay factor by averaging the sublot pay factors.

QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
Revised: December 1, 2021

Density Sublot	**Density Intervals (cores)**						
	1	**2**	**3**	**4**	**5**	**Sublot Ave.**	**Sublot PF**
1	**90.4**	**90.8**	**91.6**	**92.4**	**92.1**	**91.5**	**95**
2	**93.8**	**94.1**	**92.3**	**92.1**	**92.6**	**93.0**	**100**
3	**91.8**	**93.5**	**93.9**	**92.8**	**92.5**	**92.9**	**100**
4	**93.7**	**94.2**	**93.5**	**93.3**	**92.8**	**93.5**	**105**
5	**92.1**	**94.1**	**92.6**	**93.8**	**92.3**	**93.0**	**100**
6	**94.1**	**94.3**	**93.2**	**94.5**	**93.9**	**94.0**	**105**
7	**93.6**	**93.3**	**92.5**	**91.9**	**92.7**	**92.8**	**100**
8	**92.8**	**93.3**	**94.2**	**93.5**	**93.7**	**93.5**	**105**
9	**91.5**	**91.2**	**91.9**	**91.8**	**90.9**	**91.5**	**95**
10	**93.0**	**92.6**	**92.1**	**92.3**	**94.1**	**93.8**	**100**
11	**92.3**	**93.0**	**93.8**	**92.6**	**94.1**	**92.1**	**100**
12	**91.5**	**93.5**	**92.7**	**93.8**	**92.1**	**92.7**	**100**
PF / 12 Sublots = 100.5							
Average Density Sublot PF = 100 (capped at 100)							

Composite Pay Factor:

Determine the Composite Pay Factor using Equation 1.

$$CPF = 0.30(PF_{Voids}) + 0.30(PF_{VMA}) + 0.40(PF_{Density})$$

$$= 0.30(98.6) + 0.30(98.6) + 0.40(100.0)$$

CPF = 99.2%

QCP Adjusted Pay and Pay Adjustment:

Determine the adjusted pay and pay adjustment for the given mixture using Equations 2, 3, and 4.

Where: Mixture Unit Price = $65.00/ton

Mixture Quantity = 6,900 tons placed.

Plan Unit Pay = $65.00/ton x 6,900 tons = $448,500

Adjusted Pay = $448,500 x 99.2/100 = $444,912

Pay Adjustment = ($65.00/ton x 6,900 tons x 99.2 / 100) – ($65.00/ton x 6,900 tons)
= - $3,588

In this case a $3,588 disincentive would be applied as per Construction Memorandum #4.

QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
Revised: December 1, 2021

Full Depth Example 1:

Given: a full-depth project with two mixtures whose composite pay factors were determined to be 100.0% and 98.2%. The bid price per square yard = $40.00 and 1,400 sq yd were placed.

The full-depth combined composite pay factor will be calculated as follows:

100.0(1/2) + 98.2(1/2) = 99.1%

Determine the full-depth adjusted pay and pay adjustment.

Plan Unit Pay = $40.00/ sq yd x 1,400 sq yd = $56,000

Adjusted Pay = $40.00/ sq yd x 1,400 sq yd x 0.991 = $55,496

Pay Adjustment = $55,496 – $56,000 = - $504

Full Depth Example 2:

Given: a full-depth project with three mixtures whose composite pay factors were determined to be 98.9%, 100.0% and 99.2%. The bid price per square yard = $40.00 and 1,400 sq yd were placed.

The full-depth combined composite pay factor is calculated as follows:

98.9(1/3) + 100.0(1/3) + 99.2(1/3) = 99.4%

Determine the full-depth adjusted pay and pay adjustment.

Plan Unit Pay = $40.00/ sq yd x 1,400 sq yd = $56,000

Adjusted Pay = $40.00/ sq yd x 1,400 sq yd x 0.994 = $55,664

Pay Adjustment = $55,664 – $56,000 = - $336

Illinois Department of Transportation

Best Practices
for
Hot-Mix Asphalt PFP and QCP
Appendix E.7

Effective Date: April 1, 2012
Revised Date: December 1, 2021

Purpose

This document is intended to aid District personnel in successfully supporting the Pay-For-Performance (PFP) and Quality Control for Performance (QCP) Quality Management Programs. Following these guidelines will lower risk to both the Department and Contractor, which should result in lower bid prices.

Lab

Since payment on PFP and QCP projects is based on Department test results, attention to laboratory equipment, qualified lab personnel and laboratory efficiency becomes paramount. Review of results from recent “Annual HMA Uniformity Studies” (aka Round Robins), dispute resolutions, and addressing any District lab issues resulting in poor comparisons will prove beneficial.

1) Equipment

It is imperative to inspect and calibrate all laboratory testing equipment according to frequencies listed in Policy Memorandum 21-08 ”Minimum Department And Local Agency Laboratory Requirements For Construction Materials Testing Or Mix Design” at a minimum. Inspection and calibration immediately prior to PFP and QCP testing is highly recommended. Always use the same gyratory compactor for an individual PFP or QCP contract.

Assessment of existing and needed equipment should be performed to determine possible benefits of purchasing additional equipment to optimize productivity. Each district should also develop an action plan in the event key equipment breaks down.

2) Personnel

It is also imperative that all laboratory personnel intended to be involved in PFP and QCP testing be qualified with successful completion of HMA Level I as a minimum. It is also important to keep technician assignments as consistent as possible. It is highly recommended to conduct in-house round robins with the above-mentioned laboratory personnel to ensure repeatability.

3) Sample Treatment

Inconsistent treatment of samples prior to testing has been identified as the leading reason for differences in test results between the contractor and the state. It is recommended that samples, for all parties involved, be allowed to cool to room temperature immediately after blending and splitting. The samples should then be reheated and compacted as soon as the samples reach compaction temperature. In each sublot, it is recommended to maintain mixture bulk specific gravity (G_{mb}) specimen dry weights within 10 grams for HMA and 15 grams for SMA. This would the entail the QC lab communicating the dry G_{mb} sample weight being used to the District Lab by writing it on the sample bag or some other means.

Illinois Department of Transportation

Best Practices
for
Hot-Mix Asphalt PFP and QCP
Appendix E.7

Effective Date: April 1, 2012
Revised Date: December 1, 2021

4) Laboratory Efficiency

The PFP and QCP QMP's are based heavily on Department testing which involves higher testing frequencies for the for the District laboratories when compared to the QC/QA QMP Timely QA test completion has been proven to reduce risk for Contractors and, if done consistently, should reduce bid prices. An internal audit of your District laboratory for efficiency may help identify ways to improve productivity. This activity should be conducted by District materials staff that are not involved in day-to-day testing or CBM staff if requested.

While the PFP and QCP specifications allow a 10 day turnaround, the District should attempt to reduce the turnaround time as much as possible. Nationally recognized successful programs have test turnaround results within 5 days.

Project Personnel

Key components of PFP and QCP which provide the necessary compliance with the Code of Federal Regulations (CFR) are 1) undisclosed random mix and density sample locations, 2) samples witnessed by the Engineer, and 3) sample security. The CFR is intended to assure that samples are under control of the Engineer at all times to verify the quality of the product. Most Districts will need to rely on project staff to determine random mix sample and density core locations. It will be important for project personnel to understand their role in witnessing and securing the sample. District Materials and Construction staff should meet prior to the start of a PFP or QCP project to discuss:

1) Responsibilities

   a) Who will be responsible for generating random mix samples and random density locations according to the Manual of Test Procedures for Materials documents "**Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling" and "Hot-Mix Asphalt PFP and QCP Procedure for Determining Random Density Locations".**
   b) Who will be responsible for identifying undisclosed sample locations and sample layout.
   c) How will samples be secured; discuss who will transport and / or store samples.
   d) Who will be responsible for entering data in QMP Package software, calculating pay and how communication regarding pay factors will occur.

2) Communication

   a) Random mix sample locations
      i) Discuss when to disclose sampling locations.
      ii) Discuss how to move mix sampling locations due to unsafe conditions according to the Manual of Test Procedures for Materials documents "**Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling".**

b) Density Locations
   i) Discuss whether there will be obstacles that will warrant moving random core locations according to the Manual of Test Procedures for Materials document "**Hot-Mix Asphalt PFP and QCP Procedure for Determining Random Density Locations".**
   ii) Discuss how to handle coring locations that need to be opened immediately to traffic.

Also, it will be important to make sure Construction personnel have copies of all the necessary supporting documents.

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Illinois Department of Transportation

Hot-Mix Asphalt PFP and QCP Calculations of Monetary Deductions
Appendix E.8

Effective Date: December 1, 2021
Revised Date: May 13, 2022

This document explains the procedures used to determine the unconfined edge density sublot monetary deduction for Pay for Performance (PFP), and the dust/AB ratio sublot deduction for hot-mix asphalt (HMA) mixtures and full-depth pavements when PFP or Quality Control for Performance (QCP) is selected as the Quality Management Program.

A. Determining and Applying an Unconfined Edge Density Monetary Deduction

The following steps are used to determine the unconfined edge density for a PFP mixture or full-depth pavement and calculate any monetary deductions. The Unconfined Edge Density Deduction Table in Standard Specification Article 406.14 will be used to determine the monetary deductions.

1. Test all sublots for unconfined edge density.
2. Determine the monetary deductions using the Unconfined Edge Density Deduction Table.
3. Total all unconfined edge density monetary deductions. For full-depth pavements, total all monetary deductions for all mixtures comprising the pavement.
4. If the total unconfined edge density monetary deductions are not $0,
   a) For full-depth pavements, apply the total monetary deductions to the adjusted full-depth pay.
   b) For all other HMA mixtures, apply the total monetary deductions for the mixture to the adjusted mixture pay.

B. Determining and Applying a Dust/AB Ratio Deduction

The following steps are used to determine the dust/AB ratio for PFP and QCP mixtures or full-depth pavements and to determine any monetary deduction. The Dust/AB Ratio Deduction Table in 406.14 will be used to determine sublot monetary deductions for both PFP and QCP Quality Management Programs.

Note: The dust/AB ratio monetary deduction procedure is not applicable to Stone Matrix Asphalt (SMA) mixtures.

1. PFP:

a) Test all sublots for minus No. 200 (75 µm) (dust) content and asphalt binder (AB) content.

b) Determine the sublot deductions using the Dust/AB Ratio Deduction Table.

c) Total all dust/AB ratio monetary deductions. For full-depth pavements, total all monetary deductions for all mixtures comprising the pavement.

d) If the total dust/AB ratio monetary deductions are not $0,

1) For full-depth pavements, apply the total monetary deductions to the adjusted full-depth pay.

2) For all other HMA mixtures, apply the total monetary deductions for the mixture to the adjusted mixture pay.

2. QCP:

a) Test for the sublot dust/AB ratio for the randomly selected sublot of each lot.

1) If the air voids and field VMA meet the 100% pay factor limits of Table 1 of the document “Hot-Mix Asphalt QCP Pay Adjustments” and compare within the precision limits table of the 1030.08.

i. And the dust/AB ratio range is within the $0 Deduct/Sublot using the Dust/AB Ratio Deduction Table, the entire lot will have a $0 monetary deduction.

ii. If the dust/AB ratio range is within any monetary deduction other than $0 Deduct/Sublot, all sublots will be tested for dust and AB and the dust/AB ratio monetary deduction will be calculated for each sublot.

2) If the air voids or field VMA do not meet the 100% pay factor limits of Table 1 of the document “Hot-Mix Asphalt QCP Pay Adjustments” or do not compare within the precision limits table of the 1030.08.

i. All sublots will be tested for dust and AB and the dust/AB ratio monetary deduction will be calculated for each sublot.

b) Total all dust/AB ratio monetary deductions. For full-depth pavements, total all monetary deductions for all mixtures comprising the pavement.

c) If the total dust/AB ratio monetary deductions are not $0,

1) For full-depth pavements, apply the total monetary deductions to the adjusted full-depth pay.

2) For all other HMA mixtures, apply the total monetary deductions for the mixture to the adjusted mixture pay.

Hot-Mix Asphalt PFP and QCP Calculations of Monetary Deductions
Appendix E.8

Effective Date: December 1, 2021
Revised Date: May 13, 2022

PFP Unconfined Edge Density Mixture Example

Given: The HMA pavement consists of a 13.0 ft wide mat 1.5 in. thick with the left edge confined without LJS and the right edge unconfined without LJS. Calculate the unconfined edge density sublot monetary deductions within the first mile.

There will be two unconfined edge density sublots along the right edge within the first mile.

Sublot #	Core #	Density	Deduct/Sublot1/
1	1	90.5%	$0
2	2	89.3%	$1,000
Total Monetary Deduction for Unconfined Edge Density = $1,000			

1/ From the Unconfined Edge Density Deduction Table

In addition to any PFP pay adjustments calculated for the mixture; based upon the air voids, field VMA and density tests; and any dust/AB ratio monetary deductions, a monetary deduction for unconfined edge density of $1,000 would be applied to this mixture.

Hot-Mix Asphalt PFP and QCP Calculations of Monetary Deductions
Appendix E.8

Effective Date: December 1, 2021
Revised Date: May 13, 2022

PFP Unconfined Edge Density Full-Depth Example

Given: A 75,000 sq yd full-depth pavement with a surface 24 ft wide is constructed with three mixtures. The contractor used two passes to achieve the width of the pavement. Each mixture was placed in one lift. The first pass of the first two mixtures had both edges unconfined. The second adjacent passes had one unconfined edge (centerline confined). The surface mixture was placed on LJS on all longitudinal joints. Calculate the unconfined edge density monetary deductions for the last 0.3 miles.

The first mix, first pass will have one random core taken in the last 0.3 miles from both unconfined edges. The second pass will have one random core taken in the last 0.3 miles from the unconfined edge. The second mix will be sampled the same way as the first mix. The third mix, the surface, will have no cores because LJS was used.

			Sublot #	Core #	Density	Deduct/Sublot[1/]
Mix 1	Pass 1	Left Edge	1	1	90.5%	$0
		Right Edge	2	2	90.2%	$0
	Pass 2	Left Edge	3	3	89.2%	$1,000
		Right Edge		-	-	-
Mix 2	Pass 1	Left Edge	4	4	90.3%	$0
		Right Edge	5	5	90.1%	$0
	Pass 2	Left Edge	6	6	88.5%	$3,000
		Right Edge		-	-	-
Mix 3	Pass 1	-		-	-	-
	Pass 2	-		-	-	-
Total Monetary Deduction for Unconfined Edge Density = $4,000						

1/ From the Unconfined Edge Density Deduction Table

In addition to the PFP combined pay adjustments calculated from the three mixtures; based upon the air voids, field VMA and density tests; and any dust/AB ratio monetary deductions, a monetary deduction for unconfined edge density of $4,000 would be applied to this full-depth pavement.

Hot-Mix Asphalt PFP and QCP Calculations of Monetary Deductions
Appendix E.8

Effective Date: December 1, 2021
Revised Date: May 13, 2022

PFP Dust/AB Ratio Example

Given: A N90 IL-9.5 HMA surface being placed at 1.5 inches thick as an overlay. The project consists of 10,000 tons over 16 miles.

Note: The mix sample and density lots are independent of each other.

In this example the mix sample lot represents 10,000 tons.

Note: All PFP sublots are tested for dust/AB ratio.

Lot #	Sublot #	Dust	AB	Dust/AB Ratio	Deduct/Sublot[1/]
1	1	5.1	6.0	0.8	$0
	2	4.9	6.0	0.8	$0
	3	4.8	5.9	0.8	$0
	4	5.3	5.9	0.9	$0
	5	5.8	5.8	1.0	$0
	6	7.4	5.8	1.3	$1,000
	7	7.3	5.7	1.3	$1,000
	8	5.2	6.1	0.8	$0
	9	5.3	5.9	0.9	$0
	10	5.1	5.8	0.9	$0
Total Monetary Deduction for Dust/AB Ratio = $2,000					

1/ From the Dust/AB Deduction Table

In addition to any PFP pay adjustments calculated for the mixture; based upon the air voids, field VMA and density tests; and any unconfined edge monetary deductions, a monetary deduction for dust/AB ratio of $2,000 would be applied to this mixture.

Illinois Department of Transportation

Hot-Mix Asphalt PFP and QCP Calculations of Monetary Deductions
Appendix E.8

Effective Date: December 1, 2021
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QCP Dust/AB Ratio Example

Given: A N70 IL-9.5 HMA surface mixture being placed at 1.5 inches thick as an overlay with QCP specified as the Quality Management Program. The project consists of 6,900 tons placed over a distance of 12 lane miles. From the mix requirements table in the contract plans and 1030.05(b) the target air voids are 4.0% and the target minimum field VMA is 15.0%, respectively.

Note: The mix sample lots and density lots are independent of one another.
In this example, the first mix lot represents 4,000 tons while the second lot represents 2,900 tons.

Mix samples: Each sublot represents 1,000 tons except for Lot 2, Sublot 3 which represents 900 tons. (Note: All sublots are weighted the same.)

Mixture Sample		Air Voids		Field VMA		District			Deduct/ Sublot[1/]
Lot	Sublot	Contractor	District	Contractor	District	Dust	AB	Dust/AB Ratio	
1	1	4.1	***3.2***	14.9	***14.6***				-
	2	3.9		14.5		4.8	5.9	0.8	$0[2/]
	3	2.5		14.0					-
	4	3.0		14.8					-
2	1	2.3	***2.5***	14.3	***14.5***	7.3	5.6	1.3	$1,000
	2	2.1	2.2	14.0	14.1	7.4	5.5	1.3	$1,000
	3	3.8	3.6	14.7	14.6	5.6	5.8	1.0	$0
Total Monetary Deduction for Dust/AB Ratio = $2,000									

Note: Bolded and italicized test results denote the sublot split that was randomly selected by the District for testing.

1/ From the Dust/AB Ratio Deduction Table

2/ If the tested mixture sublot is outside of the $0 deduction range, the District will test the remaining sublots for dust/AB ratio monetary deductions. This in itself will not trigger testing the other sublots for air voids or field VMA.

Since the District randomly selected and tested the split from Sublot 2 in Lot 1, and the Air Void and Field VMA results were 1) within the 100% pay factor tolerance <u>and</u> 2) within Precision Limits of the Contractor's results, and the District Dust/AB Ratio test result is in the range of no monetary deduction, the District does not need to test the remaining sublots in Lot 1 for Dust/AB Ratio and the entire lot receives no Dust/AB Ratio monetary deduction.

For the second lot, the District randomly selected and tested the split from Sublot 1. Since the District Air Void results were not within the 100% pay factor tolerance, the District had to test all of the remaining sublots, including Dust/AB Ratio. The Dust/AB Ratio test results for Sublot 1 and Sublot 2 were both in the range of a $1,000/sublot monetary deduction. The Dust/AB Ratio test result for Sublot 3 is in the range of no monetary deduction.

In addition to any QCP pay adjustments calculated for the mixture; based upon the air voids, field VMA and density tests; a monetary deduction for Dust/AB Ratio of $2,000 would be applied to this mixture.

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