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 4 - 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
"d", TSR	A, B	A, B	C, D	C, D
"D" & Splitting	C	D	A	B
AB Content	D	C	B	A

TUESDAY OR WEDNESDAY - DAY 2 or DAY 3

4:30 p.m. to 7:30 p.m.

NUCLEAR DENSITY TESTER COURSE

THURSDAY - DAY 4

7:00 a.m. to 9:00 am

Lecture on control charts 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.

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
Minimum grade of 70 is required.

Practical Test (Part 2):
No time limit is specified
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 1, 2017, the last date to retest is August 31, 2018)** 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.

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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 1, 2017, the last date to retest is August 31, 2018.)** 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.

QC/QA = Quality Control/Quality Assurance
PFP = Payment for Performance
QCP = Quality Control for Payment
MoTP = Manual of Test Procedures
BDE = BDE Special Provisions

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QC/QA Specifications

ASPHALT AND BITUMINOUS ITEMS

SECTION 1030. HOT-MIX ASPHALT

1030.01 Description. This section describes the materials, mix design, quality control/quality assurance (QC/QA), proportioning, mixing, and transportation requirements to produce hot-mix asphalt (HMA) using Illinois Modified Strategic Highway Research Program (SHRP) Superpave criteria.

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

High ESAL	IL-19.0 binder; IL-9.5 surface
Low ESAL	IL-19.0L binder; IL-9.5L surface; Stabilized Subbase (HMA) 1/ HMA Shoulders 2/

1/ Uses 19.0L binder mix.

2/ Uses 19.0L for lower lifts and 9.5L for surface lift.

1030.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate	1004.03
(b) Fine Aggregate	1003.03
(c) RAP Material	1031
(d) Mineral Filler	1011
(e) Hydrated Lime	1012.01

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(f) Slaked Quicklime (Note 1)
(g) Performance Graded Asphalt Binder (Note 2) 1032
(h) Fibers (Note 3)
(i) Warm Mix Asphalt (WMA) Technologies (Note 4)

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

Note 2. The asphalt binder shall be an SBS PG 76-28 when the SMA is used on a full-depth asphalt pavement and SBS PG76-22 when used as an overlay.

Note 3. A stabilizing additive such as cellulose or mineral fiber shall be added to SMA mixtures according to Illinois Modified AASHTO M 325. The stabilizing additive shall meet the Fiber Quality 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 4. Warm mix additives or foaming processes shall be selected from the Department's qualified producer list.

1030.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Hot-Mix Asphalt Plant	1102.01
(b) Heating Equipment (Note 1)	1102.07
(c) Hot-Mix Surge Bins	1102.01(a)(6)

Note 1. 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. Polymer modified asphalt binder shall be placed in an empty tank and shall not be blended with other asphalt binders.

1030.04 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 current Bureau of Materials and Physical Research 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 current Quality Control/Quality Assurance document "Hot-Mix Asphalt Design Verification Procedure". In no case will a mix design be verified until determination of the apparent low bidder.

When specified on the plans, RAP material meeting the requirements of Section 1031 may be used. The Engineer reserves the right to adjust the quantities of RAP material contained in the mixture for the purpose of mix design or field production, on the basis of test results.

The HMA mixtures shall be designed according to the respective Illinois Modified AASHTO references listed below.

AASHTO M 323	Standard Specification for Superpave Volumetric Mix Design
AASHTO R 30	Standard Practice for Mixture Conditioning of Hot-Mix Asphalt (HMA)
AASHTO R 35	Standard Practice for Superpave Volumetric Design for Hot-Mix Asphalt (HMA)
AASHTO T 209	Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
AASHTO T 305	Standard Method of Test for Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures
AASHTO T 312	Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
AASHTO T 308	Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
AASHTO T 324	Hamburg Wheel-Track Testing of Compacted Hot Mix Asphalt (HMA)
AASHTO T 283	Resistance of Compacted Hot Mix Asphalt (HMA) to Moisture-Induced Damage

The SMA mixture shall be designed according to the following additional Illinois Modified AASHTO references listed below, except as modified herein.

AASHTO M 325	Standard Specification for Designing Stone Matrix Asphalt (SMA)
AASHTO R 46	Standard Practice for Designing Stone Matrix Asphalt (SMA)
AASHTO T 305	Determination of Draindown Characteristics in Uncompacted Mixtures

(a) Mixture Composition. The Job Mix Formula (mix design) represents the aggregate grading and asphalt binder content that produce the desired mix criteria in the laboratory. The ingredients of the HMA shall be combined in such proportions as to produce a mixture conforming to the composition limits by weight.

For all HMA mixtures, it is recommended that the selected combined aggregate gradation not pass through the restricted zones specified in Illinois Modified AASHTO M 323.

(1) High ESAL Mixtures. The Job Mix Formula (JMF) shall fall within the following limits.

HIGH ESAL, MIXTURE COMPOSITION (% PASSING) [1/]								
Sieve Size	IL-19.0 mm		SMA 12.5 [4/]		IL-9.5 mm		IL-4.75 mm	
	min	max	min	max	min	max	min	max
1 1/2 in. (37.5 mm)								
1 in. (25 mm)		100						
3/4 in. (19 mm)	90	100		100				
1/2 in. (12.5 mm)	75	89	90	99		100		100
3/8 in. (9.5 mm)			50	85	90	100		100
#4 (4.75 mm)	40	60	20	40	32	69	90	100
#8 (2.36 mm)	26	42	16	24 [5/]	32	52 [2/]	70	90
#16 (1.18 mm)	15	30			10	32	50	65
#50 (300 µm)	6	15			4	15	15	30
#100 (150 µm)	4	9			3	10	10	18
#200 (75 µm)	3	6	8.0	11.0 [3/]	4	6	7	9 [3/]
Ratio Dust/Asphalt Binder		1.0				1.0		1.0

1/ Based on percent of total aggregate weight.

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

3/ Additional minus No. 200 (0.075 mm) material required by the mix design shall be mineral filler, unless otherwise approved by the Engineer.

4/ The maximum percent passing the #635 (20 µm) sieve shall be ≤ 3 percent.

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

Art. 1030.04 Hot-Mix Asphalt

(2) Low ESAL Mixtures. The Job Mix Formula (JMF) shall fall within the following limits.

Low ESAL, MIXTURE COMPOSITION (% PASSING)				
Sieve Size	IL-9.5L		IL-19.0L	
	min.	max.	min.	max.
1 in. (25.0 mm)				100
3/4 in. (19.0 mm)			95	100
1/2 in. (12.5 mm)		100		
3/8 in. (9.5 mm)	95	100		
#4 (4.75 mm)	52	80	38	65
#8 (2.36 mm)	38	65		
#30 (600 µm)		< 50% of the percentage passing the #4		< 50% of the percentage passing the #4
#200 (75 µm)	4.0	8.0	3.0	7.0
Asphalt Binder %	4.0	8.0	4.0	8.0
Ratio Dust/Asphalt Binder		1.0 @ design		1.0 @ design

(b) Volumetric Requirements.

(1) High ESAL Mixtures. The target value for the air voids of the HMA shall be 4.0 percent at the design number of gyrations. The VMA and VFA 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.

VOLUMETRIC REQUIREMENTS High ESAL				
Ndesign	Voids in the Mineral Aggregate (VMA), % minimum			Voids Filled with Asphalt Binder (VFA),%
	IL-19.0	IL-9.5	IL-4.75 1/	
50	13.5	15.0	18.5	65 - 78 2/
70				65 - 75
90				

1/ Maximum Draindown for IL-4.75 shall be 0.3 percent.

2/ VFA for IL-4.75 shall be 76-83 percent.

(2) Low ESAL Mixtures.

VOLUMETRIC REQUIREMENTS Low ESAL				
Mixture Composition	Design Compactive Effort	Design Air Voids Target, %	VMA (Voids in the Mineral Aggregate), % min.	VFA (Voids Filled with Asphalt Binder), %
IL-9.5L	N_{DES}=30	4.0	15.0	65 - 78
IL-19.0L	N_{DES}=30	4.0	13.5	N/A

(3) SMA Mixtures.

ESALs (million)	Ndesign	Design Air Voids Target, %	Voids in the Mineral Aggregate (VMA), % min.	Voids Filled with Asphalt (VFA), %
≤ 10	50	4.0	16.0	75 – 80
> 10	80	4.0	17.0	75 – 80

(c) Determination of Need for Anti-Stripping Additive. The mixture designer shall determine if an additive is needed in the mix to prevent stripping. The determination will be made on the basis of tests performed according to Illinois Modified AASHTO T 283. To be considered acceptable by the Department as a mixture not susceptible to stripping, the conditioned to unconditioned split tensile strength ratio (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 original conditioned tensile strength determined for 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, at the Contractor's option.

Dry hydrated lime shall be added at a rate of 1.0 to 1.5 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 exact rate of application for all anti-stripping additives will be determined by the Engineer. The method of application shall be according to Article 1102.01(a)(10).

(d) Verification Testing. High ESAL, IL-4.75, and SMA mix designs submitted for verification will be tested to ensure that the resulting mix designs will pass the required criteria for the Hamburg Wheel Test (Illinois Modified AASHTO T 324) and the Tensile Strength Test (Illinois Modified AASHTO T 283). The Department will perform a verification test on gyratory specimens compacted by the Contractor. If the mix fails the Department's

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verification test, the Contractor shall make necessary changes to the mix and provide passing Hamburg Wheel and tensile strength test results from a private lab. The Department will verify the passing results.

All new and renewal mix designs shall meet the following requirements for verification testing.

(1) Hamburg Wheel Test Criteria. 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 criteria shall be based on the high temperature binder grade of the mix as specified in the mix requirements table of the plans.

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

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

(2) Tensile Strength Criteria. The minimum allowable conditioned tensile strength shall be 60 psi (415 kPa) for non-polymer modified performance graded (PG) asphalt binder and 550 kPa (80 psi) for polymer modified PG asphalt binder. The maximum allowable unconditioned tensile strength shall be 200 psi (1380 kPa).

1030.05 Quality Control/Quality Assurance (QC/QA).

(a) QC/QA Documents. QC/QA documents shall be as follows.

(1) Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
(2) Model Quality Control (QC) Addenda for Hot-Mix Asphalt (HMA) Production
(3) Hot-Mix Asphalt QC/QA Laboratory Equipment
(4) Illinois Modified ASTM D 2950, Standard Test Method for Determination of Density of Bituminous Concrete In-Place by Nuclear Method
(5) Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities
(6) Hot-Mix Asphalt QC/QA Start-Up Procedures
(7) Hot-Mix Asphalt QC/QA QC Personnel Responsibilities and Duties Checklist
(8) Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples
(9) Determination of Random Density Test Site Locations
(10) Hot-Mix Asphalt QC/QA Control Charts/Rounding Test Values

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(11) Hot-Mix Asphalt Design Verification Procedure
(12) Hot-Mix Asphalt Mix Design Procedure for Dust Correction Factor Determination
(13) Development of Gradation Bands on Incoming Aggregate at Mix Plants
(14) Bureau of Materials and Physical Research Policy Memorandum, "Minimum Private Laboratory Requirements for Construction Materials Testing or Mix Design"
(15) Segregation Control of Hot-Mix Asphalt
(16) Calibration of Equipment for Asphalt Content Determination

1030.05 Quality Control/Quality Assurance (QC/QA) – (Continued)

(b) Laboratory. The Contractor shall provide a laboratory, at the plant, according to the current Bureau of Materials and Physical Research Policy Memorandum, “Minimum Private Laboratory Requirements for Construction Materials Testing or Mix Design”. The laboratory shall be of sufficient size and be furnished with the necessary equipment and supplies for adequately and safely performing the Contractor's QC testing. The Contractor is referred to the QC/QA document "Model Annual Quality Control Plan for Hot-Mix Asphalt (HMA) Production" for detailed information on the required laboratories. The required laboratory equipment for production and mix design is listed in the QC/QA document "Hot-Mix Asphalt QC/QA Laboratory Equipment".

The laboratory and equipment furnished by the Contractor shall be properly maintained. The Contractor shall maintain a record of calibration results at the laboratory. The Engineer may inspect measuring and testing devices at any time to confirm both calibration and condition. 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. If laboratory equipment becomes inoperable, the Contractor shall cease mix production.

(c) Annual Quality Control (QC) Plan and Addenda. 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 will result in suspension of HMA production or other appropriate actions as directed by the Engineer.

The Contractor shall submit, in writing to the Engineer, a proposed Annual QC Plan for each HMA plant for approval before each construction season. Job-specific QC Addenda to the Annual QC Plan must be submitted in writing to the Engineer 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. The proposed QC Plan shall be the QC/QA document "Model Annual Quality Control Plan for Hot-Mix Asphalt (HMA) Production", and the QC Addenda shall be the QC/QA document "Model Quality Control Addendum for Hot-Mix Asphalt (HMA) Production".

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

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The Contractor may propose revisions to portions of the Annual QC Plan and QC Addenda. Likewise, the Annual QC Plan and QC Addenda may be amended during the progress of the work, by either party, subject to mutual agreement. Revisions require proper justification 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.

(d) Quality Control by Contractor. The Contractor shall perform or have performed the inspection and tests required to assure conformance to contract requirements. Control includes the recognition of obvious defects and their immediate correction. This 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. Inability to control HMA production is cause for the Engineer to stop the operation until the Contractor completes an investigation identifying the problems causing failing test results.

The Engineer shall be immediately notified of any failing tests and subsequent remedial action. Passing tests shall be reported to the Engineer no later than the start of the next work day.

If the Contractor receives approval to use an alternative mixture to that required by the contract, the QC program will be specified by the Department.

(1) Personnel. The Contractor shall provide a Quality Control (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” Technician 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”. All technicians performing mix design testing and plant sampling/testing shall have successfully completed the Department's “Hot-Mix Asphalt Level I Technician 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 required density tests on the job site.

All quality control personnel shall perform the required quality control duties. The Contractor is referred to the QC/QA document "Hot-Mix Asphalt QC/QA QC Personnel Responsibilities and Duties Checklist" for a description of personnel qualifications and duties. Testing shall be conducted to control the production of the mixture.

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(2) Plant Tests. Contractor testing of all plant samples shall be completed within 3 1/2 hours of sampling.

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

Parameter	Frequency of Tests High ESAL Mixture Low ESAL Mixture	Test Method See Manual of Test Procedures for Materials
Aggregate Gradation % passing sieves: 1/2 in. (12.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 30 (600 µm), No. 200 (75 µm)	1 washed ignition oven test on the mix per half day of production Note 3.	Illinois Procedure
Asphalt Binder Content by Ignition Oven Note 1.	1 per half day of production	Illinois Modified AASHTO T 308
VMA Note 2.	Day's production ≥ 1200 tons (1090 metric tons) 1 per half day of production	Illinois Modified AASHTO R 35
	Day's production < 1200 tons (1090 metric tons) 1 per half day of production for first 2 days and 1 per day thereafter (first sample of the day)	

Parameter	Frequency of Tests High ESAL Mixture Low ESAL Mixture	Test Method See Manual of Test Procedures for Materials
Air Voids Bulk Specific Gravity of Gyratory Sample Note 4.	Day's production ≥ 1200 tons (1090 metric tons) 1 per half day of production	Illinois Modified AASHTO T 312
	Day's production < 1200 tons (1090 metric tons) 1 per half day of production for first 2 days and 1 per day thereafter (first sample of the day)	
Maximum Specific Gravity of Mixture	Day's production ≥ 1200 tons (1090 metric tons) 1 per half day of production	Illinois Modified AASHTO T 209
	Day's production < 1200 tons (1090 metric tons) 1 per half day of production for first 2 days and 1 per day thereafter (first sample of the day)	

Note 1. The Engineer may waive the ignition oven requirement for asphalt binder content if the aggregates to be used are known to have ignition asphalt binder content calibration factors which exceed 1.5 percent. If the ignition oven requirement is waived, other Department approved methods shall be used to determine the asphalt binder content.

Note 2. The G_{sb} used in the voids in the mineral aggregate (VMA) calculation shall be the same average G_{sb} value listed in the mix design.

Note 3. The Engineer reserves the right to require additional hot bin gradations for batch plants if control problems are evident.

Note 4. The WMA compaction temperature for mixture volumetric testing shall be 270 ± 5 °F (132 ± 3 °C) for quality control testing. The WMA compaction temperature for quality assurance testing will

be 270 ± 5 °F (132 ± 3 °C) if the mixture is not allowed to cool to room temperature. If the mixture is allowed to cool to room temperature, it shall be reheated to standard HMA compaction temperatures.

b. Dust-to-Asphalt and Moisture Content. During production, the dust-to-asphalt binder ratio and the moisture content of the mixture at discharge from the mixer shall meet the following.

Parameter	High ESAL Mixture Low ESAL Mixture
Ratio Dust/Asphalt Binder 1/	0.6 to 1.2
Moisture	0.3 %

1/ Does not apply to SMA.

If at any time the dust-to-asphalt binder 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.

c. Anti-Strip Additive. During production, mixtures containing an anti-strip additive will be tested by the Department for stripping according to Illinois Modified AASHTO T 283. If the mixture fails to meet the TSR criteria for acceptance, no further mixture will be accepted until the Contractor takes such action as is necessary to furnish a mixture meeting the criteria.

d. Small Tonnage. The Contractor may apply the following for small tonnage of mixture.

Gradation analysis, voids, and asphalt binder content tests may not be required on a specific mixture if the day's production is less than 250 tons (225 metric tons) per mix. A minimum of one set of plant 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 quality control operations. If the required tonnage of any mixture for a single pay item is less than 250 tons (225 metric tons) in total, the Contractor shall state his/her intentions of waiving the "Required Plant 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.

e. Asphalt Binder Sampling. Asphalt binder samples shall be taken by the Contactor and witnessed by the Engineer at a frequency of

one injection line-sample per week, per HMA plant. Sample containers will be furnished by the Department. The Engineer will submit the properly identified samples to the Bureau of Materials and Physical Research for testing.

f. HMA Sampling. For HMA mixture sampling, the Contractor shall obtain required plant samples according to the QC/QA document, "Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples". The Contractor shall split all required samples and identify the split samples per the Engineer's instructions. These split samples shall be retained by the Contractor for assurance testing by the Engineer and be disposed of only with the permission of the Engineer. The split samples shall be stored in a dry, protected location.

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 and shall not be plotted on the control charts. The Contractor shall detail the situations in which check samples will be taken in his/her Annual QC Plan.

(3) Required Field Tests. The Contractor shall control the compaction process by testing the mix density at random locations as determined according to the QC/QA document, "Determination of Random Density Test Site Locations", and recording the results on forms approved by the Engineer. The Contractor shall follow the density testing procedures detailed in the QC/QA document, "Illinois Modified ASTM D 2950, Standard Test Method for Determination of Density of Bituminous Concrete In-Place by Nuclear Method".

The Contractor shall be responsible for establishing the correlation to convert nuclear density results to core densities according to the QC/QA document, "Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities". The Engineer may require a new nuclear/core correlation if the Contractor's gauge is recalibrated during the project.

If the Contractor and Engineer agree the nuclear density test method is not appropriate for the mixture, cores shall be taken at random locations determined according to the QC/QA document "Determination of Random Density Test Site Locations". Three cores shall be taken at equal distances across the test site. These cores shall be averaged to provide a single test site result. Core densities shall be determined using the Illinois Modified AASHTO T 166 or T 275 procedure.

Quality control density tests shall be performed at randomly selected locations within 1/2 mile (800 m) intervals and 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 1/4 mile (400 m) intervals.

Testing of lifts equal to or greater than 4 in. (100 mm) compacted thickness shall be performed in the direct transmission mode according to the QC/QA document "Illinois Modified ASTM D 2950, Standard Test Method for Determination of Density of Bituminous Concrete In-Place by Nuclear Method". Density testing shall be accomplished intermittently throughout the day. In no case shall more than one-half day's production be completed without performing density testing.

Density tests shall be performed each day on patches located nearest the randomly selected location. The daily testing frequency shall be a minimum of two density tests per mix. Density testing shall be accomplished intermittently throughout the day. In no case shall more than one half day's production be completed without performing density testing.

(4) Control Limits. Target values shall be determined by applying adjustment factors to the AJMF where applicable. The target values shall be plotted on the control charts within the following control limits.

CONTROL LIMITS						
Parameter	High ESAL Low ESAL		SMA		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 %		
No. 4 (4.75 mm)	± 5 %	± 4 %	± 5 %	± 4 %		
No. 8 (2.36 mm)	± 5 %	± 3 %	± 4 %	± 2 %		
No. 16 (1.18 mm)			± 4 %	± 2 %	± 4 %	± 3 %
No. 30 (600 µm)	± 4 %	± 2.5 %	± 4 %	± 2.5 %		
Total Dust Content No. 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 %
Voids	± 1.2 %	± 1.0 %	± 1.2 %	± 1.0 %	± 1.2 %	± 1.0 %
VMA	-0.7 % 2/	-0.5 % 2/	-0.7 % 2/	-0.5 % 2/	-0.7 % 2/	-0.5 % 2/

1/ Based on washed ignition oven

2/ Allowable limit below minimum design VMA requirement

Art. 1030.05 Hot-Mix Asphalt

DENSITY CONTROL LIMITS		
Mixture Composition	Parameter	Individual Test
IL-4.75	Ndesign = 50	93.0 – 97.4 % 1/
IL-9.5	Ndesign = 90	92.0 – 96.0 %
IL-9.5, IL-9.5L,	Ndesign < 90	92.5 – 97.4 %
IL-19.0	Ndesign = 90	93.0 – 96.0 %
IL-19.0, IL-19.0L	Ndesign < 90	93.0 2/ – 97.4 %
SMA	Ndesign = 50 & 80	93.5 – 97.4 %

1/ Density shall be determined by cores or by correlated, approved thin lift nuclear gauge.

2/ 92.0 percent when placed as first lift on an unimproved subgrade.

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

Individual required test results 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. Any additional testing of check samples may be used for controlling the Contractor's processes, but shall be documented in the plant diary.

The results of assurance tests performed by the Engineer will be posted as soon as available.

The following parameters shall be recorded on standardized control charts as described in the QC/QA document "Hot-Mix Asphalt QC/QA Control Charts/Rounding Test Values".

Control limits for each required parameter, both individual tests and the average of four tests, shall be exhibited on control charts. Test results shall be posted within the time limits previously outlined.

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CONTROL CHART REQUIREMENTS	HIGH ESAL, LOW ESAL, SMA, & IL-4.75
Gradation 1/ 3/	% Passing Sieves: 1/2 in. (12.5 mm) 2/ No. 4 (4.75 mm) No. 8 (2.36 mm) No. 30 (600 µm)
Total Dust Content 1/	No. 200 (75 µm)
	Asphalt Binder Content
	Bulk Specific Gravity
	Maximum Specific Gravity of Mixture
	Voids
	Density
	VMA

1/ Based on washed ignition oven.

2/ Does not apply to IL-4.75.

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

(6) Corrective Action for Required Plant Tests.

a. 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 continue the required plant test frequency. Additional check samples should be taken to verify mix compliance.

1. Voids, VMA, and Asphalt Binder Content for High ESAL and Low ESAL Mixtures. If the retest for voids, 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. HMA production may continue when approved by the Engineer. The corrective action shall be documented.

2. 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.

b. Moving Average. When the moving average values trend toward the moving average control limits, the Contractor shall take

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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 operations. Corrective action shall be immediately instituted by the Contractor. Operations shall not be reinstated without the approval of the Engineer. Failure to cease operations shall subject all subsequently produced material to be considered unacceptable.

c. Dust Control. If the washed ignition oven gradation test results indicate a problem with controlling dust, corrective action to control the dust shall be taken and approved by the Engineer. If the Engineer determines that Positive Dust Control Equipment is necessary, the equipment as specified in Article 1102.01(d)(7), shall be installed prior to the next construction season.

d. HMA Production Control. If the Contractor is not controlling the production process and is making no effort to take corrective action, the operation shall stop.

(7) Corrective Action for Required Field Tests (Density). When an individual 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.

a. 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.

b. 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, any 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.

If the Contractor is not controlling the compaction process and is making no effort to take corrective action, the operation, as directed by the Engineer, shall stop.

(e) Quality Assurance by the Engineer. The Engineer will conduct independent assurance tests on split samples taken by the Contractor for quality control testing. In addition, the Engineer will witness the sampling and splitting of these samples a minimum of twice a month and will immediately retain the samples for quality assurance testing.

The overall testing frequency will be performed over the entire range of Contractor samples and will be equal to or greater than ten percent for gradations and equal to or greater than 20 percent for asphalt binder content, bulk specific gravity, maximum specific gravity and field density. The Engineer may select any or all split samples for assurance testing. The Engineer will initiate independent assurance testing during mixture field verification. These tests may be performed immediately or anytime up to ten working days after sampling. The test results will be made available to the Contractor as soon as they become available.

The Contractor's nuclear/core correlation will be verified utilizing Department nuclear gauges.

The Engineer may witness the sampling and testing being performed by the Contractor. The Engineer will document all witnessed samples and tests.

The Engineer will promptly notify the Contractor, both verbally and in writing, of observed deficiencies. If the Engineer observes that the sampling and quality control tests are not being performed according to the applicable test procedures, the Engineer may stop production until corrective action is taken.

The Engineer may elect to obtain samples for testing, separate from the Contractor's quality control process, to verify specification compliance. No more than 20 cores per day will be required by the Engineer for the purpose of acceptance and/or comparison with nuclear gauge measurements. The cost of this work will not be paid for separately, but shall be considered as

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included in the unit price bid for the HMA item involved. Differences between the Contractor's and the Engineer's split sample test results will be considered acceptable if within the following limits.

Test Parameter	Acceptable Limits of Precision
% Passing: 1/	
1/2 in. (12.5 mm)	5.0 %
No. 4 (4.75 mm)	5.0 %
No. 8 (2.36 mm)	3.0 %
No. 30 (600 µm)	2.0 %
Total Dust Content No. 200 (75 µm)	2.2 %
Asphalt Binder Content	0.3 %
Maximum Specific Gravity of Mixture	0.026
Bulk Specific Gravity	0.030
VMA	1.4 %
Density (% Compaction)	1.0 % (Correlated)

1/ Based on washed ignition.

The Department may run extractions for assurance, when deemed necessary by the Engineer.

In the event comparison of the required plant test results is outside the above acceptable limits of precision, Department split or independent samples fail the control limits, a Department extraction indicates non-compliance, or a continual trend of difference between Contractor and Department test results is identified, the Engineer will immediately investigate. The Engineer may suspend production as stated in Article 108.07 of the Standard Specifications, while the investigation is in progress. The investigation may include testing by the Engineer of any remaining split samples or a comparison of split sample test results on the HMA currently being produced. The investigation may also include review and observation of the Contractor's technician performance, testing procedure, and equipment.

If a problem is identified with the mix, the Contractor shall take immediate corrective action. After corrective action, both the Contractor and the Engineer shall immediately resample and retest according to Article 1030.05(d)(6).

In the event comparison of the required field test results (densities) are outside the above acceptable limits of precision, Department split or independent samples fail the density limits, or a continual trend of difference between Contractor and Department test results is identified, the Engineer will immediately investigate. The investigation will include testing by the Engineer of any remaining random density locations. The Engineer may establish additional locations for testing by both the Contractor and the

Department to provide further comparison results. The investigation shall also include review and observation of the Density Tester performance, testing procedure, and equipment. The original correlation and/or comparison data, for both gauges, shall be reviewed as part of the investigation process. If the problem continues, the Engineer may require a new correlation be performed.

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

(1) Validation of the Contractor's quality control by the assurance process.

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

(3) Department assurance tests for voids, field VMA, and density.

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

(g) Documentation. 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 in duplicate and sent to the Engineer on forms approved by the Engineer.

Each construction season, prior to production of HMA, the Contractor shall submit to the Engineer, on appropriate forms, documentation that the HMA plant(s) have been calibrated and approved.

1030.06 Start of HMA Production and Job Mix Formula (JMF) Adjustments. The start of HMA production and JMF adjustments shall be as follows.

(a) High ESAL, IL-4.75, WMA, and SMA Mixtures. For each contract, a 300 ton (275 metric tons) test strip will be required at the beginning of HMA production for each mixture with a quantity of 3000 tons (2750 metric tons) or more according to the Manual of Test Procedures for Materials "Hot-Mix Asphalt Test Strip Procedures".

Before start-up, target values shall be determined by applying gradation correction factors to the JMF when applicable. These correction factors shall be determined from previous experience. The target values, when approved by the Engineer, shall be used to control HMA production. Plant settings and control charts shall be set according to target values.

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Before constructing the test strip, target values shall be determined by applying gradation correction factors to the JMF when applicable. After any JMF adjustment, the JMF shall become the Adjusted Job Mix Formula (AJMF). 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 an adjustment/plant change is made, the Engineer may require a new test strip to be constructed. 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.

The limitations between the JMF and AJMF are as follows.

Parameter	Adjustment
1/2 in. (12.5 mm)	± 5.0 %
No. 4 (4.75 mm)	± 4.0 %
No. 8 (2.36 mm)	± 3.0 %
No. 30 (600 µm)	*
No. 200 (75 µm)	*
Asphalt Binder Content	± 0.3 %

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

Any adjustments outside the above limitations will require a new mix design.

Mixture sampled to represent the test strip shall include additional material sufficient for the Department to conduct Hamburg Wheel testing according to Illinois Modified AASHTO T 324 (approximately 60 lb (27 kg) total).

The Contractor shall immediately cease production upon notification by the Engineer of failing Hamburg Wheel tests. All prior produced material may be paved out provided all other mixture criteria is being met. No additional mixture shall be produced until the Engineer receives passing Hamburg Wheel tests.

The Department may conduct additional Hamburg Wheel tests on production material as determined by the Engineer.

(b) Low ESAL Mixtures. In the field, slight adjustments to the gradation and/or asphalt binder content may be necessary to obtain the desired air voids, density, uniformity, and constructability. These adjustments define the Adjusted Job Mix Formula (AJMF) and become the target values for quality control operations. Limitations between the JMF and AJMF are as follows. Any adjustments outside the limitations will require a new mix design.

Parameter	Adjustment
1/2 in. (2.5 mm)	± 6 %
No. 4 (4.75 mm)	± 5 %
No. 200 (75 µm)	± 2.5 %
Asphalt Binder Content	± 0.5 %

Production is not required to stop after a growth curve has been constructed. The test results shall be available to both the Contractor and Engineer before production may resume the following day.

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 plant tests.

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Hot Mix Asphalt Test Strip Procedures
Appendix B.4

Effective: May 1, 1993
Revised: ~~January 1, 2018~~December 1, 2017~~2014~~

For mixtures where the quantity exceeds 3000 tons (2750 metric tons), the Contractor and the Department shall evaluate the mixture to be produced for each contract using a 300 ton test strip. The Contractor shall follow the following procedures for constructing a test strip.

A. Contractor/Department Test Strip Team

A team of both Contractor and Department personnel shall construct a test strip and evaluate mix produced at the plant.

The test strip team may consist of the following, as necessary:

1. Resident Engineer
2. District Construction Supervising Field Engineer, or representative
3. District Materials Mixtures Control Engineer, or representative
4. Contractor's QC Manager, required
5. Contractor's Density Tester
6. ~~Bureau of Materials and Physical Research~~Central Bureau of Materials representative when requested
7. Bureau of Construction representative when requested

B. Communications

The Contractor shall advise the team members of the anticipated start time of production for the 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. Acceptance Criteria

1. Mix Design and Plant Proportioning - The mix design shall be 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.

2. Evaluation of Growth Curves - Mixtures which exhibit density potential less than or greater than the density ranges specified in Article 1030.05(d)(4) shall be considered to have a potential density problem which is normally sufficient cause for mix adjustment.

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

3. Evaluation of Required Plant Tests - If the results of the required plant tests exceed the JMF target value control limits, the Contractor shall make allowable

mix adjustments/plant changes, resample, and retest. If the Engineer determines additional adjustments to the mix will not produce acceptable results, a new mix design may be required.

D. Test Strip Method

The Contractor shall produce 300 tons (275 metric tons) of mix for the test strip. The test strip will be included in the cost of the mix and will not be paid for separately since the Contractor may continue production, at their own risk, after the test strip has been completed.

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

a. 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.

b. 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 solely with a vibratory roller as directed by the QC Manager.

c. Required Plant Tests - A set of mixture samples shall be taken at such a time as to represent the mixture in between the two growth curve trucks.

The mixture sampled to represent the test strip shall also include material sufficient for the Department to conduct a Hamburg Wheel test according to Illinois modified AASHTO T 324.

E. Compaction Requirements

1. Compaction Equipment - The Contractor shall provide a vibratory roller meeting the requirements of Article 1101.01(g) of the Standard Specifications. It shall be the responsibility of the test strip team to verify specification compliance before commencement of growth curve construction. An appropriate amplitude shall be selected on the basis of 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).

2. Compaction Temperature - In order to make an accurate analysis of the density potential of the mixture, the temperature of the mixture on the pavement at the beginning of the growth curve shall not be less than 280 °F (140 °C).

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.

F. Nuclear/Core Correlation

A correlation of core and nuclear gauge test results may be performed on-site as defined in the Department's "Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities". All correlation locations should be cooled with ice or dry ice so that cores can be taken as soon as possible. Three locations should be selected. Two sites should be located on the two growth curves from the first acceptable test strip. The third location should be in an area corresponding to the second set of mixture samples taken at the plant. This correlation should be completed at the same time 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 strips, required plant tests, and rolling pattern information (including growth curves) will be tabulated by the Contractor with a copy provided to each team member and the original retained in the project files.

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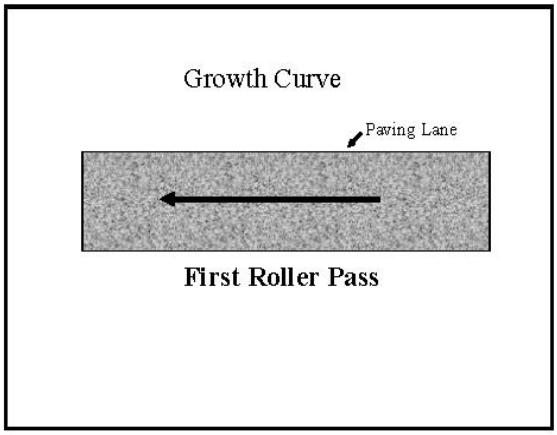
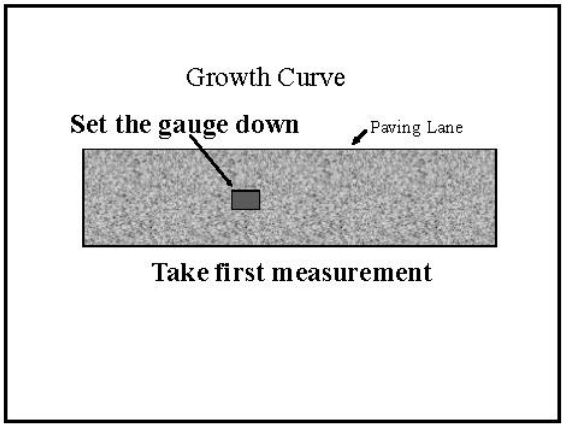
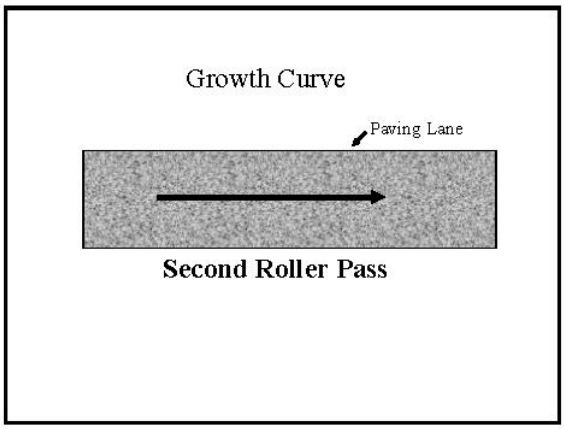
Determining Growth Curve during the Test Strip Procedure

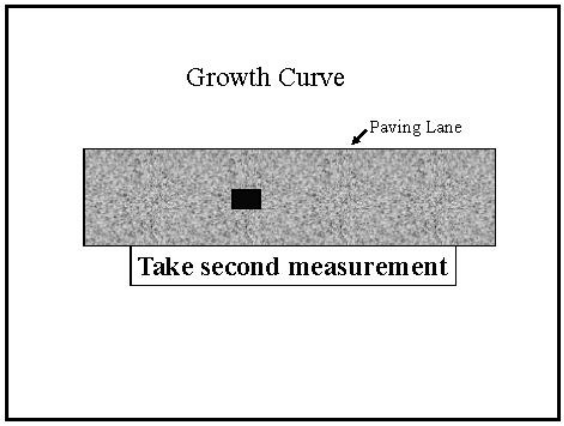


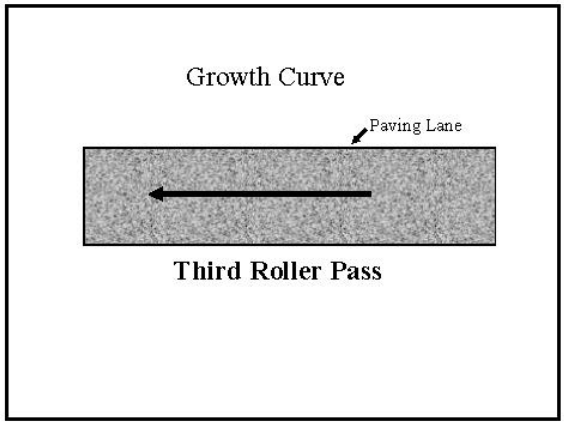
Determining Growth Curve during the Test Strip Procedure



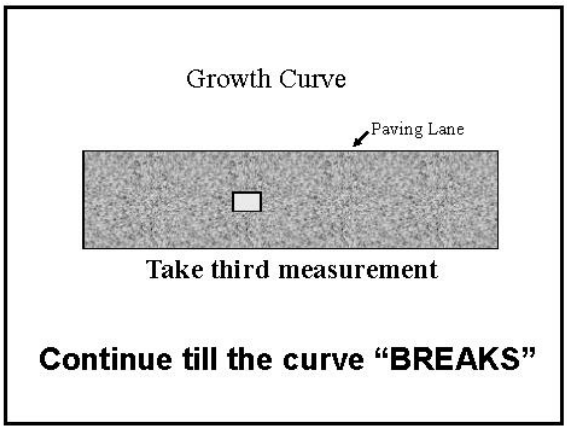


Determining Growth Curve during the Test Strip Procedure

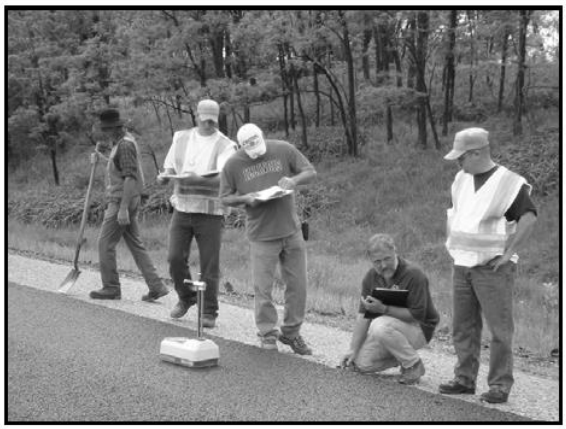




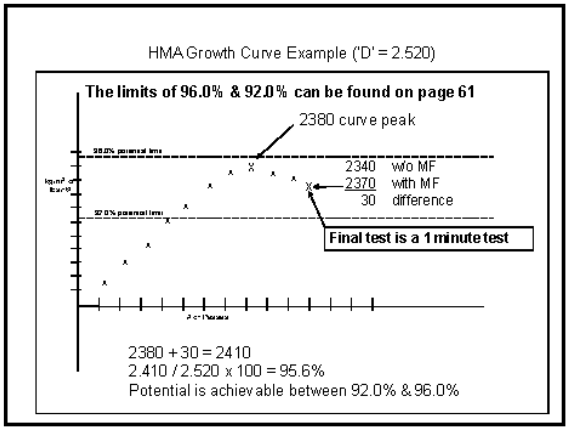
Determining Growth Curve during the Test Strip Procedure



Determining Growth Curve during the Test Strip Procedure



Determining Growth Curve during the Test Strip Procedure



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%

Standard Test Method for Correlating
Nuclear Gauge Densities with Core Densities
Appendix B.3
Effective: May 1, 2001
Revised: December 1, 2017~~April 1, 2011~~

A. Scope

1. This method covers the proper procedures for correlating nuclear gauge densities to core densities. Procedures are applicable to both direct transmission and backscatter techniques.

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. The direct transmission method shall be used for thick-lift layers. "Thick-lift" is defined as a layer 6 in. (152.4) mm or greater in compacted thickness.

B. Applicable Documents

1. Illinois Department of Transportation Standard Test Methods

   Illinois-Modified AASHTO T 166, "Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface Dry Specimens"

   Illinois-Modified AASHTO T 275, "Bulk Specific Gravity of Compacted Asphalt Mixtures Using Paraffin-Coated Specimens"

2. The density test procedure shall be in accordance with the Department's "Illinois-Modified ASTM D 2950, Standard Test Method for Determination of Density of Bituminous Concrete In-Place by Nuclear Method".

C. Definitions

Test location: The station location used for density testing.

Test site: Individual test site where a single density is determined. Five (5) test sites are located at each test location.

Nuclear Density: The average of 2 or possibly 3 density readings on a given test site.

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

Standard Test Method for Correlating
Nuclear Gauge Densities with Core Densities
Appendix B.3
Effective: May 1, 2001
Revised: December 1, 2017~~April 1, 2011~~

D. Significance and Use

1. Density results from a nuclear gauge are relative. If an approximation of core density results is required, 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 (direct transmission only), 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 material.

E. Site Selection

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

2. Three correlation locations shall be selected. Two sites will be located on the two growth curves from the first acceptable test strip. The third 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 start-up. The material from the third site shall correspond to the same material from which the second hot-mix sample was taken.

3. If a mixture start-up is not required, two of the three correlation locations shall be in an area containing a growth curve.

F. Procedures for Obtaining Nuclear Readings and Cores

1. Backscatter Mode

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

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

c. One core in good condition shall be obtained from each of 15 individual sites (Figure 1). Care should be exercised that no additional compaction occurs between the nuclear testing and the coring. 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 correlation form.

For quality assurance purposes, the Department may direct the Contractor to take additional cores adjacent to those above or to submit the quality control cores for Department testing.

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

2. Direct Transmission Mode

a. At each of the three correlation locations, five individual sites shall be chosen across the mat as shown on Figure 1.

b. A smooth hole in the pavement, slightly larger than the probe, shall be formed to a depth 2 in. (50 mm) greater than the test depth. The probe shall be inserted so that the side of the probe facing the center of the gauge is in intimate contact with the side of the hole. Two nuclear readings shall be taken at each of the 15 individual sites. (See Figures 1 and 2)

The gauge shall be rotated 180 degrees (see Figure 2) around the core area at each site. (The two uncorrected readings taken at a specific individual site shall be within 2.0 lbs/ft^3 [30 kg/m^3] (see Figure 2). If the two readings do not meet this criterion, one additional reading shall be taken in the desired direction. The nuclear densities are to be recorded on the correlation form (Figure 3).

c. One core in good condition shall be obtained from each of the 15 individual sites. (See Figures 1 and 2) The cores shall be obtained from beneath the center of the gauge no closer than 3-1/2 in (87.5 mm) from either access hole. The thickness of the core should represent the thickness of the layer being tested. The layer shall be carefully separated for testing in accordance with Illinois-Modified AASHTO T 166. Care should be exercised that no additional compaction occurs between the nuclear testing and the coring. The cores shall be tested for density in accordance with Illinois-Modified AASHTO T 166 or T 275.

Standard Test Method for Correlating
Nuclear Gauge Densities with Core Densities
Appendix B.3
Effective: May 1, 2001
Revised: December 1, 2017~~April 1, 2011~~

For quality assurance purposes, the Department may direct the Contractor to take additional cores adjacent to those above or to submit the quality control cores for Department testing.

The core densities are to be entered on the correlation form.

d. Extreme care shall be taken in identifying which location 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 individual site shall be entered on the correlation form and then averaged. The core density taken at each individual site shall be entered on the correlation form. After the averaging, there will be 15 paired data points, each pair containing the average nuclear density and core density for each of the 15 individual sites.

2. The paired density values shall be correlated using the Department's linear regression program. (Disks are available from the Central Bureau of Materials) 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 nuclear density 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. An "r" value greater than 0.715 is considered acceptable.

6. The correlation shall be stated and used in the form: $y = mx + b$

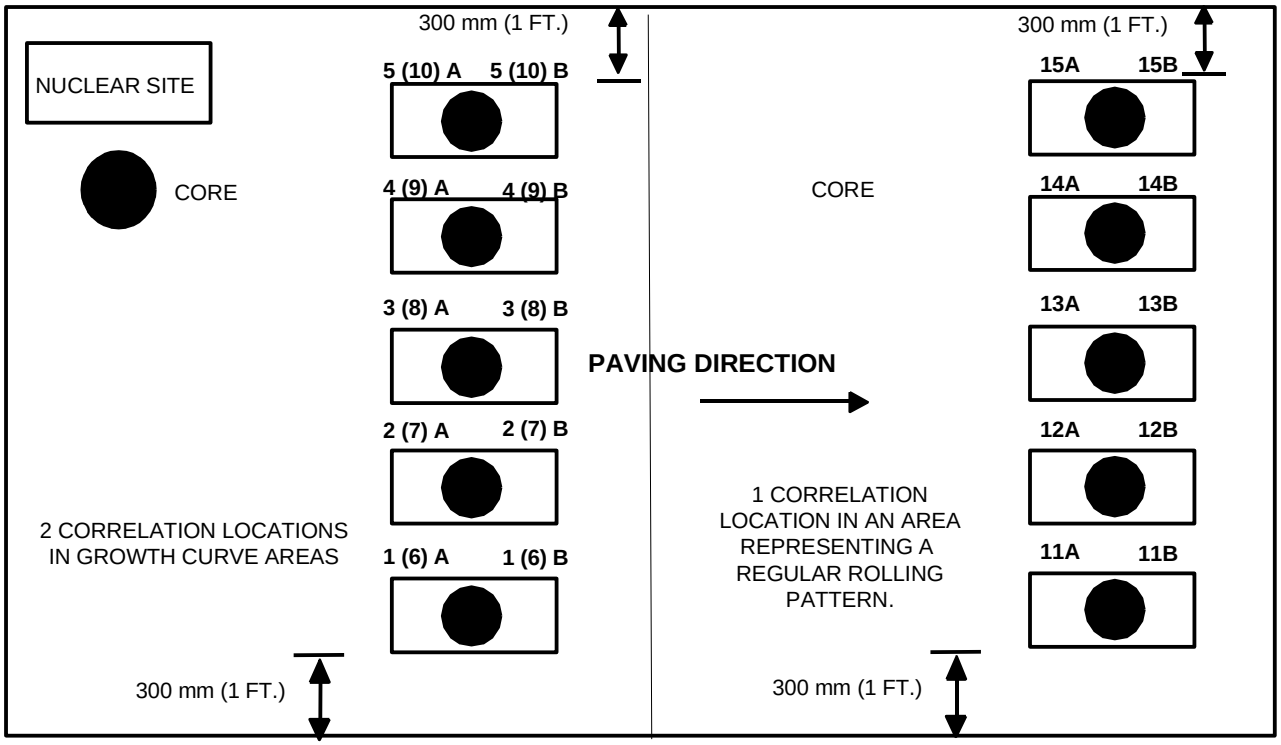
where:

y	=	core density
x	=	nuclear gauge density
b	=	intercept
m	=	slope of linear regression ("best fit") line

Standard Test Method for Correlating
Nuclear Gauge Densities with Core Densities
Appendix B.3
Effective: May 1, 2001
Revised: December 1, 2017~~April 1, 2011~~

FIRST GROWTH CURVE IS BETWEEN 200 AND 225 METRIC TONS (225 AND 250 TONS), THE SECOND GROWTH CURVE IS BETWEEN 250 AND 275 METRIC TONS (275 AND 300 TONS).

(BACKSCATTER)



2 of 3 sites **1 of 3 sites**

NUCLEAR/CORE CORRELATION TEST LOCATIONS

FIGURE 1

Standard Test Method for Correlating
Nuclear Gauge Densities with Core Densities
Appendix B.3
Effective: May 1, 2001
Revised: December 1, 2017~~April 1, 2011~~

DIRECT TRANSMISSION MODE

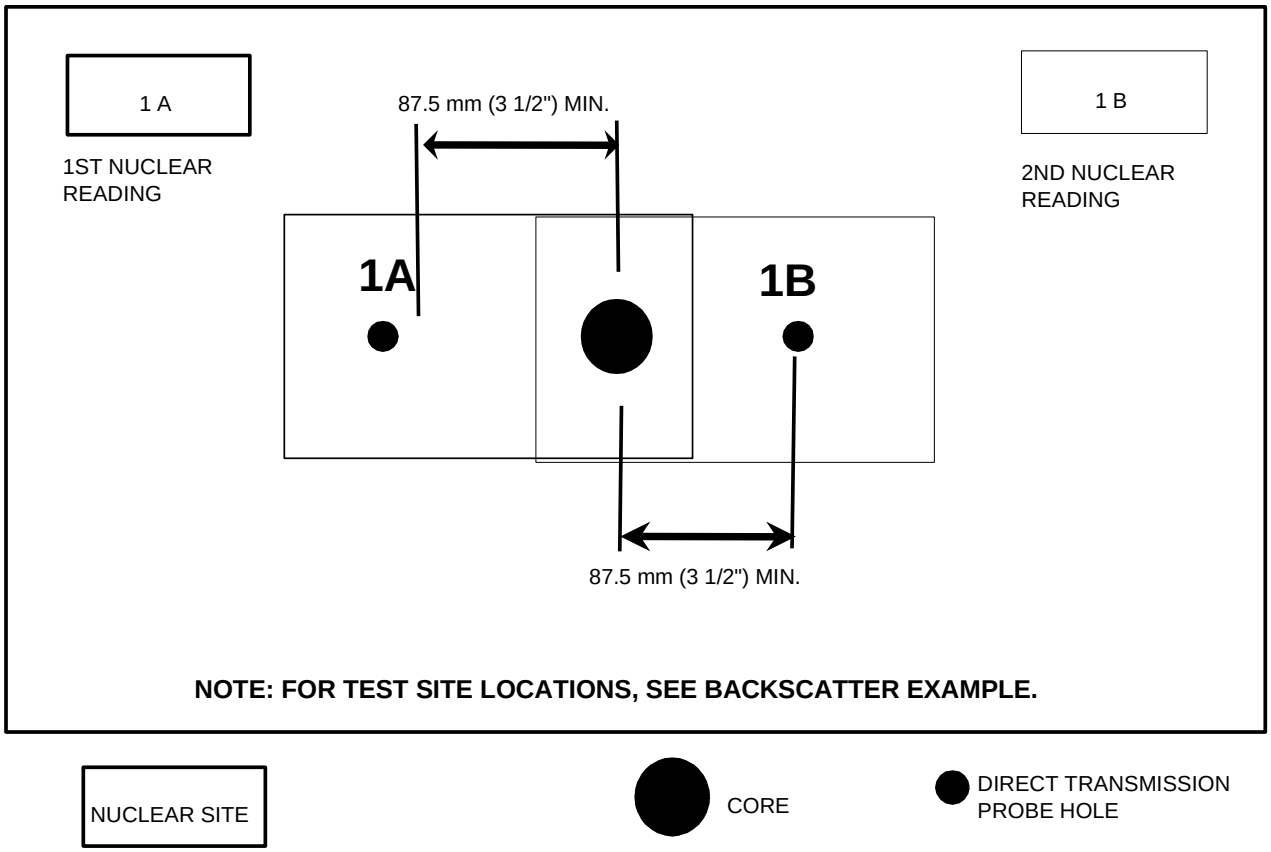


FIGURE 2

NUCLEAR/CORE CORRELATION

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	(23 kg/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)

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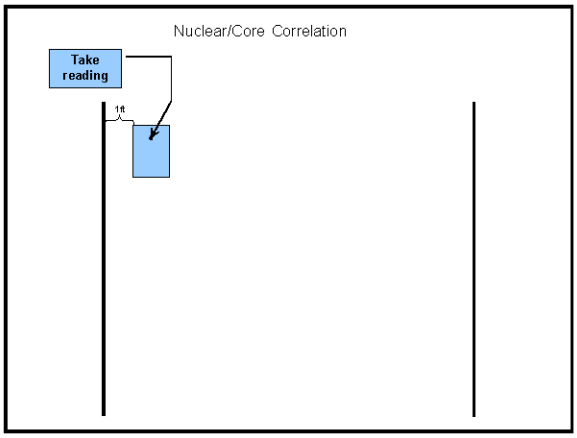
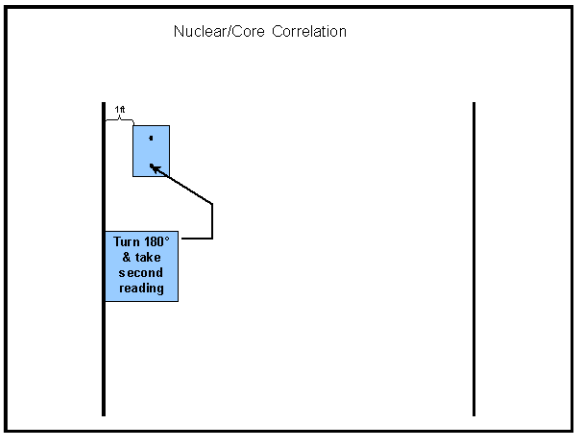
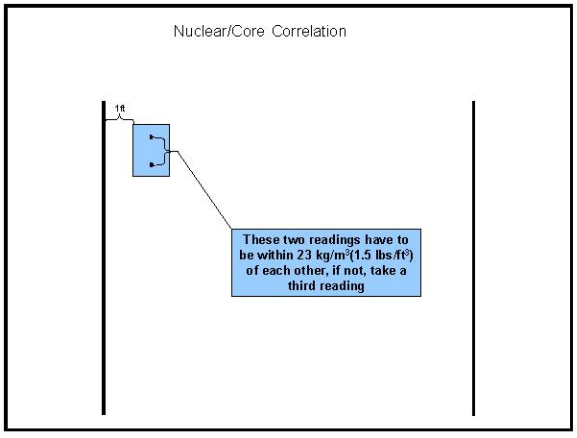
Nuclear Core Correlation Example

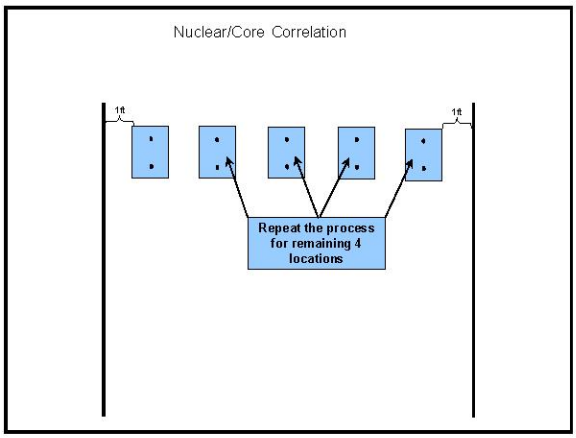




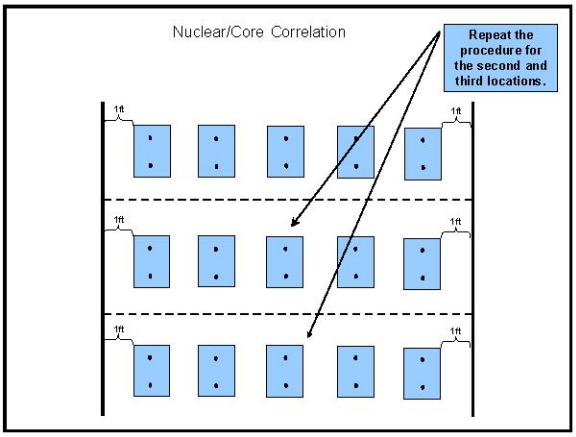
Nuclear Core Correlation Example

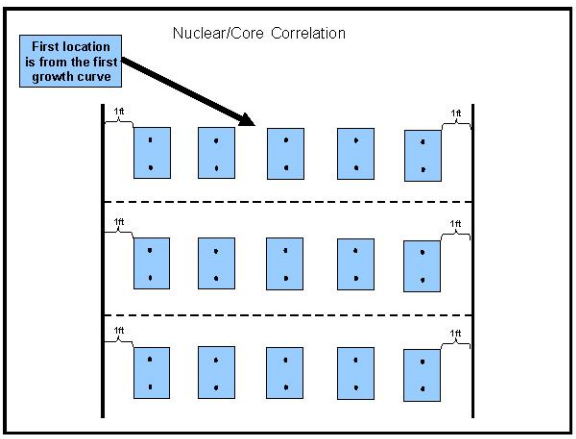


Nuclear Core Correlation Example

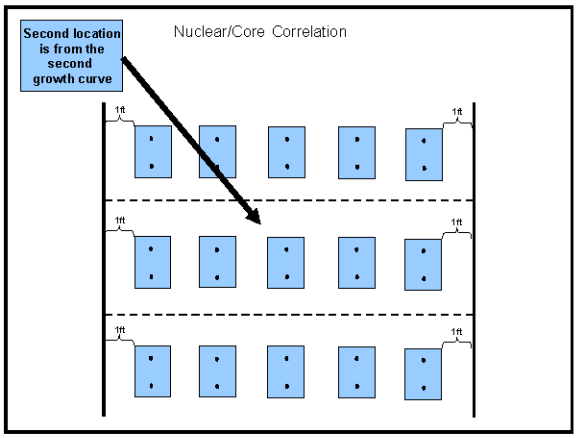


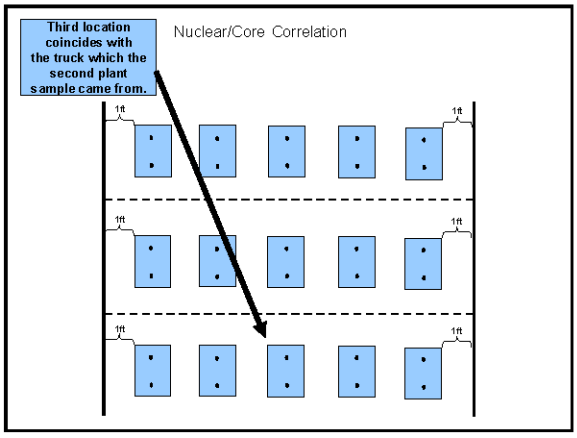
Nuclear Core Correlation Example

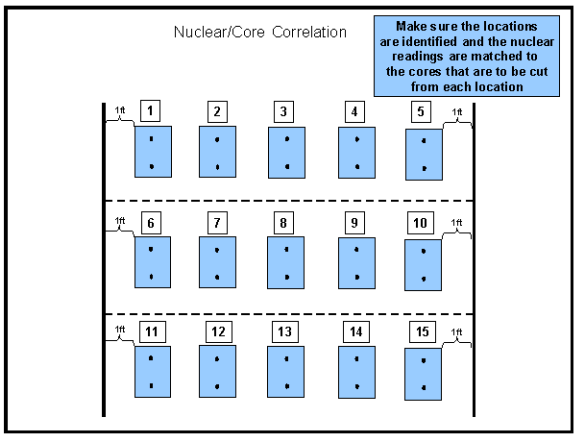




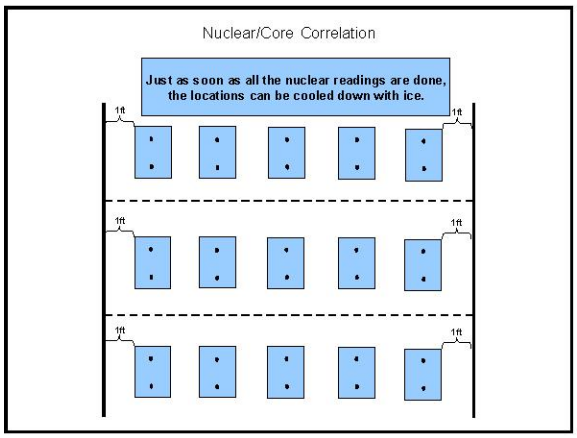
Nuclear Core Correlation Example

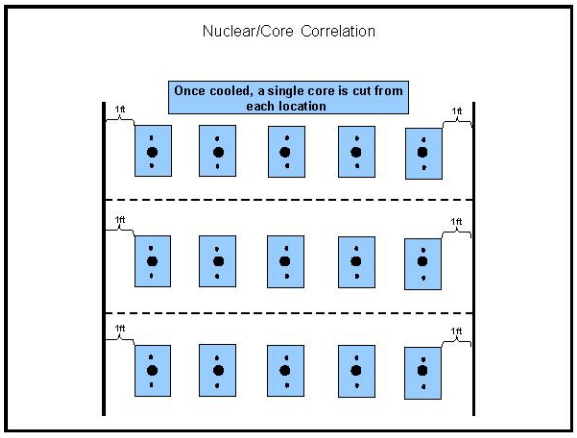






Nuclear Core Correlation Example





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

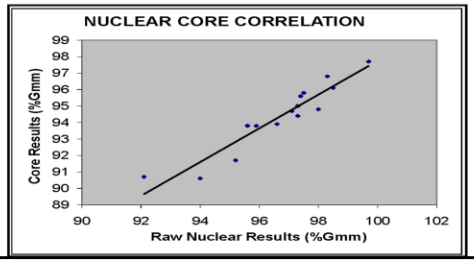
Lab Work – Core Densities Ran



Data Obtained Nuclear/core Correlation

NUC	RAW NUC	CORE	Slope mX+b
	95.6	93.8	93.3
MAX	97.6	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 #:	97BIT010
Test Date:	11/19/2007
Base Material:	Milled Surface
Lift Number:	0.1
Big D:	2.444



1-33

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

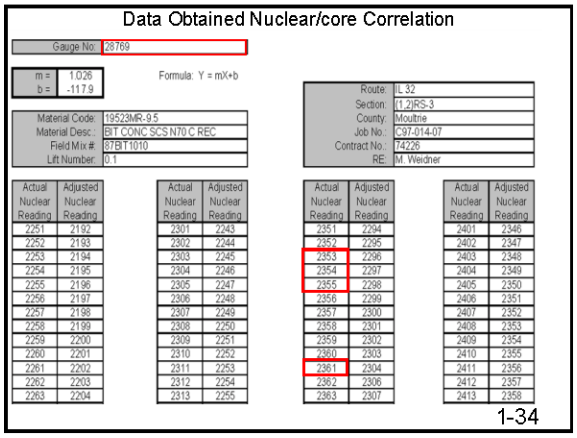
Reliability Factor = 0.947

Version 1.0 3/22/01

11/19/2007

1-33

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
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

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

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

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

1-34

Data Obtained Nuclear/core Correlation

- Formula Y= m(X) + b

Formula: Y = mX+b

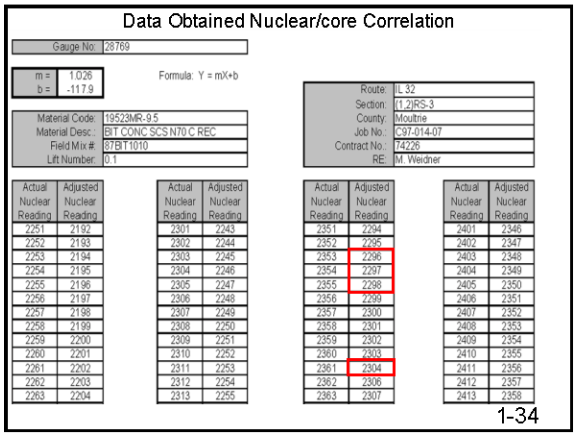
m = 1.026
b = -117.9

X = to actual nuclear density reading

Y = 1.026(2361) + (-117.9)

Y = 2304

1-33



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
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

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

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

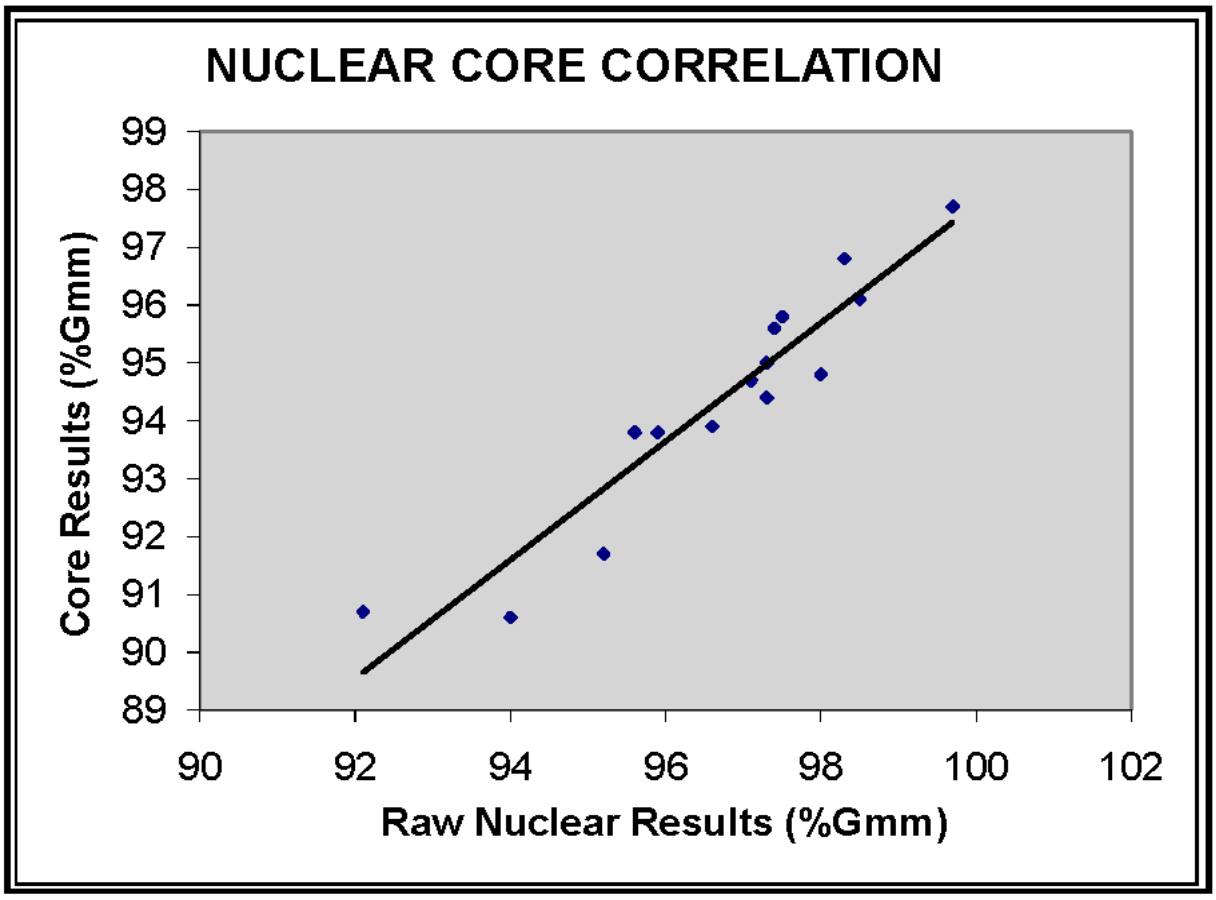
Actual Nuclear Reading	Adjusted Nuclear Reading
2401	2346
2402	2347
2403	2348
2404	2349
2405	2350
2406	2351
2407	2352
2408	2353
2409	2354
2410	2355
2411	2356
2412	2357
2413	2358

1-34

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.:	C9701417
Contract No.:	74226
RE:	M. Weidner
Material Code:	19523MR-9.5
Material Desc.:	BIT CONC SCS N70 C REC
Field Mix #:	87BIT1017
Test Date:	07/19/2017
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:	C9701417
Contract No.:	74226
RE:	M. Weidner

Material Code:	19523 -9.5
Material Desc:	BIT CONC SCS N70 C REC
Field Mix #:	87BIT1017
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**								

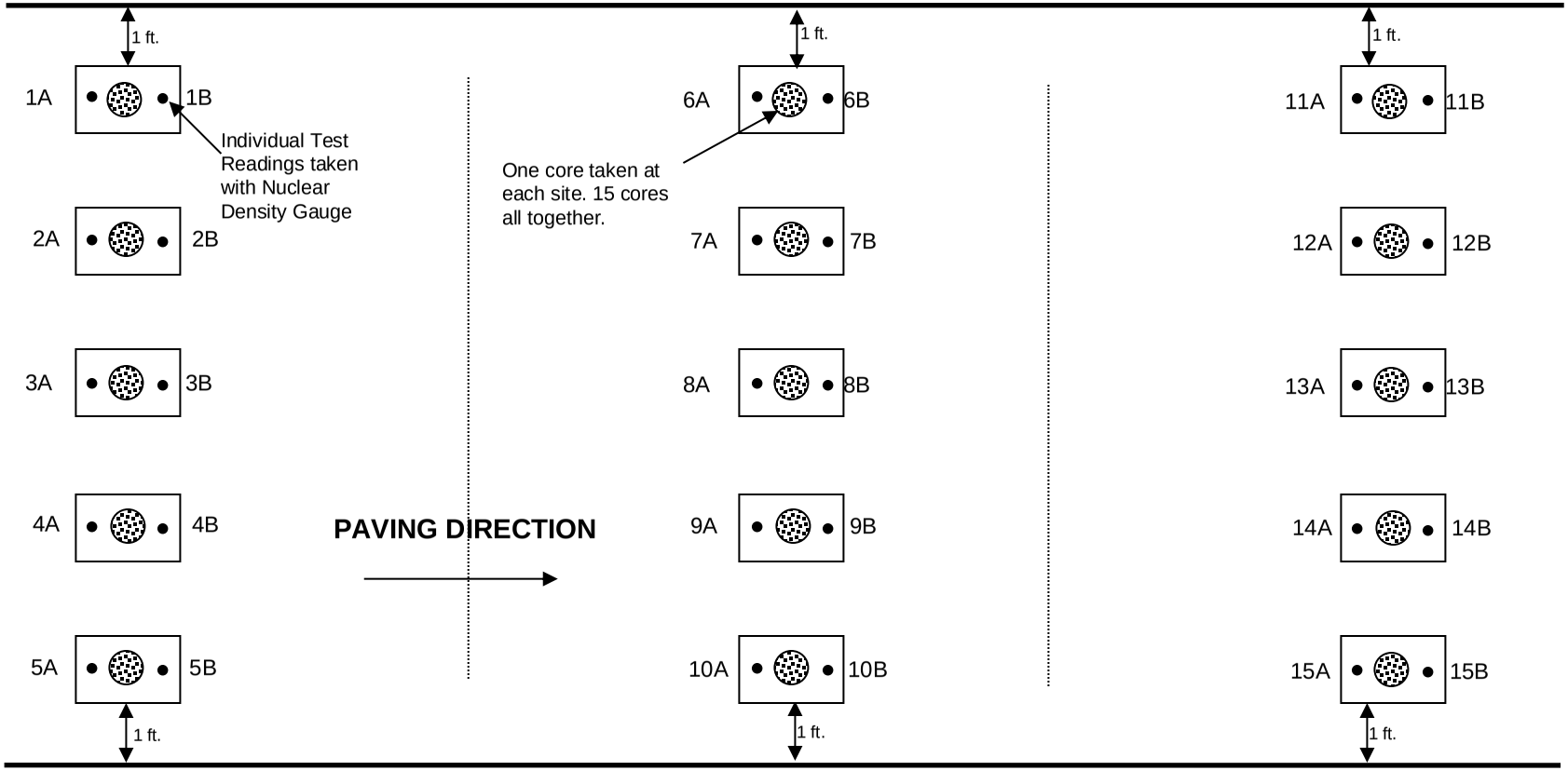
SUMMARY											
RAW NUCLEAR GAUGE READINGS											CORES
Gauge #:	1	2	3	4	5	6	7	8	9	10	
Gauge ID:	25124	28769									
1	2353.5	2336.5									2292
2	2413	2384									2342
3	2427	2406.5									2349
4	2441	2437.5									2388
5	2406.5	2379.5									2336
6	2393	2372.5									2315
7	2419	2402.5									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).**



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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HOT MIX ASPHALT - PAY FOR PERFORMANCE USING PERCENT WITHIN LIMITS - JOBSITE SAMPLING (BDE)

Effective: November 1, 2014
Revised: January 1, 2018

Description. This special provision describes the procedures for production, placement and payment for hot-mix asphalt (HMA) under the pay for performance (PFP) program. This special provision shall apply to the HMA mixtures specified in the plans. This work shall be according to the Standard Specifications except as modified herein.

Delete Articles:	406.06(b)(1), 2nd paragraph	(Temperature requirements)
	406.06(e), 3rd paragraph	(Paver speed requirements)
	406.07(b)	(Rolling)
	406.07(c)	(Density)
	1030.04, last two sentences of first paragraph	(Mix design verification)
	1030.05(a)(4, 5, 7, 8, 9, & 10)	(QC/QA Documents)
	1030.05(d)(2)a.	(Plant Tests)
	1030.05(d)(2)b.	(Dust-to-Asphalt and Moisture Content)
	1030.05(d)(2)d.	(Small Tonnage)
	1030.05(d)(2)f.	(HMA Sampling)
	1030.05(d)(3)	(Required Field Tests)
	1030.05(d)(4)	(Control Limits)
	1030.05(d)(5)	(Control Charts)
	1030.05(d)(6)	(Corrective Action for Required Plant Tests)
	1030.05(d)(7)	(Corrective Action for Field Tests (Density))
	1030.05(e)	(Quality Assurance by the Engineer)
	1030.05(f)	(Acceptance by the Engineer)
	1030.06(a), 2nd paragraph	(Before start-up…)

Definitions.

(a) Quality Control (QC): All production and construction activities by the Contractor required to achieve the required level of quality.

(b) Quality Assurance (QA): All monitoring and testing activities by the Engineer required to assess product quality, level of payment, and acceptability of the product.

(c) Percent Within Limits (PWL): The percentage of material within the quality limits for a given quality characteristic.

(d) Quality Characteristic: The characteristics that are evaluated by the Department for payment using PWL. The quality characteristics for this project are field voids in the mineral aggregate (Field VMA), voids, and density. Field VMA will be calculated using the combined aggregates bulk specific gravity (G_{sb}) from the mix design.

(e) Quality Level Analysis (QLA): QLA is a statistical procedure for estimating the amount of product within specification limits.

(f) Mixture Sublot: A mixture sublot for Field VMA and voids shall be a maximum of 1000 tons (910 metric tons). If the quantity is less than 8000 tons (7260 metric tons), the sublot size will be adjusted to achieve a minimum of 8 tests.

(1) If the remaining quantity is greater than 200 tons (180 metric tons) but less than 1000 tons (910 metric tons), the last mixture sublot will be that quantity.

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

(g) Density Interval: Density intervals shall 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). If a density interval is less than 200 ft (60 m), it will be combined with the previous density interval.

(h) Lot: A lot consists of ten mixture sublots or 30 density intervals. If seven or less mixture sublots or 19 or less 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.

Lots for mixture testing are independent of lots for density testing.

(i) Density Test: A density test shall consist of a core taken at a random location within each density interval.

When establishing the target density, the HMA maximum theoretical gravity (G_{mm}) shall be based on the running average of four Department test results including the current day of production. Initial G_{mm} shall be based on the average of the first four test results.

(j) Unconfined Edge Density: The unconfined edge density shall be randomly selected within each 1/2 mile (800 m) section for each unconfined edge.

Pre-Production Meeting. The Engineer will schedule a pre-production meeting prior to the start of production. The HMA QC Plan, test frequencies, and responsibilities of all parties involved in testing and determining the PWL will be addressed. The Engineer will provide the random locations and tonnages in a sealed envelope for the Contractor to sign at the pre-production meeting or prior to paving. The random locations and tonnages may be adjusted due to field conditions according to the Department's Manual of Test Procedures for Materials "PFP and QCP Hot-Mix Asphalt Random Jobsite Sampling" and "PFP and QCP Random Density Procedure". The signed sealed envelope will be given to the Contractor after paving is complete along with documentation of any adjustments. Personnel attending the meetings may include the following:

(a) Resident Engineer

(b) District Mixture Control Representative

(c) QC Manager

(d) Contractor Paving Superintendent

(e) Any consultant involved in any part of the HMA sampling or testing on this project

Quality Control (QC) by the Contractor. The Contractor's QC plan shall include the schedule of testing for both quality characteristics and non-quality characteristics required to control the product such as asphalt binder content and mixture gradation. The schedule shall include sample location. The minimum test frequency shall be according to the following table.

Table 1
Minimum Quality Control Sampling and Testing Requirements

Quality Characteristic	Minimum Test Frequency	Sampling Location
Mixture Gradation	1/day	per QC Plan
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 the time of sampling.

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.

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 Field VMA, voids, and dust/AC ratio; and each density interval for density to determine payment for each lot. A sublot shall begin once an acceptable test-strip has been completed and the AJMF has been determined. All Department testing will be performed in a qualified laboratory by personnel who have successfully completed the Department HMA Level I training.

(a) Voids, Field VMA, and Dust/AC 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 Department's Manual of Test Procedures for Materials "PFP and QCP Hot-Mix Asphalt 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.

(b) Density. The Engineer will not disclose the random location of the sample until after the final rolling.

The Contractor shall cut the 4 in. (100 mm) diameter cores within the same day and prior to opening to traffic unless otherwise approved by the Engineer. All core holes shall be filled immediately upon completion of coring. All water shall be removed from the core holes prior to filling. All core holes shall be filled with a rapid hardening mortar or concrete which shall be mixed in a separate container prior to placement in the hole. Any depressions in the surface of the filled core holes greater than 1/4 in. (6 mm) at the time of final inspection will require removal of the fill material to the depth of the lift thickness and replacement.

The Engineer will witness and secure all mixture and density samples. The Contractor shall transport the secured sample to a location designated by the Engineer.

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 all Department test results. Copies will be furnished upon request. 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 quality level analysis calculations.

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 Department's Manual of Test Procedures for Materials "Pay for Performance Dispute Resolution". If dispute resolution is necessary, the Contractor shall submit a request in writing within four working days of receipt of the results of the quality index analysis for the lot. 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 Department's Manual of Test Procedures for Materials "Pay for Performance Dispute Resolution". The Central Bureau of Materials laboratory will be used for dispute resolution testing.

Acceptance by the Engineer. All of the Department's tests shall be within the acceptable limits listed below:

Table 2

Acceptable Limits	
Parameter	Acceptable Range
Field VMA	-1.0 – +3.0 %[1/]
Voids	2.0 – 6.0 %

Density: IL-19.0, IL-9.5 SMA	 90.0 – 98.0 % 92.0 – 98.0 %
Dust / AC Ratio	0.4 – 1.6[2/]

1/ Based on minimum required Field VMA from mix design

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.

Basis of Payment. Payment will be based on the calculation of the composite pay factor for each mixture according to the Department's Manual of Test Procedure for Materials "PFP Quality Level Analysis" document. Payment for full depth pavement will be based on the calculation of the Full Depth Pay Factor according to the "PFP Quality Level Analysis" document.

Additional Pay Adjustments. In addition to the composite pay factor for each mix, monetary deductions will be made for dust/AC ratios and unconfined edge densities as shown in Tables 3 and 4 as follows.

Table 3

Dust / AC Pay Adjustment Table [1/]	
Range	Deduct / sublot
$0.6 \le X \le 1.2$	$0
$0.5 \le X < 0.6$ or $1.2 < X \le 1.4$	$1000
$0.4 \le X < 0.5$ or $1.4 < X \le 1.6$	$3000
$X < 0.4$ or $X > 1.6$	Shall be removed and replaced

1/ Does not apply to SMA.

Table 4

Unconfined Edge Density Adjustment Table	
Density	Deduct / 0.5 mile (800 m)
≥ 90%	$0
89.0% to 89.9%	$1000
88.0% to 88.9%	$3000
< 88.0%	Outer 1.0 ft (300 mm) will require remedial action acceptable to the Engineer

80347

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Illinois Department of Transportation

Memorandum

To:	Regional Engineers MA
From:	Maureen M. Addis
Subject:	Special Provision for Hot-Mix Asphalt – Quality Control for Performance
Date:	August 4, 2017

This special provision was developed by the Central Bureau of Materials to provide procedures for production, placement and payment of hot-mix asphalt (HMA) under the quality control for performance (QCP) program. It has been revised to secure random number selections, revise the Intelligent Compaction temperature requirements and provide retesting requirements for the Department when precision limits are exceeded.

This special provision should be inserted into HMA contracts utilizing the QCP quality management program. The QCP quality management program is to be used for the following HMA mixtures.

1. Mainline mixture quantities between 1,200 and 8,000 tons (1,016 and 7,620 metric tons).
2. Shoulder applications that are greater than 8 feet (2.4 meters) wide and 1,200 tons (1,016 metric tons) and greater.
3. Leveling binder applications that are 1,200 tons (1,016 metric tons) and greater.

Note to designers: The option of using intelligent compaction should be given to the contractor (i.e. a number of roller passes should be entered in the HMA mix table on the plans) for leveling binder which will be placed at variable depth/thickness (i.e. used to correct cross-slope or rutting).

The districts should include the BDE Check Sheet marked with the applicable special provisions for the November 17, 2017 and subsequent lettings. The Project Development and Implementation Section will include a copy in the contract.

This special provision will be available on the transfer directory August 4, 2017.

80383m

HOT MIX ASPHALT – QUALITY CONTROL FOR PERFORMANCE (BDE)

Effective: April 1, 2017
Revised: November 1, 2017

Description. This special provision describes the procedures for production, placement and payment of hot-mix asphalt (HMA) under the quality control for performance (QCP) program; as well as the requirements for intelligent compaction. This special provision shall apply to the HMA mixtures specified in the plans. This work shall be according to the Standard Specifications except as modified herein.

Delete Articles:	406.06(b)(1), 2nd Paragraph	(Temperature Requirements)
	406.06(b)(2)d.	(Temperature Requirements)
	406.06(b)(3)b.	(Temperature Requirements)
	406.06(e), 3rd Paragraph	(Paver Speed Requirements)
	406.07(b)	(Rolling)
	406.07(c)	(Density)
	1030.05(a)(4, 5, 9,)	(QC/QA Documents)
	1030.05(d)(2)a.	(Plant Tests)
	1030.05(d)(2)b.	(Dust-to-Asphalt and Moisture Content)
	1030.05(d)(2)d.	(Small Tonnage)
	1030.05(d)(2)f.	(HMA Sampling)
	1030.05(d)(3)	(Required Field Tests)
	1030.05(d)(4)	(Control Limits)
	1030.05(d)(5)	(Control Charts)
	1030.05(d)(7)	(Corrective Action for Field Tests (Density))
	1030.05(e)	(Quality Assurance by the Engineer)
	1030.05(f)	(Acceptance by the Engineer)
	1030.06(a), 2nd paragraph	(Before start-up…)

Definitions.

(a) Quality Control (QC). All production and construction activities by the Contractor required to achieve the required level of quality.

(b) Quality Assurance (QA). All monitoring and testing activities by the Engineer required to assess product quality, level of payment, and acceptability of the product.

c) Pay Parameters. Pay parameters shall be field voids in the mineral aggregate (Field VMA), voids, and density. Field VMA will be calculated using the combined aggregates bulk specific gravity (G_{sb}) from the mix design.

(d) Mixture Lot. A mixture lot shall begin once an acceptable test strip has been completed and the adjusted job mix formula has been determined. If the test strip is waived, a mixture lot shall begin with the start of production. A mixture lot shall consist of four

sublots unless it is the last or only lot, in which case it may consist of as few as one sublot.

(e) Mixture Sublot. A mixture sublot for Field VMA, voids, and dust/AC shall be a maximum of 1000 tons (910 metric tons).

(1) If the remaining quantity is greater than 200 tons (180 metric tons) but less than 1000 tons (910 metric tons), the last mixture sublot will be that quantity.

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

(f) Density Interval. Density intervals shall 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). If a density interval is less than 200 ft (60 m), it will be combined with the previous density interval.

(g) Density Sublot. A density sublot shall be the average of five consecutive density intervals.

(1) If less than three density intervals remain outside a density sublot, they shall be included in the previous density sublot.

(2) If three or more density intervals remain, they shall be considered a density sublot.

(h) Density Test. A density test shall consist of a core taken at a random location within each density interval.

When establishing the target density, the HMA maximum theoretical gravity (G_{mm}) shall be based on the running average of four Department test results. Initial G_{mm} shall be based on the average of the first four test results. If less than four G_{mm} results are available, an average of all available Department G_{mm} test results shall be used.

Pre-Production Meeting. The Engineer will schedule a pre-production meeting prior to the start of production. The HMA QC Plan, test frequencies, and responsibilities of all parties involved in testing will be addressed. The Engineer will provide the random locations, tonnages, and sublot selected from each lot in a sealed envelope for the Contractor to sign at the pre-production meeting or prior to paving. The locations, tonnages, and sublot selected from each lot may be adjusted due to field conditions according to the Department's Manual of Test Procedures for Materials "PFP and QCP Hot-Mix Asphalt Random Jobsite Sampling" and "PFP and QCP Random Density Procedure". The signed sealed envelope will be given to the Contractor after paving is complete, along with documentation of any adjustments. Personnel attending the meetings may include the following:

(a) Resident Engineer

(b) District Mixture Control Representative

(c) QC Manager

(d) Contractor Paving Superintendent

(e) Any consultant involved in any part of the HMA sampling or testing on this project

Quality Control (QC) by the Contractor. The Contractor's QC plan shall include the schedule of testing for both pay parameters and non-pay parameters required to control the product such as asphalt binder content and mixture gradation. The minimum test frequency shall be according to Table 1.

Table 1

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

The Contractor's splits in conjunction with other quality control tests shall be used to control production.

The Contractor shall submit split jobsite mix sample test results to the Engineer within 48 hours of the time of sampling. All QC testing shall be performed in a qualified laboratory by personnel who have successfully completed the Department's HMA Level I training.

Intelligent Compaction. When a "Number of Roller Passes" is specified in the HMA Mixture Requirements table on the plans, the Contractor may opt to use intelligent compaction (IC) in lieu of density testing. Coring according to the Department's Manual of Test Procedures for Materials "PFP and QCP Random Density Procedure" is required and will be used for pay adjustments for density sublots that are not in compliance with the contract specifications.

The IC equipment shall be mounted on the breakdown roller(s) and shall record GPS location data, roller pass counts, roller speeds, and HMA mat temperatures. Each day, the accuracy of the GPS and temperature data shall be verified and documented. If the verification fails or is not performed, the IC data will not be used for the affected density sublots.

The IC data for each density sublot shall be analyzed using Veta software to determine the average roller speed, percent roller coverage, and average mat surface temperature for the final roller pass. The Contractor shall submit these summary results, and if requested the raw data

from the IC equipment and the data analysis software, to the Engineer within 24 hours of each day of paving using IC.

The required number of roller passes shall be as specified on the plans. The roller speeds shall be according to Article 406.07. The minimum roller coverage shall be 90 percent. The average HMA mat temperature for the initial break down roller pass shall be according to Table 2.

Table 2

Asphalt Mixture Type	Temperature Range (ºF (ºC))
Warm Mix Asphalt	215-275 °F (102-135 °C)
IL-4.75	300-350 °F (155-175 °C)
HMA using SBS PG76-22	300-350 °F (155-175 °C)
HMA using SBS PG76-28	300-350 °F (155-175 °C)
HMA using SBS PG70-22	300-350 °F (155-175 °C)
HMA using SBS PG70-28	300-350 °F (155-175 °C)
Other HMA not listed above	260-325 °F (125-165 °C)

Quality Assurance (QA) by the Engineer. Quality Assurance by the Engineer will be as follows.

(a) Voids, Field VMA, and Dust/AC Ratio. The Engineer will determine the random tonnage and the Contractor shall be responsible for obtaining the sample according to the Department's Manual of Test Procedures for Materials "PFP Hot-Mix Asphalt Random Jobsite Sampling Procedure".

(b) Density: After final rolling, the Engineer will identify the random core locations within each density testing interval according to the Department's Manual of Test Procedures for Materials "PFP and QCP Random Density Procedure".

The Contractor shall cut the 4 in. (100 mm) cores within the same day and prior to opening to traffic unless otherwise approved by the Engineer. All core holes shall be filled immediately upon completion of coring. All water shall be removed from the core holes prior to filling. All core holes shall be filled with a rapid hardening mortar or concrete which shall be mixed in a separate container prior to placement in the hole. Any depressions in the surface of the filled core holes greater than 1/4 in. (6 mm) at the time of final inspection will require removal of the fill material to the depth of the lift thickness and replacement.

The Engineer will witness and secure all mixture and density samples. The Contractor shall transport the secured sample to a location designated by the Engineer.

The Engineer will select at random one split sample from each lot for testing of voids, Field VMA and dust/AC ratio. The Engineer will test a minimum of one sample per project. The Engineer will test all of the pavement cores for density unless intelligent compaction is used. All QA testing will be performed in a qualified laboratory by personnel who have successfully completed the Department's HMA Level I training. QA test results will be available to the

Contractor within ten working days from receipt of secured cores and split mixture samples and after 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 quality level analysis calculations.

If QA results do not meet the precision limits listed in Table 3, the Department will verify the results by retesting the retained split sample. The retest will replace the original results.

If the QA results do not meet the 100 percent sublot pay factor limits or still do not compare to QC results within the precision limits in Table 3, after retesting the Engineer will test all split mix samples for the lot.

Table 3

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

Acceptance by the Engineer. All of the Department's tests shall be within the acceptable limits listed in Table 4.

Table 4

Parameter		Acceptable Limits
Field VMA		-1.0 – +3.0%[1/]
Voids		2.0 – 6.0%
Density	IL-9.5, IL-19.0, IL-4.75, IL-9.5FG[3/]	90.0 – 98.0%
	SMA	92.0 – 98.0%
Dust / AC Ratio		0.4 – 1.6[2/]

1/ Based on minimum required VMA from mix design

2/ Does not apply to SMA.

3/ Acceptable density limits for IL-9.5FG placed less than 1 1/4 in. (32 mm) shall be 89.0% - 98.0%

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

Basis of Payment. Payment will be based on the calculation of the composite pay factor using QA test results for each mixture according to the Department's Manual of Test Procedures for Materials "QCP Pay Calculation" document.

If intelligent compaction is successfully implemented, the Contractor will receive 100 percent for the density pay factor in Equation 1 of the "QCP Pay Calculation" document for each applicable HMA mixture; otherwise, the density tests and pay adjustments will apply. The pay factor for each density sublot will be based upon either intelligent compaction or density tests and the two will not be mixed.

Dust/AC Ratio. A monetary deduction will be made using the pay adjustment table below for dust/AC ratios that deviate from the 0.6 to 1.2 range. If the tested mixture sublot is outside of this range, the Department will test the remaining sublots for dust/AC pay adjustment.

Table 5

Dust/AC Pay Adjustment Table[1/]	
Range	Deduct / sublot
$0.6 \leq X \leq 1.2$	$0
$0.5 \leq X < 0.6$ or $1.2 < X \leq 1.4$	$1000
$0.4 \leq X < 0.5$ or $1.4 < X \leq 1.6$	$3000
$X < 0.4$ or $X > 1.6$	Shall be removed and replaced

1/ Does not apply to SMA.

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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

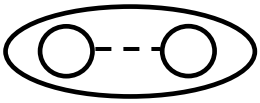

INDIVIDUAL TEST


MOVING AVERAGE


STATE SPLIT TEST (WASHED GRADATIONS)


STATE SPLIT INDIVIDUAL TEST


WASHED SAMPLE


RESAMPLE – (RS) 1/6 004-01

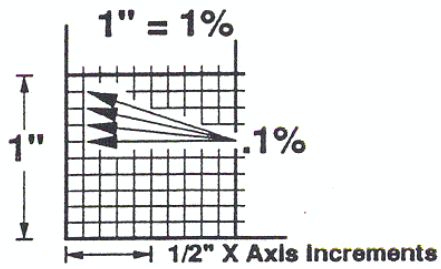

INDIVIDUAL TEST LIMITS


MOVING AVERAGE TEST LIMITS

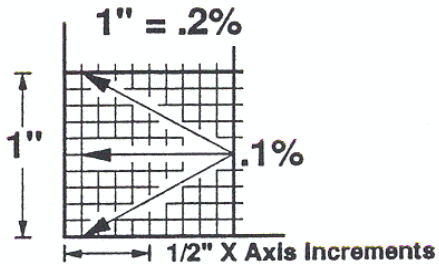
TARGET FROM JOB MIX FORMULA

Examples of Scales for Control Charts

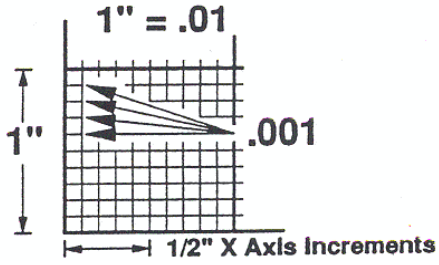
Air Voids, Field VMA, Minus No. 200, Field Density



Asphalt Binder Content



Gravities (Bulk or Max. Theoretical)



Illinois Department of Transportation

Hot-Mix Asphalt QC/QA Control Charts / Rounding Test Values
Appendix B8

Effective: May 1, 1993
Revised: January 1, 2008

A. Scope

1. All required Contractor test results, including resample tests and mixture start-up, described in Article 1030.05(g) of the Standard Specification shall be split samples and plotted on Control Charts. (No check tests shall be plotted on these Control Charts.) In addition, the Engineer's "assurance" test results shall also be displayed. The minimum frequency of such tests shall be according to Section 1030 of the Standard Specifications.

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 location of the Control Charts at all times.

B. General Procedures

1. Control Charts shall be computer-printed or plotted in ink on standard cross-section paper (10 divisions per 1 in. [25 mm]). The vertical scale used shall conform to the following requirements in respect to rounded values of:

   Gradation - 1% per 2.5 divisions (1 in [25 mm] = 4.0%).

   Air Voids, Field VMA, Minus No. 200 (Minus 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. (See Figure 1.)

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 ignition oven 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

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shall be represented by solid triangles for washed ignition 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. Department assurance test values shall not be connected with any other point. 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 except Department assurance split samples. 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 200 (minus 75 µm) for HMA production control shall include both washed ignition oven gradation and adjusted dry gradation individual results. When a given sublot includes both washed ignition and dry gradation test results for the minus 200 (minus 75 µm), only the washed ignition 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 start-up 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.

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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. Mixture Start-Up Test Values

1. Test values obtained during start-up and the Job Mix Formula (JMF) adjustment period shall be placed at the beginning of the Control Charts. Once all these required 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. This constitutes the field verification process for the mixture.

2. At the completion of the field verification, production under QC/QA shall be initiated with the agreed upon targets and appropriate limits being placed on the graph. Individual required 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 Section 1030.06 of the Standard Specifications 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.

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G. Resample Test Values

The Contractor resample tests for a failed individual test shall be the only biased process control test placed on the Control Chart. It 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 this value and the failed test value which the resample represents. Both the failed test value and the resample test value shall be used as individual points in determining moving averages.

H. Rounding Test Values

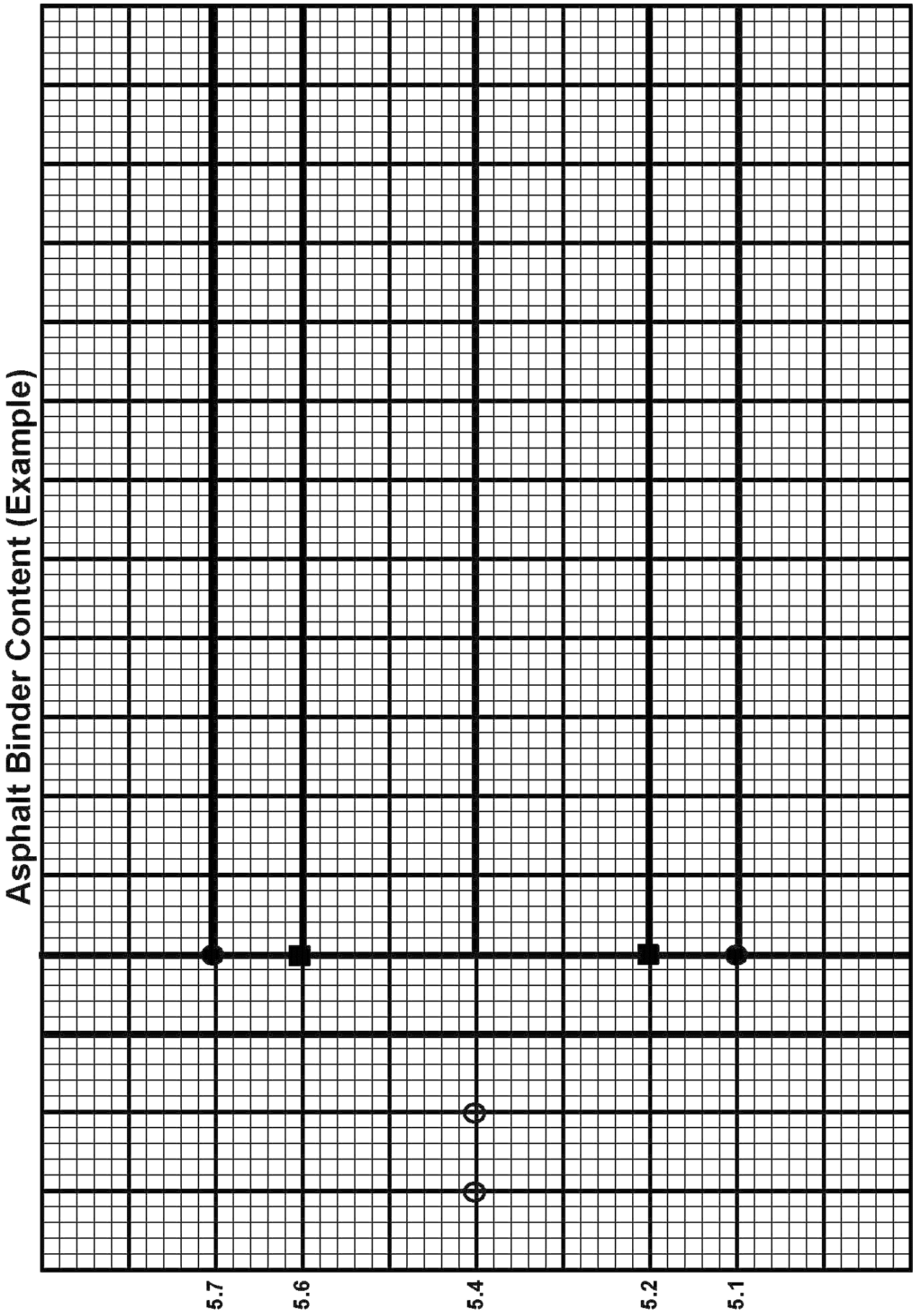
1. The intent of rounding is to limit the number of digits in an observed or calculated value to those considered significant for the purpose of determining conformance with specification limits.

   If improperly applied, rounding may contribute to loss of precision and result in increased risk to either the Department or Contractor.

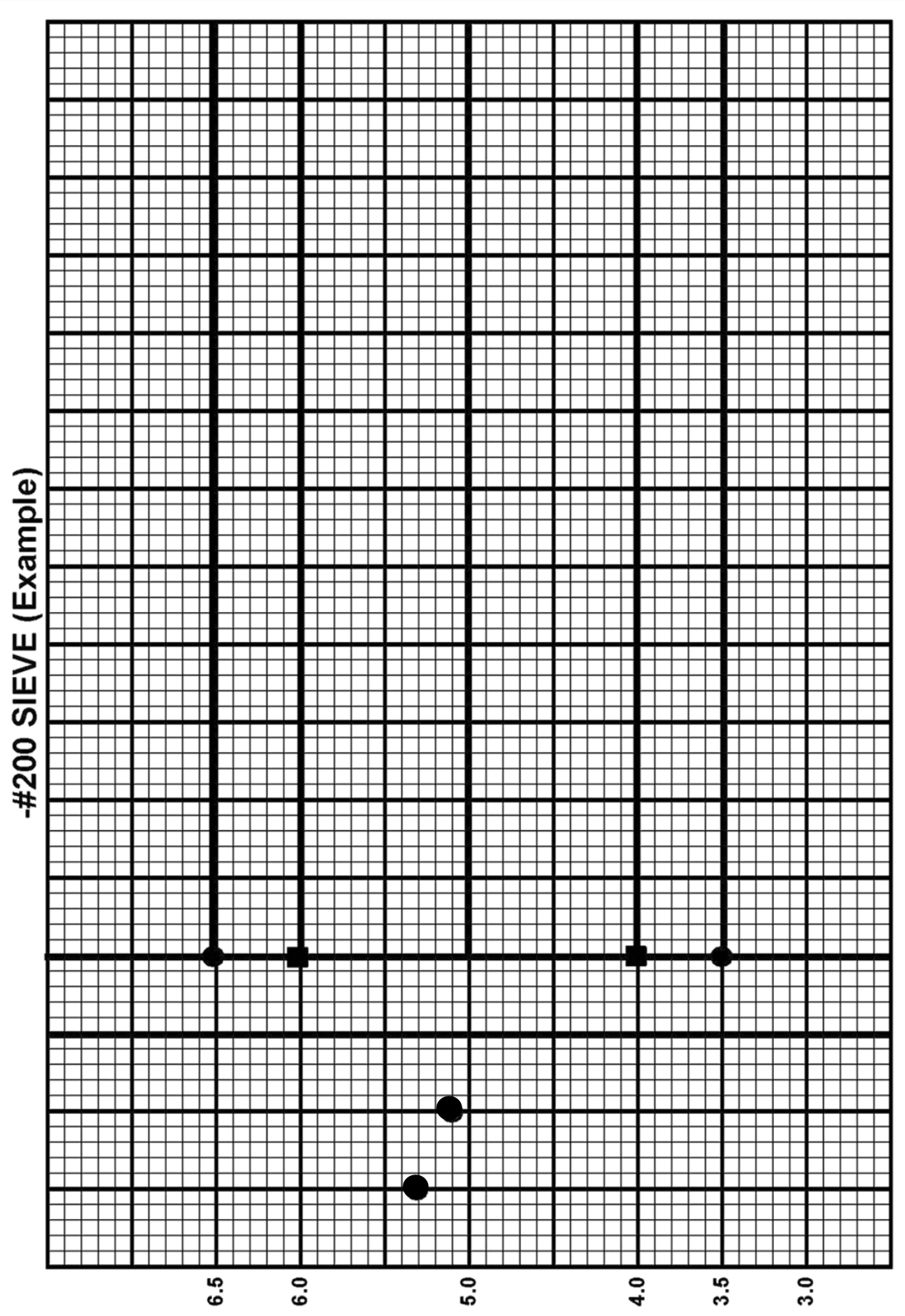
   The following are the appropriate significant digits to which test values are to be rounded for parameters described in the Section 1030:

Test	Significant Digit
Gradation (% Passing);	Nearest whole percent (no decimal)
Field Density: Air Voids; Minus No. 200 (Minus 75-µm); Asphalt Binder Content	Nearest one-tenth percent (0.1%)
Bulk Gravity, G_{mb}; Maximum Gravity, G_{mm}	Nearest one-thousandth (0.001)

   Rounding of test results shall be according to Illinois-Modified ASTM E 29, "Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications", located in this manual.


Asphalt Binder Content (Example)
5.7
5.6
5.4
5.2
5.1

PROBLEMS ASSOCIATED WITH MIX ASPHALT BINDER CONTENT


-#200 SIEVE (Example)
6.5
6.0
5.0
4.0
3.5
3.0

PROBLEMS ASSOCIATED WITH MIX -200 SIEVE (-75 MICRON)

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.

This Page Is Reserved

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)

Rap is reclaimed asphalt pavement resulting from cold milling or crushing of an existing dense graded hot-mix asphalt (HMA) pavement. The Contractor shall supply written documentation that the RAP originated from routes or airfields under federal, state, or local agency jurisdiction.

Individual sealed RAP stockpiles are constructed and are kept sufficiently separated to prevent intermingling at the base. Once the pile has been sealed, no additional RAP shall be added. These stockpiles are identified by signs indicating the type. Prior to milling the

District provides verification, upon request, of the quality of the RAP to clarify appropriate stockpile. The types of RAP stockpiles are: Fractionated Rap, Homogeneous, Congolmerate, Conglomerate “D” (DQ) and Non-Quality.

(a) Fractionated RAP (FRAP) - FRAP consists of RAP from Class I, HMA (High and Low ESAL) mixtures. The coarse aggregate in FRAP is crushed aggregate and may represent more than one aggregate type and/or quality, but is at least C quality. All FRAP is fractionated prior to testing by screening into a minimum of two size fractions with the separation occurring on or between the #4 (4.75 mm) and1/2 in. (12.5 mm) sieves. Agglomerations is minimized so 100 percent of the RAP passes the sieve size specified for the mix the FRAP will be used in. If the FRAP is used in IL- 25.0, 100% must pass the 2 in. (50 mm) sieve, for IL-19.0, 100% must pass the 1 ½” in. (40 mm) sieve, for IL-12.5, 100% must pass the 1” (25 mm) sieve, for IL-9.5, 100% must pass the ¾ in. (20 mm) sieve and for IL-4.75, 100% must pas the ½ in. (13 mm) sieve.

(b) Homogeneous - Homogeneous RAP stockpilesl consists of RAP from Class I, HMA (High and Low ESAL) mixtures and represent: 1) the same aggregate quality, but is 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.

(c) Conglomerate - Conglomerate RAP stockpiles consists of RAP from Class I, HMA (High and Low ESAL) mixtures. The coarse aggregate in this RAP is crushed aggregate and may represent more than one aggregate type and/or quality but must be at least C quality. This RAP may have an inconsistent gradation and/or asphalt binder content prior to processing. All 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 can not contain steel slag or other expansive material as determined by the Department.

(d) Conglomerate “D” Quality (DQ) - Conglomerate DQ RAP stockpiles consists of RAP from Class I, HMA (High or Low ESAL), or “All Other” (as defined byArticle 1030.04(a)(3)) mixtures. The coarse aggregate in this RAP may be crushed or round but must be at least D quality. This RAP may have an inconsistent gradation and/or asphalt binder content. Conglomerate DQ RAP stockpiles shall not contain steel slag or other expansive material as determined by the Department.

(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 that contains contaminants, such as earth, brick, sand, concrete, sheet asphalt, bituminous surface treatment (i.e. chip seal), pavement fabric, joint sealants, etc., is unacceptable unless the contaminants are removed to the satisfaction of the Engineer.

(2) Reclaimed Asphalt Shingles (RAS)

Reclaimed asphalt shingles (RAS) are shingles that have been reclaimed and processed in a Bureau of Materials and Physical Research approved processing facility. If the processed RAS meets requirements set forth they are permitted for use in all HMA mixtures used for overlay application only. RAS cannot be used in fulldepth HMA pavement.

RAS must be a clean and uniform material with a maximum of 0.5 percent unacceptable materials. The material is 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 must be uniform in gradation and asphalt binder content and must meet testing requirements. In addition, RAS must meet the following Type 1 or Type 2 requirements.

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

(b) Type 2. Type 2 RAS must 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).

Records identifying the shingle processing facility supplying the RAS, RAS type and lot number must be maintained by project contract number and kept for a minimum of 3 years.

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 Test Procedure 11)
- 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 not applicable to Class I hot mix asphalt mixtures.

(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 prevent 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

MISTIC DESIGNATIONS

MATERIALS INTEGRATED SYSTEM for TEST INSPECT and COMMUNICATION

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	**3**	**2**	**C**	**M**	**16**
Aggregate	**'B' Quality**	**Crushed Stone**	**Coarse Aggregate**	**Modified Specification**	**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 Superior Performing Asphalt Pavements 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 mix and IL-9.5 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.
$\geq$ 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.

Use	Mixture	Aggregates Allowed
Class A	Seal or Cover	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
HMA Low ESAL	Stabilized Subbase or Shoulders	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
HMA High ESAL Low ESAL	Binder IL-19.0 or IL-19.0L SMA Binder	Allowed Alone or in Combination [5/]: Crushed Gravel Carbonate Crushed Stone[2/] Crystalline Crushed Stone Crushed Sandstone Crushed Slag (ACBF) Crushed Concrete[3/]
HMA High ESAL Low ESAL	C Surface and Leveling Binder IL-9.5 or IL-9.5L SMA Ndesign 50 Surface	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/]
HMA High ESAL	D Surface and Leveling Binder IL-9.5 SMA Ndesign 50 Surface	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/]
		Other Combinations Allowed:
		Up to... — *With...*
		25% Limestone — Dolomite
		50% Limestone — Any Mixture D aggregate other than Dolomite
		75% Limestone — Crushed Slag (ACBF) or Crushed Sandstone

Art. 1004.03 Coarse Aggregates

Use	Mixture	Aggregates Allowed	
HMA High ESAL	E Surface IL-9.5 SMA Ndesign 80 Surface	<u>Allowed Alone or in Combination</u> [5/]: Crushed Gravel Crystalline Crushed Stone Crushed Sandstone Crushed Slag (ACBF) Crushed Steel Slag Crushed Concrete[3/] No Limestone.	
		<u>Other Combinations Allowed:</u>	
		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 SMA Ndesign 80 Surface	<u>Allowed Alone or in Combination</u> [5/]: Crystalline Crushed Stone Crushed Sandstone Crushed Slag (ACBF) Crushed Steel Slag No Limestone.	
		<u>Other Combinations Allowed</u>:	
		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.

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4/ Crushed steel slag shall not be used as leveling 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), other binder courses, and surface course IL-9.5L (Low ESAL), 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, 2, & 3	3/8 in. (10 mm) Seal	CA 16
Class A-1	1/2 in. (13 mm) Seal	CA 15
Class A-2 & 3	Cover	CA 14
HMA High ESAL	IL-19.0 IL-9.5	CA 11 1/ CA 16 and/or CA 13 CA 16
HMA Low ESAL	IL-19.0L IL-9.5L Stabilized Subbase or Shoulders	CA 11 1/ CA 16

1/ CA 16 or CA 13 may be blended with the gradations listed.

(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 $\leq$ 2.5 percent.

Make the following revisions according to Supplemental Specifications and Recurring Special Provisions, Adopted January 1, 2018:

Page 755: Article 1004.03(b). Revise the third sentence of the first paragraph to read “For Class A (seal or cover coat), and other binder courses, the coarse aggregate shall be Class C quality or better.”.

Page 755 Article 1004.03(c). In the table for Class A-1, 2, & 3, change the Gradation No. “CA 16” to “CA 16 or CA 20”.

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.

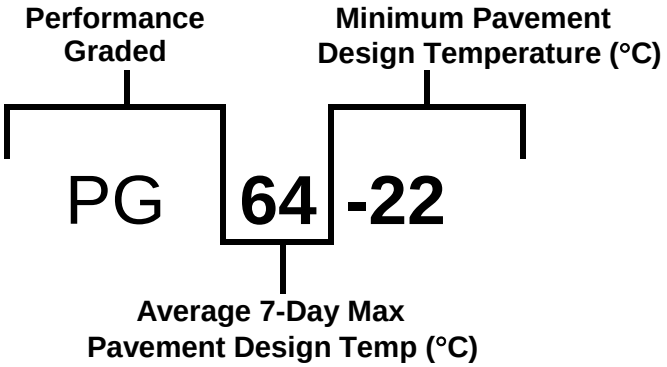
PERFORMANCE DRIVEN BINDERS

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 Bureau of Materials and Physical Research (BMPR) will perform all testing on PG binders. An approved list of PG binders is distributed by BMPR.

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.

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1032.05 Asphalt Binder (Prepared from Petroleum). These materials will be accepted according to the current Bureau of Materials and Physical Research Policy Memorandum, "Performance Graded Asphalt Binder Acceptance Procedure". 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) 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.

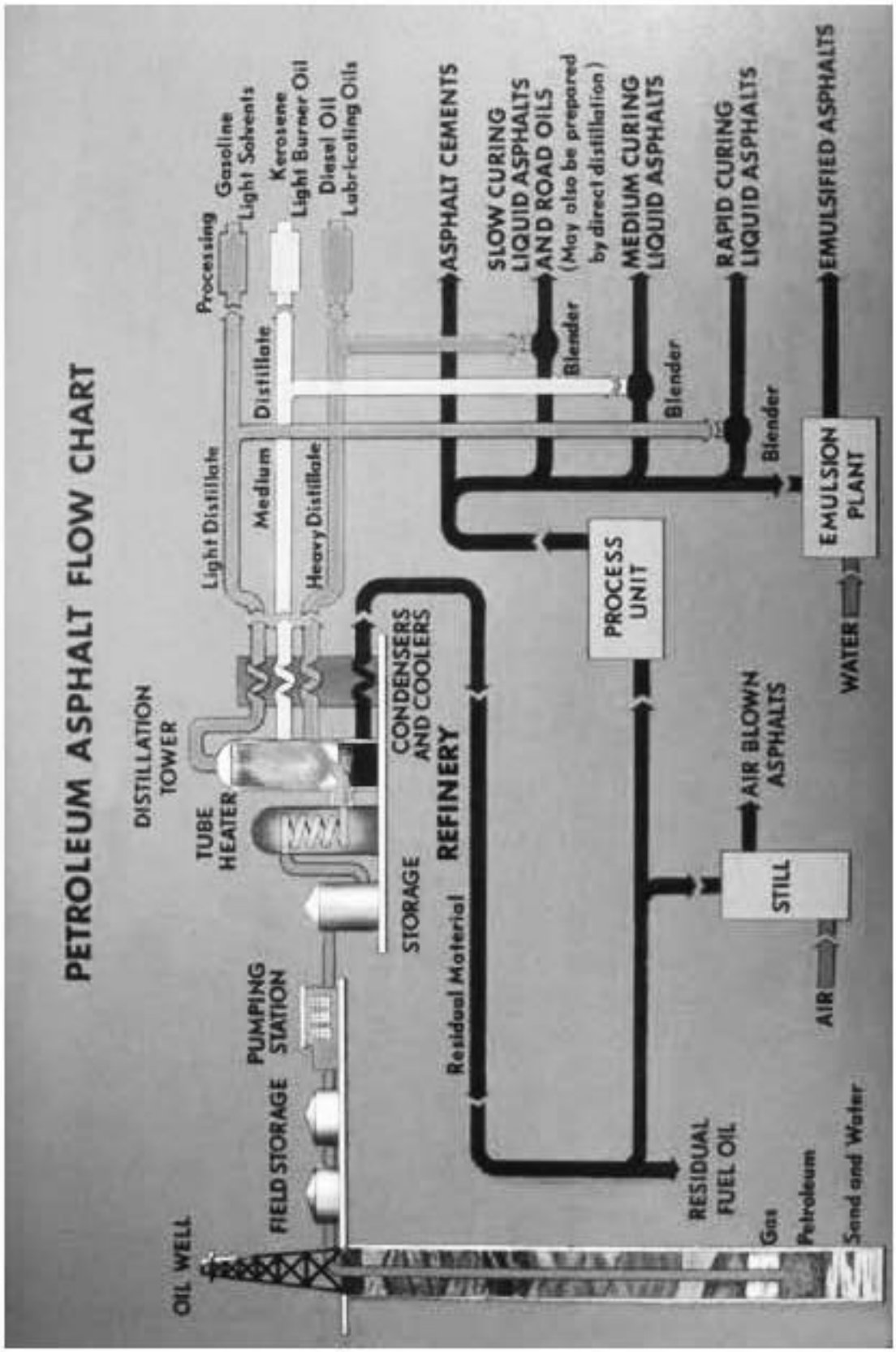
Table 1 - Requirements for Styrene-Butadiene Copolymer (SB/SBS) Modified Asphalt Binders

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), 39.2 °F (4 °C), 50 mm/min., 300 mm elongation.	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.

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.

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.


PETROLEUM ASPHALT FLOW CHART
OIL WELL
FIELD STORAGE
PUMPING STATION
STORAGE
REFINERY
DISTILLATION TOWER
TUBE HEATER
CONDENSERS AND COOLERS
Processing
Gasoline Light Solvents
Kerosene Light Burner Oil
Diesel Oil Lubricating Oils
Light Distillate
Medium
Heavy Distillate
Distillate
Residual Material
ASPHALT CEMENTS
SLOW CURING LIQUID ASPHALTS AND ROAD OILS
(May also be prepared by direct distillation)
MEDIUM CURING LIQUID ASPHALTS
RAPID CURING LIQUID ASPHALTS
EMULSIFIED ASPHALTS
Blender
Blender
Blender
PROCESS UNIT
EMULSION PLANT
WATER
AIR BLOWN ASPHALTS
STILL
AIR
RESIDUAL FUEL OIL
Gas
Petroleum
Sand and Water

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Types Of Plants (Photos)

DRIER-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 drier-drum mix plants and batch plants is that, in drier-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 drier-drum mix plant. As the mix is discharged from the drier-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 drier-drum mix plant are shown in Figure 4.1.

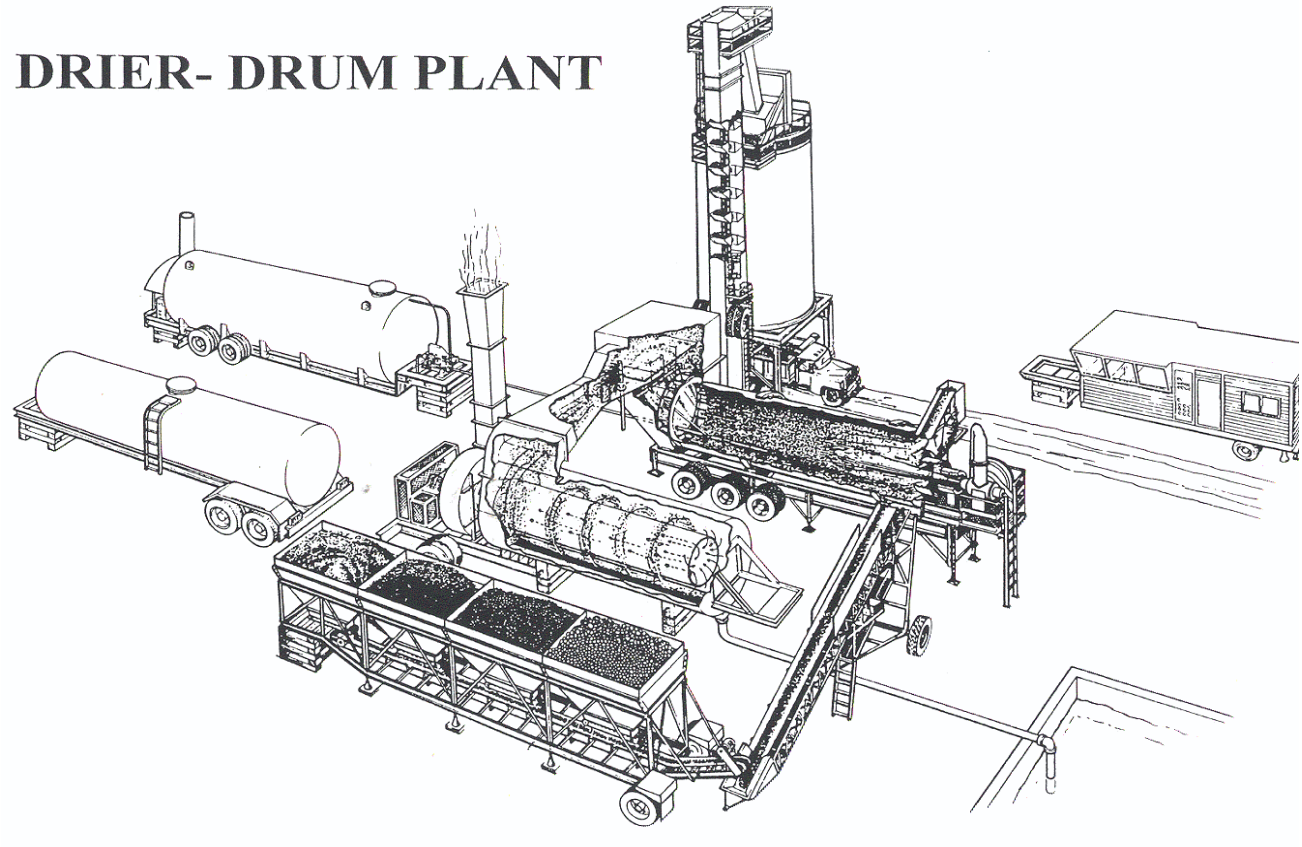

Figure 4.1

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 drier-drum plants, which produce HMA in a steady flow. Figure 4.2 illustrates the major components of a typical asphalt batch plant.

BATCH PLANT

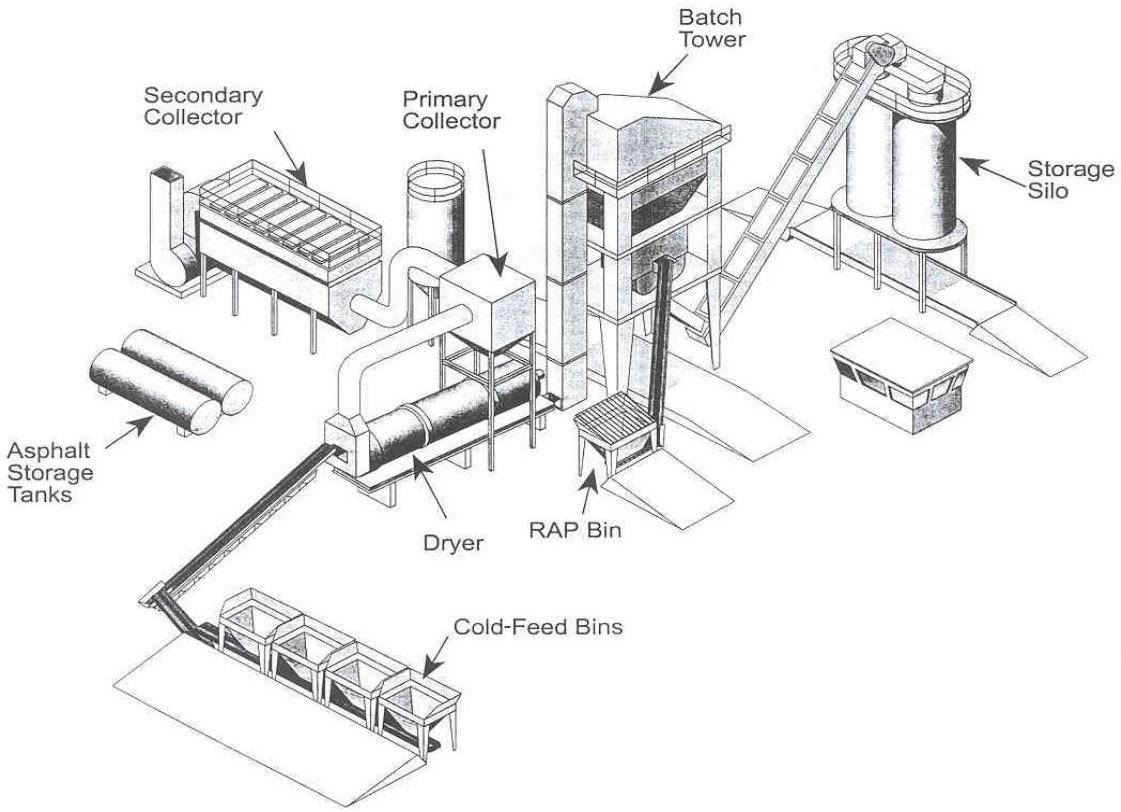

Figure 4.2

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, 2017

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[5]	110 lbs (50 kg)	10,000 g				X	X[MN]	X[MB,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[5]	55 lbs (25 kg)	5,000 g					X	X[MN]	XC	XC	X[MB,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[5]	55 lbs (25 kg)	5,000 g						X	X[MN]	XC	X[MB,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[5]	35 lbs (16 kg)	2,000 g							X		X[MN]	X	XC	X[MB,6]	XC	X[6]			X
CA14[5]	35 lbs (16 kg)	2,000 g								X	X[MN]	X[MB,6]	XC	X[6]					X
CA15	35 lbs (16 kg)	2,000 g									X	X[MN]	XC	X	XC	X			X
CA16[5]	25 lbs (11 kg)	1,500 g									X	X[MN]	XC	X[MB,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: December 1, 2017

Notes below apply to Fine and Coarse Aggregate Gradation Tables Only

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]

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, 2017

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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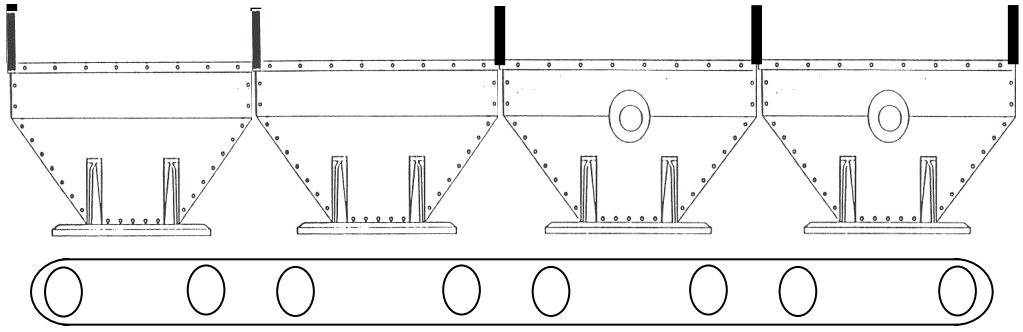
COLD AGGREGATE BINS AND FEEDERS

The specifications state, that the asphalt plant be equipped with a minimum of four (4) cold aggregate bins and feeders. (Fig. 4.3) 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 4.4 Illustrates different types of feeders).



COLD FEED SYSTEM

Figure 4.3

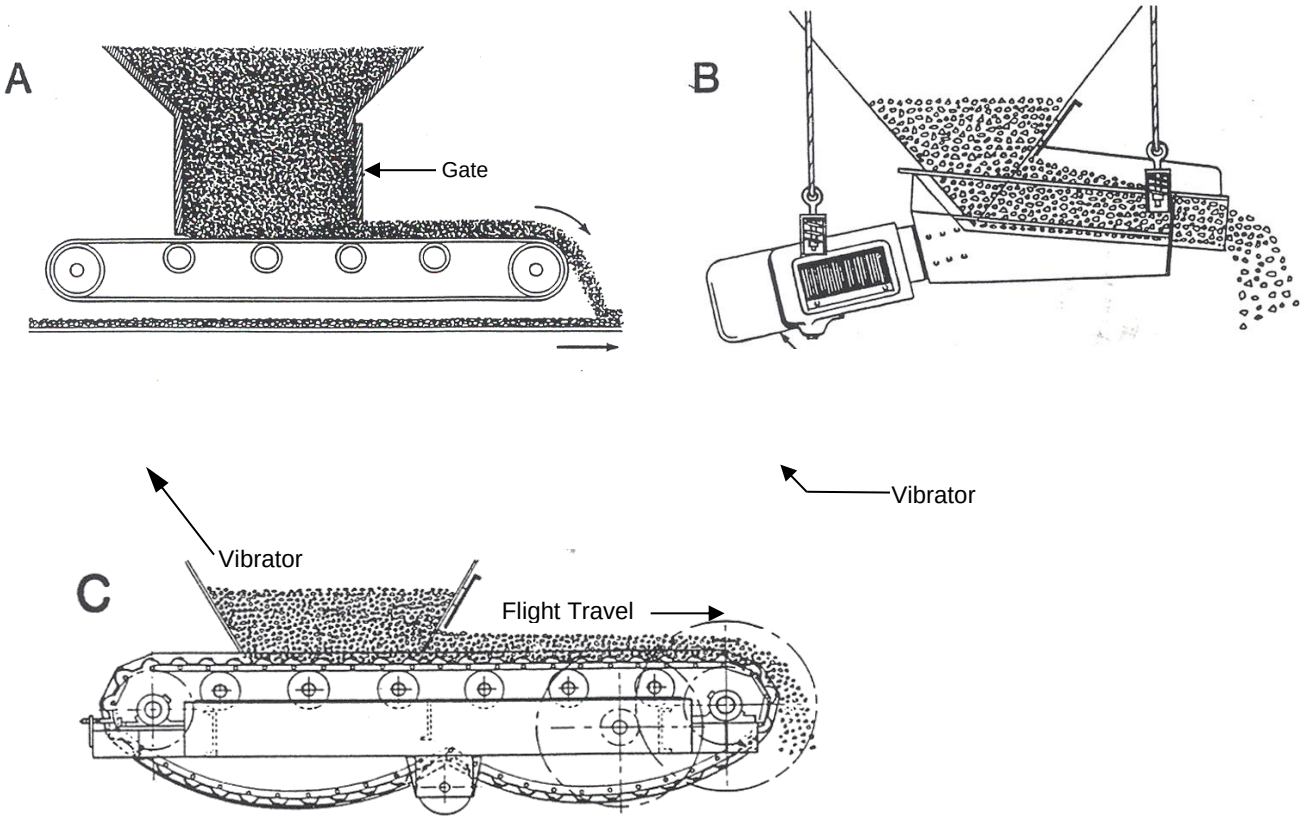


Figure 4.4 – Typical Types of Cold Feed Systems: A. Continuous Belt Feeder. B. Vibratory Feeder. And C. Apron Flow Feeder

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 drier-drum plant, samples of the combined aggregates are taken from either the collector belt or the weigh-belt conveyor. As shown in Figure 4.3, 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 4.5, 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.

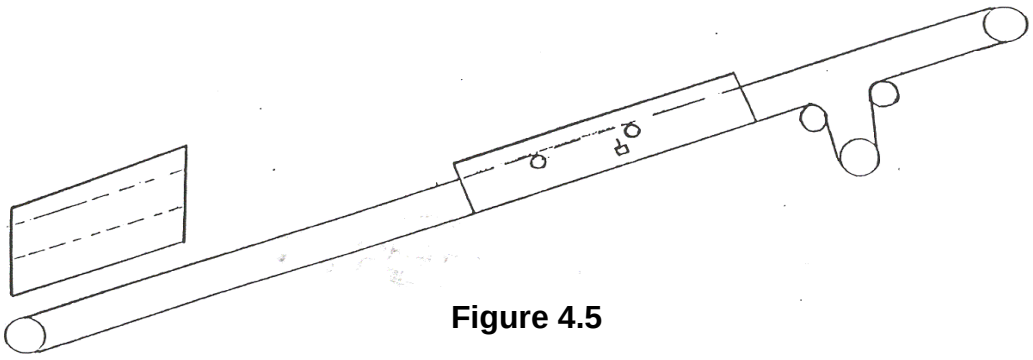


Figure 4.5

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.

DRIER

After the aggregate has been fed from the aggregate feeders it is then deposited into the drier 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 drier and elevated to the screen deck. The screen deck, as shown in Fig. 4.6 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.

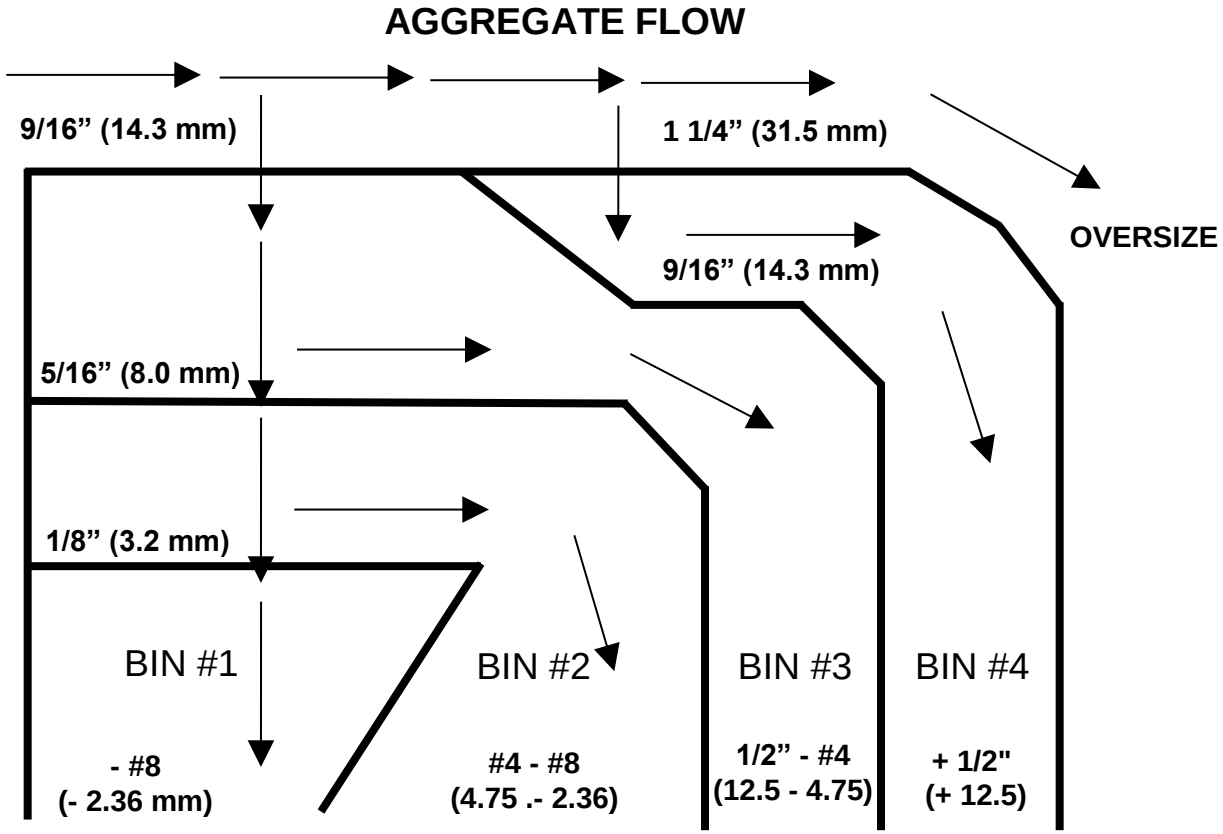


Figure 4.6

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. 4.7). 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. 4.8). The sampling pan should be inserted into its proper location, the hot-bin gate opened completely and closed immediately.

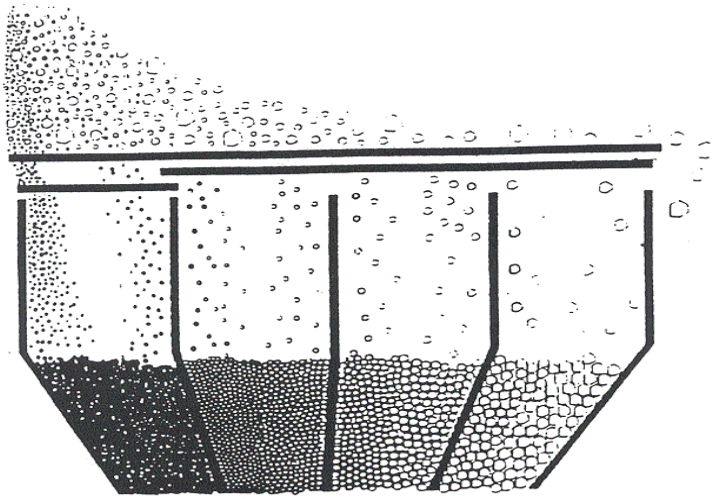


Figure 4.7 - Segregation of Materials in Hot Bins

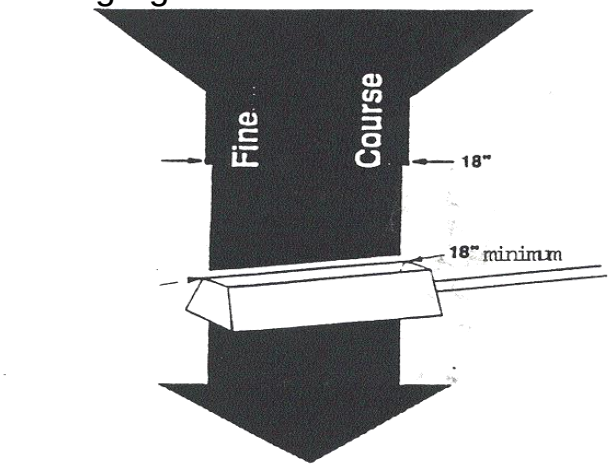


Figure 4.8 - Correct use of Sampling Device

This process shall be repeated until a minimum field sample size can be obtained from each hot bin according to the chart below. (Fig. 4.9)

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. 4.9). (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 4.9

Surge And Storage Silos

PURPOSE

The main purpose of a silo (Fig. 4.10) 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 drier-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 4.10

DRAG SLAT CONVEYOR

A variety of conveying devices are used to transport the hot-mix asphalt from the discharge chute on the drier-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 4.10. 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 4.11, 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.

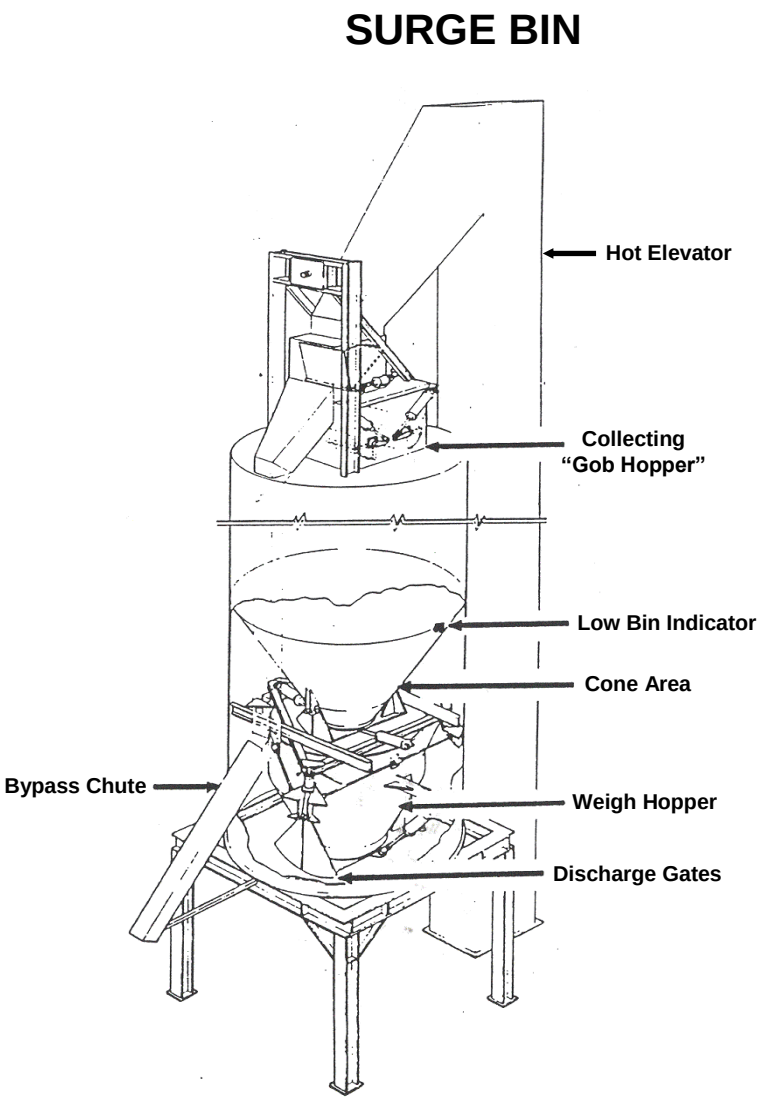


Figure 4.11

Loading And Segregation

SEGREGATION

If all the mix is dropped into the hauling vehicle in one drop from the silo (Fig. 4.12) 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 truckload.

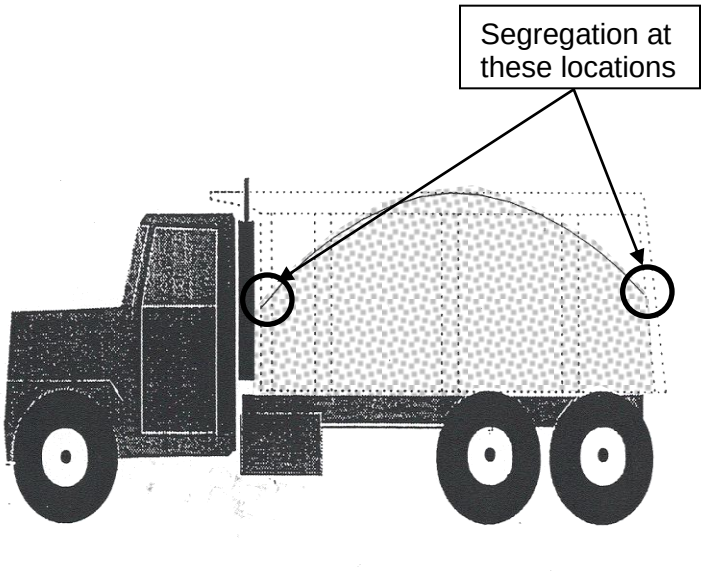


Figure 4.12

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 4.13.

Minimum Segregation in Truck

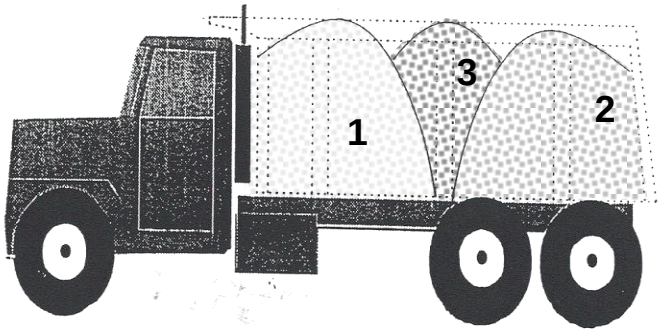


Figure 4.13

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.

GUIDELINES FOR HOT-MIX SAMPLING FROM JOB-SITE

Job-site sampling will be completed by taking samples behind the paver or from the Material Transfer Device (MTD) discharge chute. If sampling by plates or with shovel only, prior to sampling, the technician must make sure to obtain a sufficient amount of material from the paver or MTD to fill the voids left behind. Plates sampling would be used when sampling HMA directly over aggregate base, stabilized subbase, rubblized concrete or a milled surface. Shovel only sampling would be used over smooth HMA and concrete surfaces.

QC/QA Specification requires a composite sample size of 150 lbs (68 kg) minimum to be obtained, allowing 75 lbs (34 kg) for Contractor testing and 75 lbs (34 kg) for District testing.

PFP Specification requires a composite sample size of 200 lbs minimum to be obtained, allowing 50 lbs (23 kg) for District testing, 50 lbs (23 kg) for Contractor testing, 50 lbs (23 kg) for dispute resolution testing, and 50 lbs (23 kg) backup for Department testing.

QCP Specification requires a composite sample size of 100 lbs (45 kg), allowing 50 lbs (23 kg) for District testing, and 50 lbs (23 kg) for Contractor testing.

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

Effective: April 1, 2008
Revised: October 1, 2017

Hot-mix asphalt (HMA) samples shall be obtained at the frequency specified in the Hot Mix Asphalt Quality Control for Performance (QCP) and Pay for Performance (PFP) Using Percent within Limits special provisions.

The random jobsite mixture samples shall be taken at the randomly selected test location within a 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 approved software program. 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 shall be determined by calculating the longitudinal distance the truck would travel to produce 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 foot (see examples in 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 feet 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 test will not be taken and the tonnage will be added to the current 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 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).

1. Equipment

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

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

c) IDOT Approved HMA Sample Splitter.

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.

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Effective: April 1, 2008
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1) Sampling Plates (4 each). The sampling plates shall be rectangular and have a minimum size of 14 x 28 inches (360 x 720 mm). Plates shall have a hole approximately 0.25 inches (6 mm) in diameter drilled through each of the four corners.

2) Lifting Handles and Wire Lead. A 24 inch (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.

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

Overall Length = 5 feet
Shovel Width = 10 inches
Shovel Length = 12 inches
Shovel Sides = 4 inches

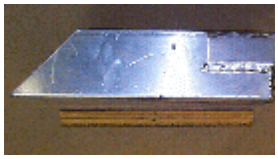

Figure 1. Aluminum Sampling Shovel & Dimensions

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

   a) The sampling shovel shall be used at each of the four offsets illustrated in Figure 2. to dig directly downward into pavement until it comes into contact with the previous pavement surface. When in contact, the shovel shall be pushed forward until it is

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PFP and QCP Hot Mix Asphalt Random Jobsite Sampling
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full. The shovel shall be lifted up slowly and carefully place the mix 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 3/4 in. level binder over a milled surface. In the case of IL-4.75 mm 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 mm 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 handle shall be placed at four locations according for Figure 2. at the designated location ahead of the paver. 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 materials transfer devices will be allowed to cross over the pate 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 pavement 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 and carefully place the mix into the sample container in order to prevent any loss of HMA.

   e) Remove sampling plates from pavement.

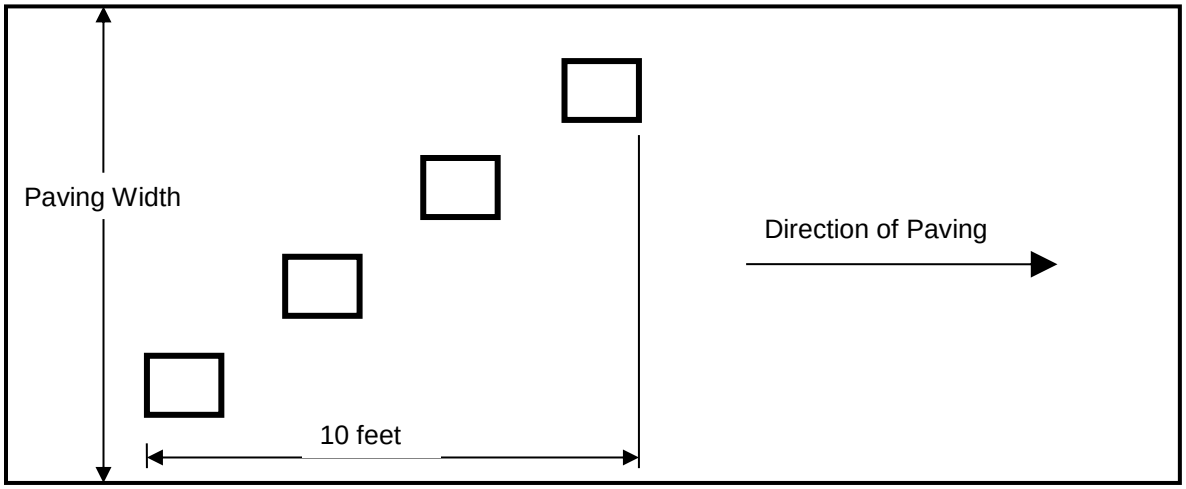

Figure 2. Behind Paver Sampling Layout

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Effective: April 1, 2008
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4. Composite/Lab Sample.

   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 feet 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.

      1) PFP. If the contractor elects to have the option to dispute test results by the Engineer, a composite sample size shall be a minimum of 200 lbs. (90 kg), allowing 50 lbs (23 kg) for District testing, 50 lbs. (23 kg) for Contractor testing, 50 lbs (23 kg) for dispute resolution testing, and 50 lbs. (23 kg backup for Department testing).

      2) QCP. A composite sample size shall be a minimum of 100 lbs. (45 kg), allowing 50 lbs. (23 kg) for District testing, and 50 lbs. (23 kg) for Contractor testing.

   c) Lab Sample.

      1) PFP. The minimum lab sample size of 50 lbs. (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.

      2) QCP. The minimum lab sample size of 50 lbs. (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.

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.

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

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Effective: April 1, 2008
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2) The metal buckets shall be filled with approximately 25% more HMA than will be removed from the void.

b) The bucket shall be dumped directly over the void.Illinois Department of Transportation

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

d) Unacceptable site repair shall be removed and replaced at the Contractors 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 HMA sample of 200 lbs (90 kg). See appendix for illustrations of various MTD sampling device configurations.

b) Sample Containers – Metal containers each capable of holding a minimum of 50 lbs. 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 lbs. (90 kg) of HMA for PFP or 100 lbs. (45 kg) for 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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Revised: October 1, 2017

1) PFP. If the contractor elects to have the option to dispute test results by the Engineer, a composite sample size shall be a minimum of 200 lbs. (90 kg), allowing 50 lbs (23 kg) for District testing, 50 lbs. (23 kg) for Contractor testing, 50 lbs (23 kg) for dispute resolution testing, and 50 lbs. (23 kg backup for Department testing).

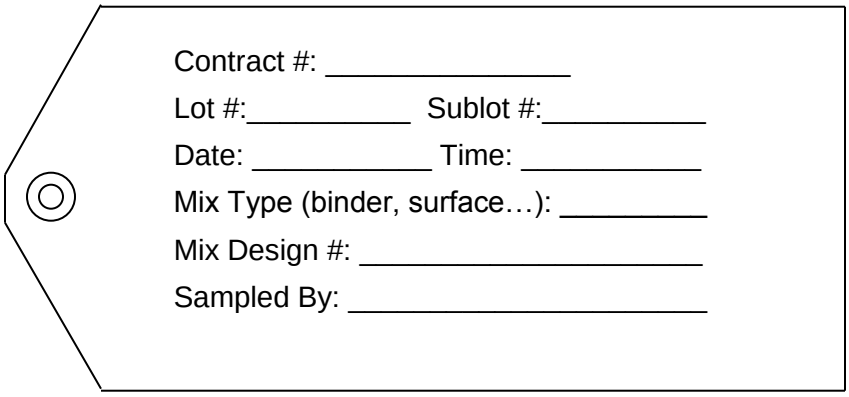
2) QCP. A composite sample size shall be a minimum of 100 lbs. (45 kg), allowing 50 lbs. (23 kg) for District testing, and 50 lbs. (23 kg) for Contractor testing.

b) Lab Sample.

1) PFP. The minimum lab sample size of 50 lbs. (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.

2) QCP. The minimum lab sample size of 50 lbs. (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.

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.



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, for testing within two days of sampling.

Illinois Department of Transportation

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

Effective: April 1, 2008
Revised: October 1, 2017

F. Examples:

1. Behind Paver Sampling. Determination of random sample location for behind 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 Gmb of 2.400 is being placed 12 feet wide and 1.5 inches thick. The Engineer has elected to determine 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. Ignore any random tonnages beyond what was placed on the project.

Sublot Number	Random Number	Sublot Tonnage	Cummulative 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 tons shall be the first sublot tested. The truck in question contains 160 to 172 cumulative tonnage 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 truck will pave using the following formula:

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

Illinois Department of Transportation

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

Effective: April 1, 2008
Revised: October 1, 2017

Where:

Longitudinal Distance = Random distance from starting station (ft)
Tons = total tons within the sample truck
RD = random distance value as calculated above
Gmb = design Gmb 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.

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

Illinois Department of Transportation

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

Effective: April 1, 2008
Revised: October 1, 2017




Illinois Department of Transportation

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

Effective: April 1, 2008
Revised: October 1, 2017

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

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

Effective: April 1, 2008
Revised: October 1, 2017

PFP Jobsite Sampling Location Determination

Date: ______________ Contract #: ______________ Route: ______________

Bit Mix #: ______________ Bit Code: ______________ Bit Desc.: ______________

Design Gmb: ______________ Pvt width(w): ______________ Pvt thickness(t): ______________

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

Begin Truck Tons (b):		Longitudinal Distance(d): *(d)=[384.6(q)(rd)] / [Gmb(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)] / [Gmb(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)] / [Gmb(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)] / [Gmb(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)*			

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.

Samples should be uniformly blended and then divided into sample sizes and properly identified. If following PFP Specifications, the 200 lbs. (90 kg) minimum composite sample shall be divided into four approximately equal size split samples of 50 lbs. (23 kg) each. The 50 lbs. (23 kg) samples shall be distributed as follows: 50 lbs. (23 kg) for District testing, 50 lbs. (23 kg) for Contractor testing, 50 lbs. (23 kg) for dispute resolution testing and 50 lbs. (23 kg) backup for Department testing. QCP requires a minimum composite sample of 100 lbs. (45 kg) and should be split into two approximately equal sample sizes of 50 lbs. (23 kg) each, one for District testing and one for Contractor testing. QC/QA requires a minimum composite sample of 150 lbs. (68 kg) and should be divided into two approximate equal sample sizes of 75 lbs. (34 kg) each, one for Contractor testing and one for District testing.

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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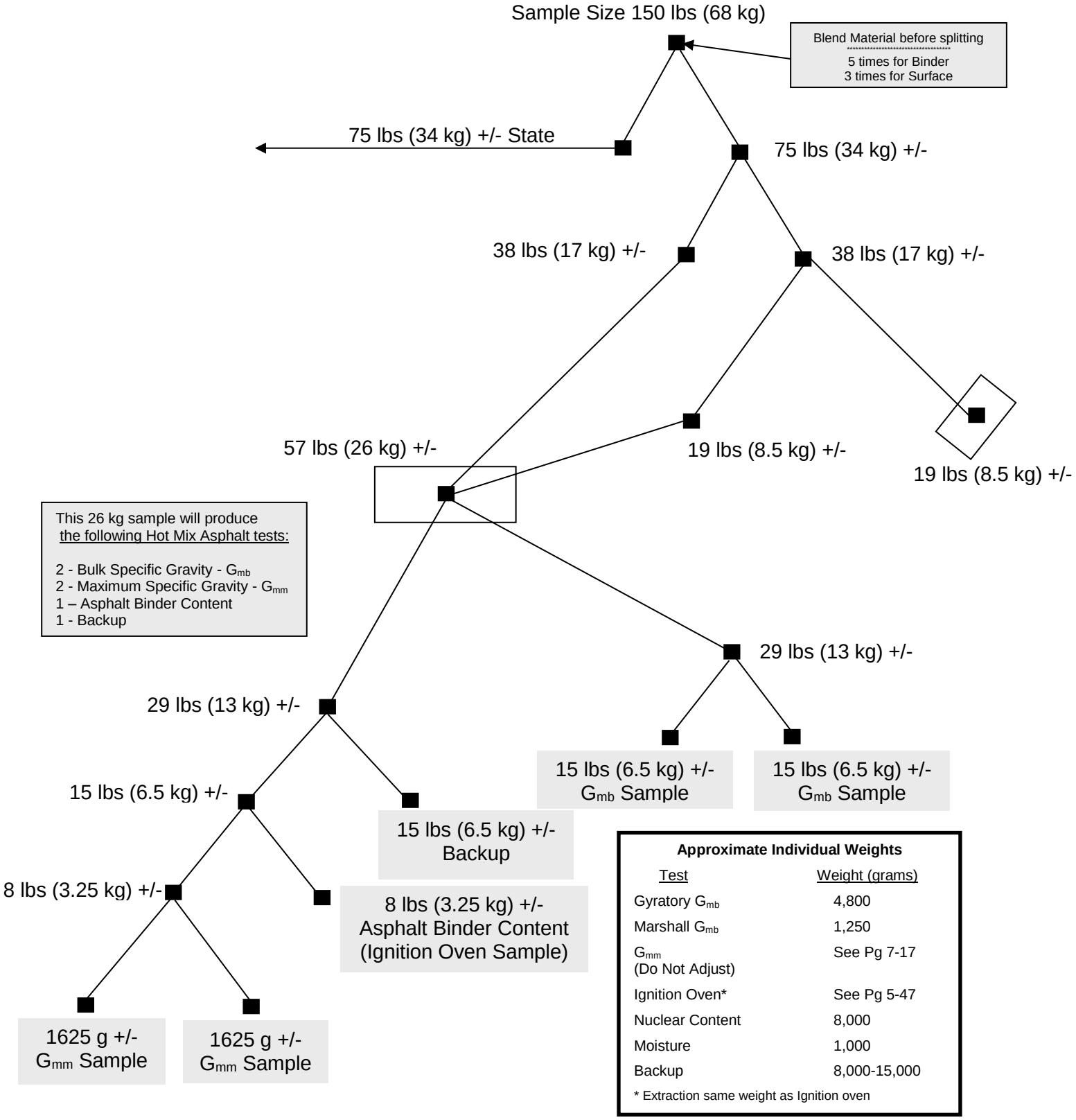
Sample Splitting Diagram

Note: All weights are approximate.



Approximate Individual Weights

Test	Weight (grams)
Gyratory G_{mb}	4,800
Marshall G_{mb}	1,250
G_{mm} (Do Not Adjust)	See Pg 7-17
Ignition Oven*	See Pg 5-47
Nuclear Content	8,000
Moisture	1,000
Backup	8,000-15,000

* Extraction same weight as Ignition oven

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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: May 1, 2007

Initial Daily Plant and Random Samples shall be obtained at the frequency specified in Section 1030 of the Standard Specifications.

A. Truck samples shall be taken of the mixture for testing. 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 150 lbs (70 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]).

B. After the sample has been obtained, it shall be divided into two approximately equal size (split) samples by the use of an approved mechanical sample splitter. One of the split samples shall be placed in a Department-approved sample container provided by the Contractor and shall be properly identified for use by the Department. These split samples shall be retained by the Contractor for assurance testing by the Engineer and may be disposed of only with the permission of the Engineer. The split samples shall be stored in a dry, protected location. The remaining split will be used for those tests described in Section 1030 of the Standard Specifications.

C. Starting with the first day of production (excluding start-up), the initial daily required plant sample shall be obtained between the first ½ to 1½ hours of daily production of a particular mixture. These daily plant test samples shall be tested for, but not limited to, the following:

1. Bulk Specific Gravity, G_{mb} (d)
2. Maximum Theoretical Gravity, G_{mm} (D)
3. Asphalt Binder Content
4. Aggregate Gradations
    a. Combined Belt
    b. Individual Cold-Feeds
    c. Hot-Bins
5. Total Dust Content of Mix from Ignition Oven or Solvent Extraction

Appendix B6
B37

Illinois Department of Transportation

Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples
Appendix B6
(continued)
Effective: May 1, 1993
Revised: May 1, 2007

D. The second daily required plant sample shall be taken at a randomly selected time within the third quarter of the anticipated production day using the "Random Numbers" table on the following page or the Department's QC/QA computer software. For HMA mixtures classified as “All Other” the Contractor shall use the anticipated full production day when calculating the random sampling time. The anticipated full production day shall be the time from a ½ hour after production begins to a ½ hour before production ends. The following procedure shall be used to calculate the second daily required plant 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 QC/QA computer 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.

Illinois Department of Transportation

Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples
Appendix B6
(continued)
Effective: May 1, 1993
Revised: May 1, 2007

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 for High ESAL and Low ESAL mixes:

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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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.

$$\left[\begin{array}{c}\text{uncorrected}\\ \text{AB content}\end{array}\right] = \frac{\text{weight of AB}}{\text{weight of mix}} = \frac{\text{wt. of mix before burn} - \text{wt. of agg. after burn}}{\text{wt. of mix before burn}}$$

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. / Sieve Size	#1	#2	#3	#4	#5	#6	Blend
25.4 (1)	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19.0 (3/4)	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12.5 (1/2)	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9.5 (3.8)	99.2	100.0	100.0	100.0	100.0	100.0	99.5
4.75 (#4)	33.9	100.0	99.0	100.0	100.0	100.0	57.0
2.36 (#8)	13.0	100.0	88.4	89.9	100.0	100.0	40.1
1.18 (#16)	4.5	100.0	74.4	55.5	100.0	100.0	26.8
600um (#30)	4.1	100.0	55.6	23.7	100.0	100.0	18.4
300um (#50)	3.7	100.0	20.0	8.3	100.0	100.0	10.0
150um (#100)	3.3	100.0	3.0	3.4	99.0	100.0	6.2
75um (#200)	2.8	100.0	1.0	1.8	88.0	100.0	5.0

	Specifications		FORMULA	FORMULA RANGE	
	Min	Max		Min	Max
25.4 (1)	--	--	100	100	100
19.0 (3/4)		100	100	100	100
12.5 (1/2)	90	100	100	94	106
9.5 (3.8)		90	99	--	--
4.75 (#4)	24	65	57	52	62
2.36 (#8)	16	40	40	35	45
1.18 (#16)	10	32	27	27	27
600um (#30)	--	--	18	--	--
300um (#50)	4	16	10	6	14
150um (#100)	3	10	6	6	6
75um (#200)	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 (Gmb)	SPEC GR (Gmm)	TOT MIX (Pa)	VMA	FILLED	AC, VOL	AC, % WT	Gse	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:								

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 $\pm$ 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.

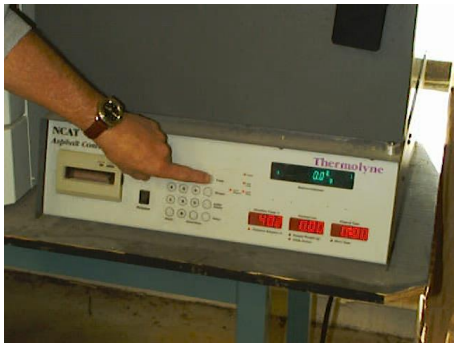
(l) Open the chamber door, remove the sample baskets, and allow cooling to room temperature (approximately 30 minutes).

(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 9.1).** 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:

$$AB = \frac{Wb - Wa}{Wb} \times 100 - \text{Temp. Comp.} - Mc - Cf$$

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:

$$AB = \frac{1310 - 1238}{1310} \times 100 - 0.09 - 0.10 - \_\_\_\_\_$$

(Temp. Comp. = 0.09; Mc = 0.10; Cf = _____)

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) **Mixture Calibration For Gilson**.

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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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).

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:

	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.

Hot-Mix Asphalt Mix Design
Procedure for Dust Correction Factor Determination
Appendix B.12

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.

Hot-Mix Asphalt Mix Design
Procedure for Dust Correction Factor Determination
Appendix B.12

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

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

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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Calibration of Equipment for Asphalt Binder Content Determination (Nuclear Gauge and Ignition Oven) Appendix B.11

Effective Date: January 1, 2002
Revised: January 1, 2016

A. Scope

The Contractor may be required to use the nuclear gauge or ignition oven to determine the asphalt binder content of a Hot-Mix Asphalt (HMA) mixture. To ensure consistency, both the Contractor and the Department shall calibrate the device(s) in the same manner using the same mixture.

B. Purpose

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 used for Quality Control, Quality Assurance, Independent Assurance, or Acceptance testing.

C. Nuclear Asphalt Content Gauge

1. Department Verification

   a. All HMA mixture designs shall be verified in accordance with the Department's "Hot-Mix Asphalt 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, "Hot-Mix Asphalt Design Procedure". All testing shall be performed by Hot-Mix Asphalt Level I Technicians or higher.

   c. At the option of the Department, previously verified mixtures may be accepted by reviewing the data listed in Section 11 of Illinois Modified AASHTO T 287, and provided a dry aggregate standard count is within ± 1.0% of the calibration aggregate count as outlined in Section 10.2 of Illinois Modified AASHTO T 287.

   d. Testing shall include, at the option of the Engineer, one or both of the following test procedures:

      (1) The District has the option of witnessing the Contractor's calibration procedures as outlined in Section 7 of Illinois Modified AASHTO T 287.

After the Contractor has calibrated his/her nuclear asphalt binder content gauge, the calibration pans shall be covered with plastic bags (to prevent the introduction of moisture) and given to the Department's representative. At the Department's option, the Department will perform an extraction for asphalt binder content determination on the Contractor's sample.

Also at the Department's option, the Department will calibrate its nuclear asphalt binder content gauge, by preparing the HMA mix using the prescribed quantities of the ingredient aggregates, asphalt binder, and other ingredient materials provided by the Contractor.

(2) Prior to calibrating the nuclear asphalt binder content gauge, the Contractor shall submit the following to the District office at least 2 weeks prior to production:

- 3 empty nuclear asphalt pans
- 22 lbs (10 kg) of the HMA mixture at the design optimum asphalt binder content
- 22 lbs (10 kg) of the HMA mixture at 1% below the optimum asphalt binder content
- 22 lbs (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 Engineer may split out approximately 16.5-lb (7500-g) and/or 4.4-lb (2000-g) samples out of the 22 lb (10 kg) mixture samples. The 16.5-lb (7500-g) samples shall be used in the calibration pans for both the Department and the Contractor. The 4.4-lb (2000-g) samples may be used by the Department to run extractions on the samples for verification. The extraction results shall be within the following tolerances:

Sieve	Tolerance
12.5 mm (1/2 in.)	± 3.0
4.75 mm (No. 4)	± 2.0
2.36 mm (No. 8)	± 1.5
600 µm (No. 30)	± 1.0
75 µm (No. 200)	± 0.5
Pb (Asphalt Content)	± 0.15

If the extraction results lie outside the above tolerances Contractor shall be required to resubmit new material as outlined above for this procedure.

The Engineer will calibrate the Department's nuclear asphalt binder content gauges using the pans and mixture the Contractor submitted. The calibration pans will be covered with plastic bags (to prevent the introduction of moisture) and sent to the Contractor. This shall be done for all 3 points.

The Contractor shall calibrate his/her nuclear asphalt binder content gauges, with the same calibrations pans as the Department used, within 24 hours of receiving the samples from the Department.

2. Calibration

a. The Contractor shall calibrate his/her nuclear asphalt binder content gauge only after the Department has verified the calibration samples as outlined above in Section C.1.

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

   a. All HMA mixture designs shall be verified in accordance with the Department's "Hot-Mix Asphalt Design Verification Procedure" before submitting materials for the ignition oven calibration.

   b. The Contractor shall provide a mix design prepared by an Hot-Mix Asphalt Level III Technician in accordance with the Department's current Hot-Mix Asphalt Level III Technician Course Manual, "Hot-Mix Asphalt Design Procedure". All testing shall be performed by Hot-Mix Asphalt Level I Technicians or higher who have also successfully completed the Superpave Field Control Course.

   c. Calibrations shall consist of, at the option of the Engineer, one or both of the following procedures:

      (1) The District has the option to witness the mixing and burning of the calibration sample. The Contractor shall provide enough aggregate, asphalt binder, and other ingredient materials to the Department so that the Department can blend and mix their own calibration samples.

      (2) The Contractor shall submit the following to the District office 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 5.6 of Illinois Modified AASHTO T308.

      - 1 L (1 qt.) asphalt binder

      Two 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 samples.

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised: January 1, 2017

Standard Method of Test
For
Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method

Reference AASHTO T 308-16

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) Replace AASHTO Standards T 2 and T 248 with the following: • Illinois Test Procedure 2 • Illinois Test Procedure 248
5.1	Revise the second sentence as follows: The convection-type furnace must be capable of maintaining a temperature of 482 ± 5°C (900 ± 9°F)
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.
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 samples after ignition.
6.2	Add the following: A sample of 1 kg, minimum, shall be split out to determine the moisture content.
7.1.1	Revise the first sentence as follows: For the Convection-type furnace, preheat the ignition furnace to 482°C (900°F).

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised: January 1, 2017

Standard Method of Test
For
Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method

Reference AASHTO T 308-16

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: $\%\ \text{Moisture Content } (M_c) = \frac{(\text{Original Sample Mass}) - (\text{Constant Mass})}{\text{Constant Mass}} \times 100$
8.1	Replace with the following: Preheat the ignition furnace to 482 °C (900 °F)

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised: January 1, 2017

Standard Method of Test
For
Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method

Reference AASHTO T 308-16

AASHTO ***Section***	***Illinois Modification***
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. Moisture content is determined as follows: $\%\ \text{Moisture Content } (M_c) = \frac{(\text{Original Sample Mass}) - (\text{Constant Mass})}{\text{Constant Mass}} \times 100$
8.7	Revise the second sentence with the following: Burn the HMA sample in the furnace for a least 60 minutes.
8.7 NOTE 7	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

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised: January 1, 2017

Standard Method of Test
For
Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method

Reference AASHTO T 308-16

AASHTO ***Section***	***Illinois Modification***
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.
10.1.8 New Section	All rounding shall be according to ASTM E 29 (Illinois Modified).
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.
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 Hot Mix Asphalt (HMA) by the Ignition Method

AASHTO Designation: T 308-16

Technical Section: 2c, Asphalt–Aggregate Mixtures

Release: Group 3 (August 2016)

1. SCOPE

1.1. This test method covers the determination of asphalt binder content of hot mix asphalt (HMA) 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.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 231, Weighing Devices Used in the Testing of Materials
- R 47, Reducing Samples of Hot Mix Asphalt (HMA) to Testing Size
- R 66, Sampling Asphalt Materials
- R 76, Reducing Samples of Aggregate to Testing Size
- T 2, Sampling of Aggregates
- T 30, Mechanical Analysis of Extracted Aggregate
- T 168, Sampling Bituminous Paving Mixtures
- T 329, Moisture Content of Asphalt Mixtures by Oven Method

2.2. *ASTM Standard*:

- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

2.3. *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 HMA 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 HMA 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 HMA. 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 HMA 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.

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 1—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).

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 HMA in accordance with T 168.

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 HMA 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 2—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. Oven dry the HMA specimen to a constant mass at a temperature of 110 ± 5°C (230 ± 9°F), or determine the moisture content of a companion specimen according to T 329.

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. 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 3—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.

7.9. Initiate the test by pressing the start/stop button. This operation will lock the specimen chamber and start the combustion blower.

Note 4—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.

7.10. 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 5—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.

7.11. 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).

7.12. 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).

7.13. 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 6—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. Oven dry the HMA specimen to a constant mass at a temperature of 110 ± 5°C (230 ± 9°F), or determine the moisture content of a companion specimen according to T 329.

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 HMA specimen in the furnace for at least 45 min.

Note 7—The appropriate time for the initial burn of an HMA 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 8—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:

$$P_b, \% = \left[\frac{\left(M_i - M_f \right)}{M_i} \times 100 \right] - C_F - MC \qquad (1)$$

where:

P_b = the measured (corrected) asphalt binder content, percent;
M_i = the total mass of the HMA 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 HMA specimen; and
MC = the moisture content of the companion HMA 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 flat pan, 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 9—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 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 content (%)	0.069	0.196
Multilaboratory precision		
Asphalt content (%)	0.117	0.330

[a] These values represent the 1s and d2s limits described in ASTM C670.

Note 10—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 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 11—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 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; hot mix asphalt; 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 T 2. 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 HMA.

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 HMA 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 HMA 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

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: January 1, 2017

Standard Method of Test
for
Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)

Reference AASHTO T 164-14 (ASTM D 2172 / D 2172M-11)

AASHTO Section	*Illinois Modification*
2.1	Replace AASHTO Standard T 84 with the following: • Illinois Test Procedure 84
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 or E. The asphalt binder content is calculated by differences from the mass of the extracted aggregate and moisture content, and mineral matter (when using centrifuge extraction from Test Method A) in the extract. 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 or B shall be used for quantitative determinations of asphalt binder in HMA mixtures and pavement samples for specification acceptance, service evaluation, quality control, and research.
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.
10.1	Replace with the following: When required, calculate the moisture content of the mixture. Moisture content in the sample is defined as follows: $\frac{\text{Original Mass} - \text{Oven Dry Mass}}{\text{Original Mass}} \times 100$
Note 9	Delete

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: January 1, 2017

Standard Method of Test
for
Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)

Reference AASHTO T 164-14 (ASTM D 2172 / D 2172M-11)

AASHTO Section	***Illinois Modification***
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	Replace the second sentence with the following: 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 or E 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, % = $\frac{\text{Sample Mass, Dry} - \text{Aggregate Mass, Dry}}{\text{Sample Mass, Dry}}$ x 100

Illinois Modified Test Procedure
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 164-14 (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 and fourth sentences.
27.1	Delete the last sentence.
27.2	Delete the last sentence.

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: January 1, 2017

Standard Method of Test
for
Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)

Reference AASHTO T 164-14 (ASTM D 2172 / D 2172M-11)

AASHTO Section	***Illinois Modification***
A1.2.2.1	Replace the third sentence with: Transfer all of the extract (from Method A, B, or E as appropriate) to an appropriate (feed) container suitably equipped with a feed control (valve or clamp, etc.).

Standard Method of Test for

Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)

AASHTO Designation: T 164-14[1]

Technical Section: 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.

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 231, Weighing Devices Used in the Testing of Materials
- R 16, Regulatory Information for Chemicals Used in AASHTO Tests
- R 59, Recovery of Asphalt Binder from Solution by Abson Method
- 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 168, Sampling Bituminous Paving Mixtures
- 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)

- 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

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.

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.

6.2. *Oven*—Capable of maintaining the temperature at 149 to 163°C (300 to 325°F), for drying the sample if the moisture content is not determined.

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 3) 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 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 3).

Note 3—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 4—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 R 16. 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 T 168.

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 5).

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 5—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 7), 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 6—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	42.9	1 11/16	155.6	6 1/8
1.6	1/16	44.5	1 3/4	157.2	6 3/16
2.0	5/64	47.6	1 7/8	158.8	6 1/4
3.2	1/8	50.8	2	163.5	6 7/16
4.0	5/32	55.6	2 3/16	165.1	6 1/2
4.8	3/16	56.4	2 7/32	187.3	7 3/8
5.6	7/32	57.2	2 1/4	203.2	8
6.4	1/4	58.7	2 5/16	247.7	9 3/4
7.9	5/16	63.5	2 1/2	254.0	10
9.5	3/8	66.7	2 5/8	257.2	10 1/8
12.7	1/2	71.4	2 13/16	260.4	10 1/4
15.9	5/8	76.2	3	279.4	11
19.1	3/4	88.9	3 1/2	304.8	12
25.4	1	95.3	3 3/4	320.7	12 5/8
28.6	1 1/8	101.6	4	330.2	13
30.2	1 3/16	108.0	4 1/4	342.9	13 1/2
35.7	1 13/32	127.0	5	355.6	14
38.1	1 1/2	138.1	5 7/16	368.3	14 1/2
40.5	1 19/32	149.2	5 7/8	384.2	15 1/8
41.3	1 5/8	152.4	6	393.7	15 1/2
47.6	1 7/8	154.8	6 3/32	406.4	16

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 7—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:

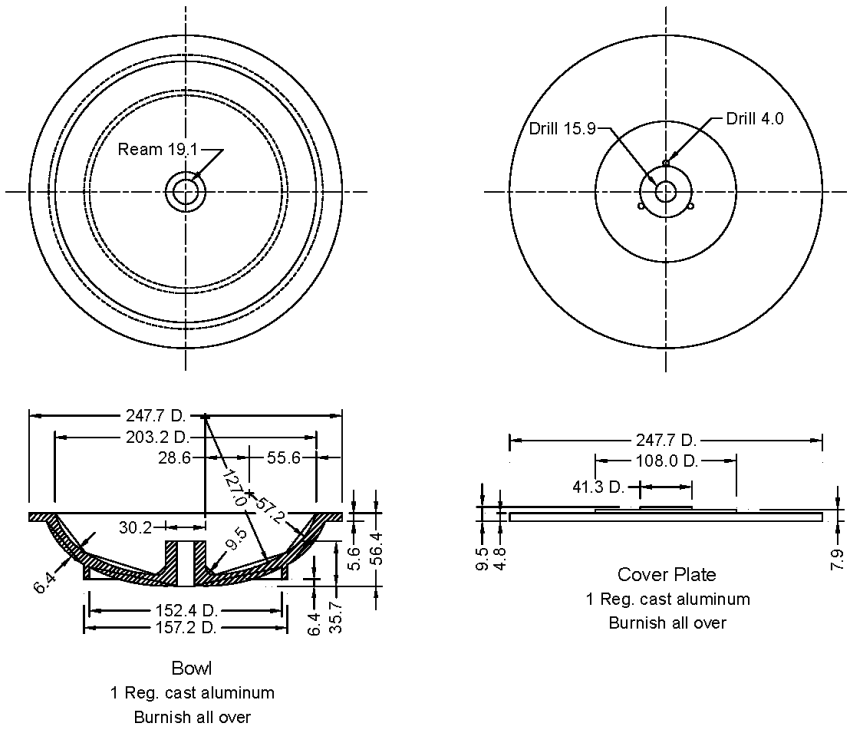
11.1.1. *Extraction Apparatus*—Consisting of a bowl approximating that shown in Figure 1 and an apparatus in which the bowl may be revolved at controlled variable speeds up to 3600 r/min. The speed may be controlled manually or with a preset speed control. The apparatus should be provided with a container 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 8—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 9—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 10 and 11). 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 10—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 11—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 12—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 13—When ashless filter rings are not used, add the increase in mass of the felt ring to W_4.

Note 14—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 15) 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 15—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 9).

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.

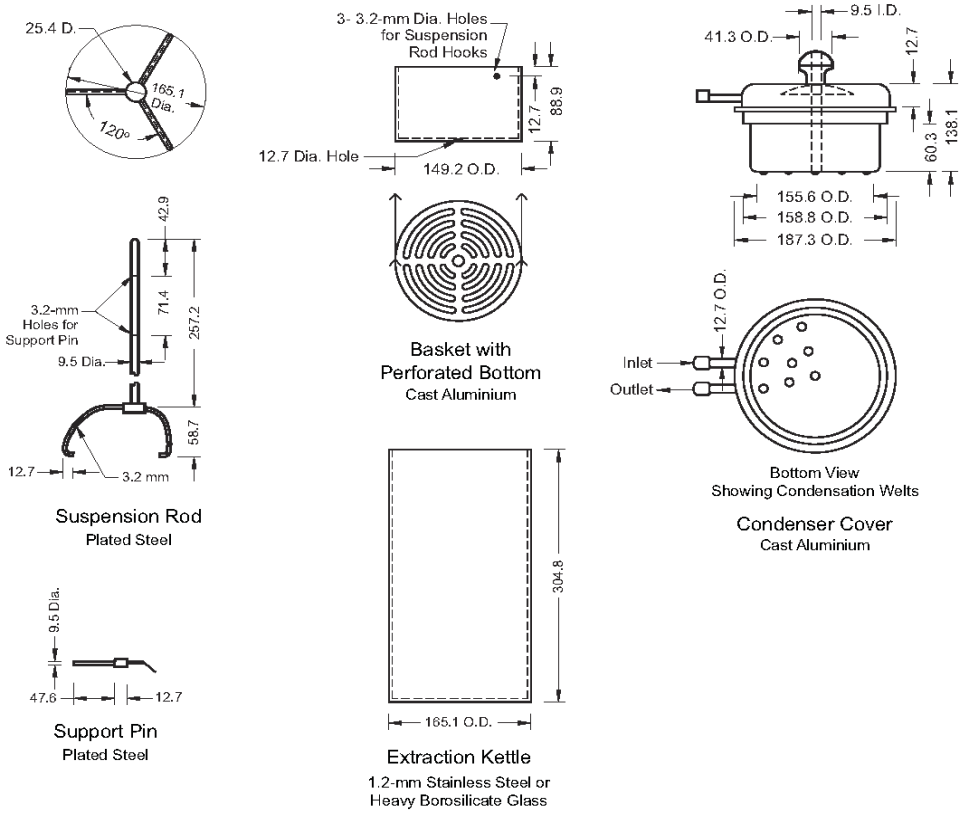
TEST METHOD D

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 8).

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

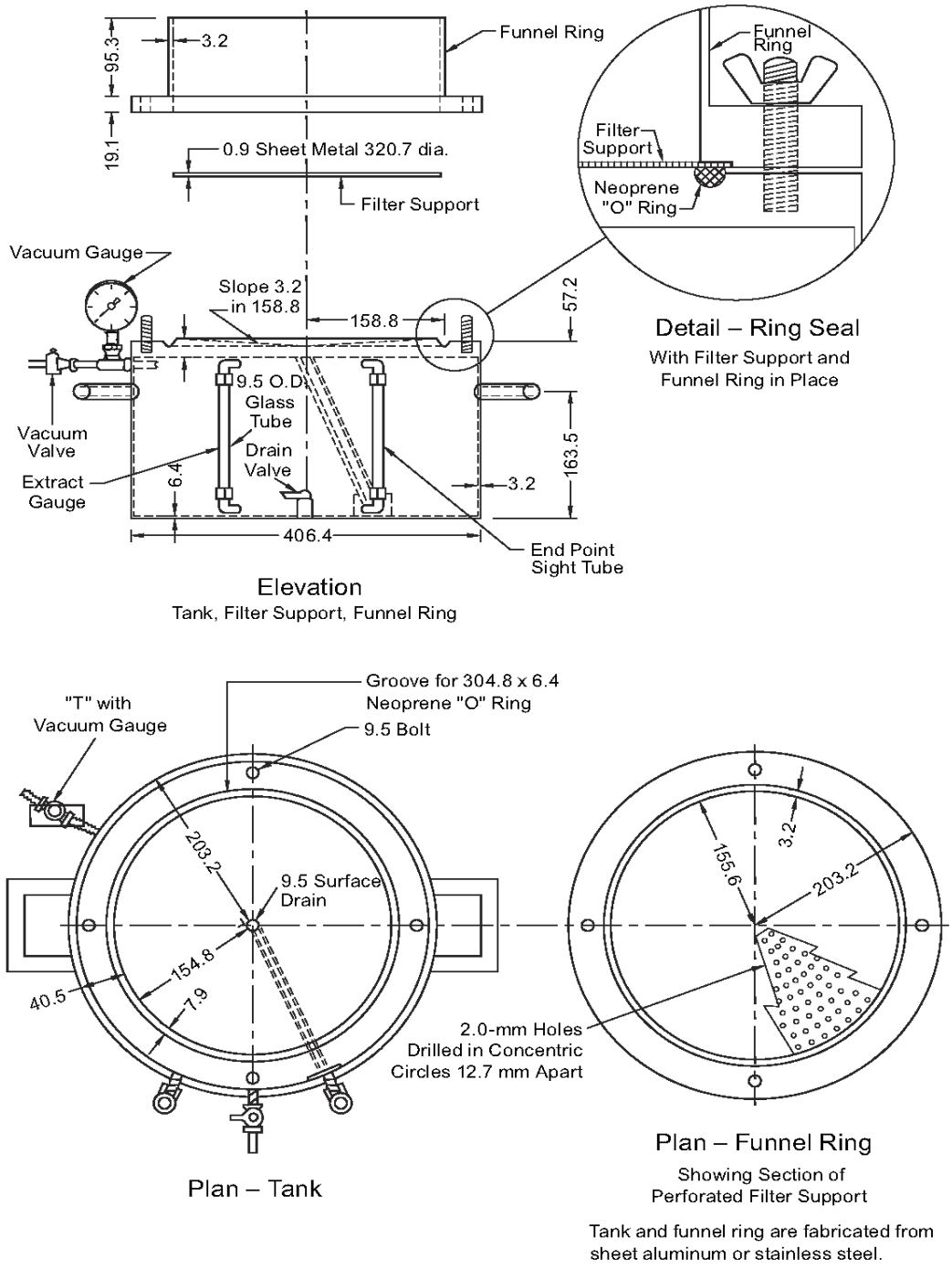
22. APPARATUS

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.

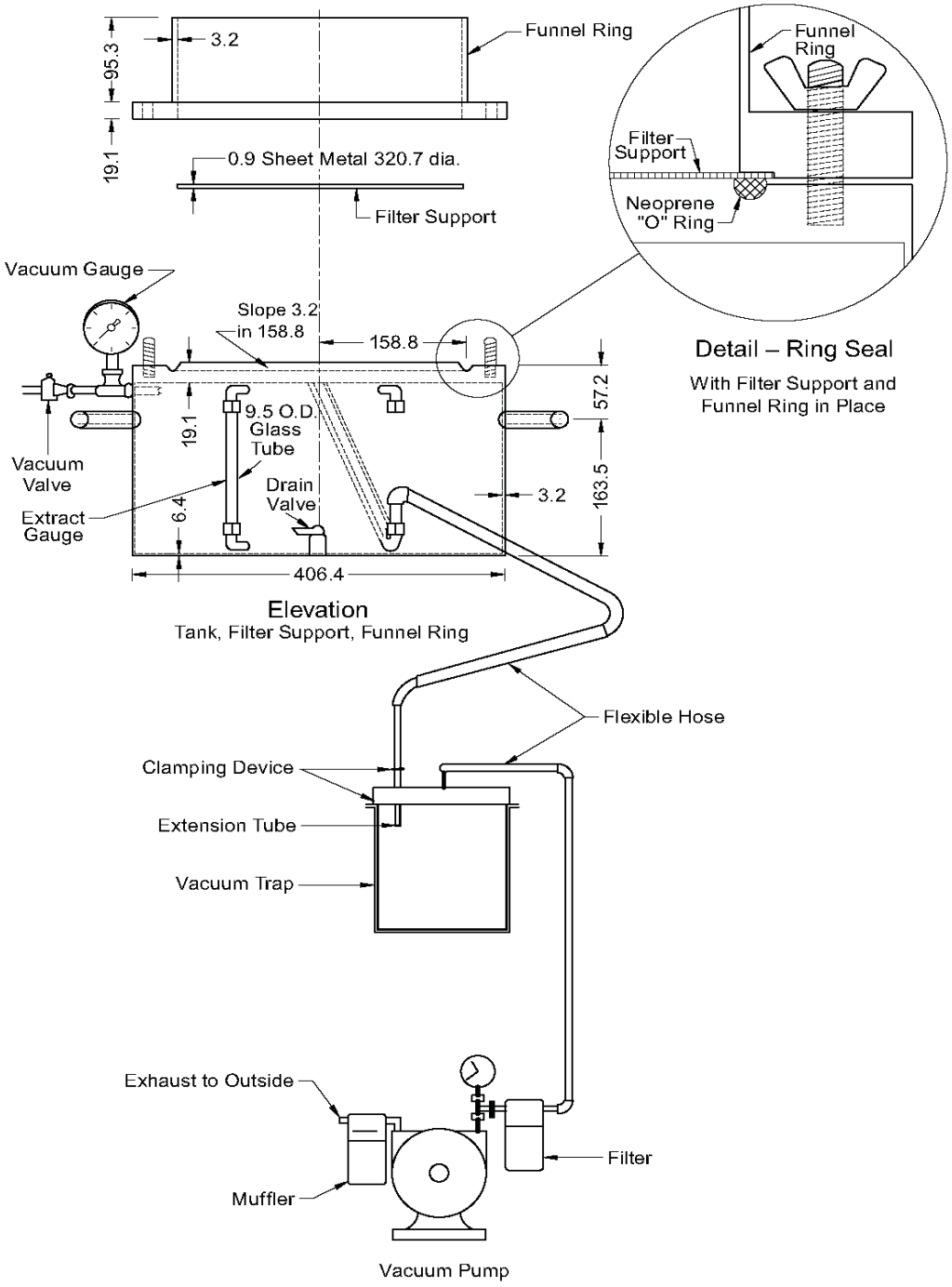
Table 3—Dimensional Equivalents

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		



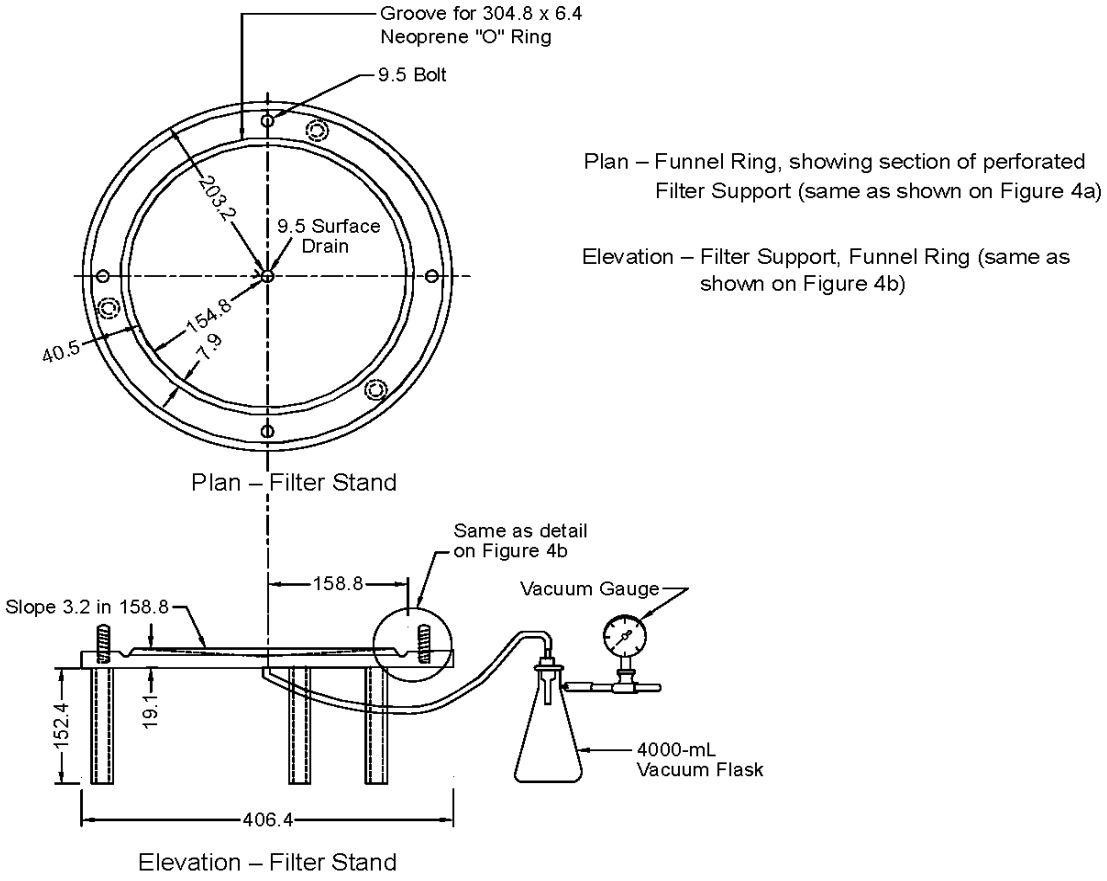
Note: See Table 3 for dimensional equivalents. All dimensions shown in millimeters unless otherwise noted.

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 16—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 17).

Note 17—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 18).

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 18). Add approximately 700 mL of extractant, and stir until the asphalt binder is visually in solution (Note 19).

Note 18—Alcohol should not be needed with terpene extractants.

Note 19—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 20).

Note 20—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).

25.2.7. Dry the extracted aggregate and filter to a constant mass in an oven at 110 ± 5°C (230 ± 9°F) (Note 21).

Note 21—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 22).

Note 22—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 20).

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 23).

Note 23—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 24). 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 24—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 22).

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 25 and 26).

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 25 and 26).

Note 25—These numbers represent, respectively, the (1s) and (d2s) limits as described in ASTM C670.

Note 26—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.

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:

$$W_4 = G\,(W_1/100) \qquad (A1.1)$$

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.

Note A1—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.

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:

$$W_4 = K\left(M_2 - G_3 V_1\right) \qquad (A1.3)$$

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.

This Page Is Reserved

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: January 1, 2017

Standard Method of Test
for
Mechanical Analysis of Extracted Aggregate

Reference AASHTO T 30-15

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 Test Procedure 255 Replace AASHTO Standard T 308 with the following: • Illinois Modified AASHTO T 308
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.

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Standard Method of Test for

Mechanical Analysis of Extracted Aggregate

AASHTO Designation: T 30-15

AASHTO

Technical Section: 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.

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 Hot Mix Asphalt (HMA)
- T 255, Total Evaporable Moisture Content of Aggregate by Drying
- T 308, Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method

2.2. *ASTM Standards*:

- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- E11-15, 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 2, 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 Section 7.6. 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 Section 7.7.

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 exceed a mass of 7 kg/m^2 (4 g/in.^{2}) retained per sieving surface on any sieve with openings smaller than 4.75 mm (No. 4) at the completion of the sieving operation (Note 7). Do not exceed a mass in kg of the product of 2.5 × (sieve opening in mm) × (the effective or clear sieving surface area, m^2) for sieves with openings 4.75 mm (No. 4) and larger. For sieves with openings 4.75 mm (No. 4) and larger, this mass is shown in Table 1 for five sieve-frame dimensions in common use. Do not cause permanent deformation of the sieve cloth due to overloading.

Note 7—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.)]. 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.

Table 1—Maximum Allowable Mass of Material Retained on a Sieve, kg

Sieve Opening Size	Nominal Dimensions of Sieve[a]				
	203.2 mm, dia[b]	254 mm, dia[b]	304.8 mm, dia[b]	350 by 350, mm	372 by 580, mm
	Sieving Area, m^2				
	0.0285	0.0457	0.0670	0.1225	0.2158
125 mm (5 in.)	[c]	[c]	[c]	[c]	67.4
100 mm (4 in.)	[c]	[c]	[c]	30.6	53.9
90 mm (3$^1/_2$ in.)	[c]	[c]	15.1	27.6	48.5
75 mm (3 in.)	[c]	8.6	12.6	23.0	40.5
63 mm (2$^1/_2$ in.)	[c]	7.2	10.6	19.3	34.0
50 mm (2 in.)	3.6	5.7	8.4	15.3	27.0
37.5 mm (1$^1/_2$ in.)	2.7	4.3	6.3	11.5	20.2
25.0 mm (1 in.)	1.8	2.9	4.2	7.7	13.5
19.0 mm ($^3/_4$ in.)	1.4	2.2	3.2	5.8	10.2
12.5 mm ($^1/_2$ in.)	0.89	1.4	2.1	3.8	6.7
9.5 mm ($^3/_8$ in.)	0.67	1.1	1.6	2.9	5.1
4.75 mm (No. 4)	0.33	0.54	0.80	1.5	2.6

[a] Sieve-frame dimensions in inch units: 8.0-in. diameter; 10.0-in. diameter; 12.0-in. diameter; 13.8 by 13.8 in. (14 by 14 in. nominal); 14.6 by 22.8 in. (16 by 24 in. nominal).

[b] The sieve area for round sieves is based on an effective or clear 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.).

[c] Sieves indicated have less than five full openings and should not be used for sieve testing.

7.7. Continue sieving for a sufficient period and in such manner that, after completion, not more than 0.5 percent by mass of the total sample passes any sieve during 60 s of continuous hand-sieving performed as follows: Hold the individual sieve, provided with a snug-fitting pan and cover, in a slightly inclined position in one hand. Strike the side of the sieve sharply 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. In determining the adequacy of sieving for sizes larger than the 4.75-mm (No. 4) sieve, limit the material on the sieve to a single layer of particles. 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.

8. CALCULATIONS

8.1. 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. 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, in order to obtain the total passing the 75-µm (No. 200) sieve. Convert the masses of fractions retained on the various sieves and the total passing the 75-µm (No. 200) sieve to percentages 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 2. 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 2—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.

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).

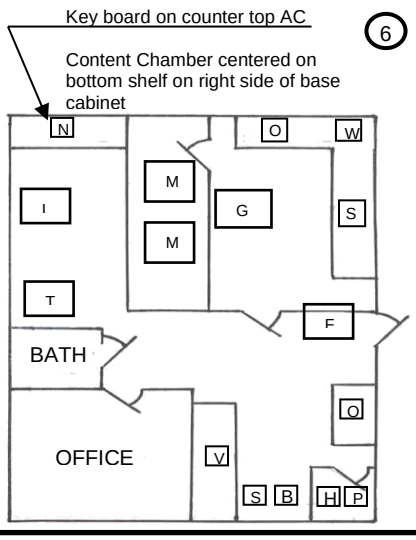
AB Content Gauge Lab Diary

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.



Diary Example of Background Counts of AB Content Gauge:

BACKGROUND COUNTS					
Date	**Count**	**Ave.**	**Toler.**	**Time**	**Initials**
6/08/10	2422			5:00 a	JMH
"	2413			5:16 a	JMH
"	2398			5:32 a	JMH
"	2385			5:48 a	JMH
6/09/10	2412			6:15 a	JMH
6/10/10	2392			5:19 a	JMH
6/11/10	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**
6/01/10	2489	0.51	1 min.	JMH
6/14/10	2472	0.47	1 min.	JMH
6/15/10	2479	0.54	1 min.	JMH
6/22/10	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 5-99)

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
Sieve Size							
25.4 (1)	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19.0 (3/4)	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12.5 (1/2)	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9.5 (3.8)	99.2	100.0	100.0	100.0	100.0	100.0	99.5
4.75 (#4)	33.9	100.0	99.0	100.0	100.0	100.0	57.0
2.36 (#8)	13.0	100.0	88.4	89.9	100.0	100.0	40.1
1.18 (#16)	4.5	100.0	74.4	55.5	100.0	100.0	26.8
600um (#30)	4.1	100.0	55.6	23.7	100.0	100.0	18.4
300um (#50)	3.7	100.0	20.0	8.3	100.0	100.0	10.0
150um (#100)	3.3	100.0	3.0	3.4	99.0	100.0	6.2
75um (#200)	2.8	100.0	1.0	1.8	88.0	100.0	5.0

Specifications		FORMULA	FORMULA RANGE	
Min	Max		Min	Max
--	--	100	100	100
	100	100	100	100
90	100	100	94	106
	90	99	--	--
24	65	57	52	62
16	40	40	35	45
10	32	27	27	27
--	--	18	--	--
4	16	10	6	14
3	10	6	6	6
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	SPEC GR	TOT MIX	VMA	FILLED	AC, VOL	AC, % WT	Gse	AC, % WT
		(Gmb)	(Gmm)	(Pa)						
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	(Gmb)	(Gmm)	(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.
6/16/16	918-01	7134	19514	7055g/2466	230°F/0.998	3.384	-7.110	3.2/2698	4.2/2933	5.2/3218	1
6/16/16	918-01	7135	19523	6998g/2511	230°F/1.000	4.454	+2.760	3.0/2638	4.0/2868	5.0/3088	2
6/22/16	918-01	7136	19533	6875g/2841	230°F/0.999	3.446	-5.980	4.6/3052	5.6/3342	6.6/3629	3
6/22/16	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 5-102)

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.**

Date:

FIGURE 5.3

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**

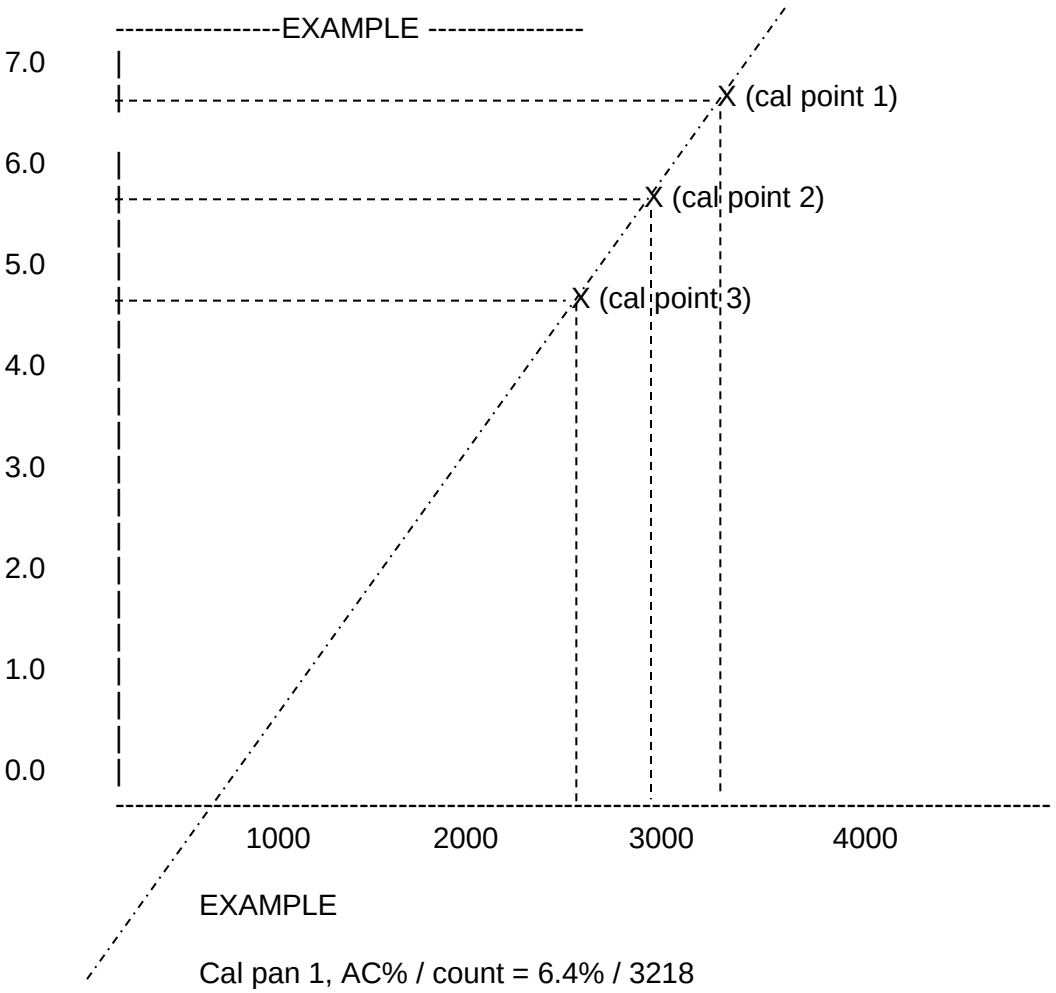
Aggregate No. / Sieve Size	#1	#2	#3	#4	#5	#6	Blend	Specifications Min	Specifications Max	FORMULA	FORMULA RANGE Min	FORMULA RANGE Max
25.4 (1)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	--	--	100	100	100
19.0 (3/4)	100.0	100.0	100.0	100.0	100.0	100.0	100.0		100	100	100	100
12.5 (1/2)	100.0	100.0	100.0	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	EFFECTIVE AC, % WT	ABORPTION 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.

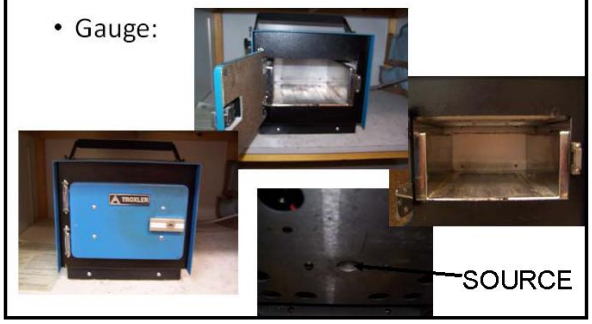
Nuclear Asphalt Content Gauge

Purpose of Test

- Asphalt Content.
- Does not give any other test result.

Equipment

- Gauge:

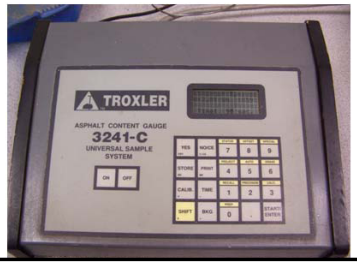


Equipment

- Americium/Beryllium or other neutron emitting source.
- Electronic detectors
- Microprocessor capable of a 3-point calibration

Equipment

- Readout instrument calibrated in % asphalt.



Equipment

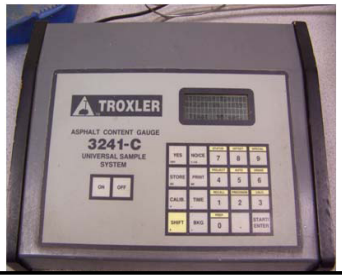
- 6 Gauge pans

Equipment

- Americium/Beryllium or other neutron emitting source.
- Electronic detectors
- Microprocessor capable of a 3-point calibration

Equipment

- Readout instrument calibrated in % asphalt.

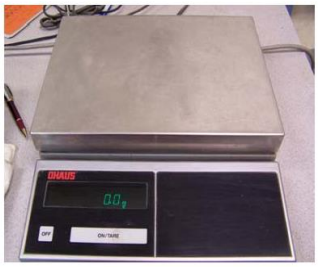


Equipment

- 6 Gauge pans

Equipment

- Electronic Balance capable of weighing to 12 kg (26.5 lbs.) readable to 1.0 g



Equipment

- Power vented oven capable of heating to 350º ± 5º F.

Equipment

- Straight edge, steel, approximately 0.5m (18 in.) in length
- Plywood 19 mm (3/4 in.) minimum thickness, or metal plate 10 mm (3/8 in.) minimum thickness
- Assorted spoons, scoops and mixing bowls
- Metal stemmed thermometers with a temperature range 50º-500º F, readable to 5º F.

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:

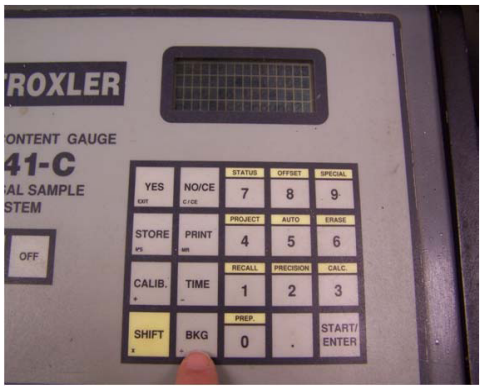
(1) Let the gauge warm up for ten minutes.

(2) Obtain background count:

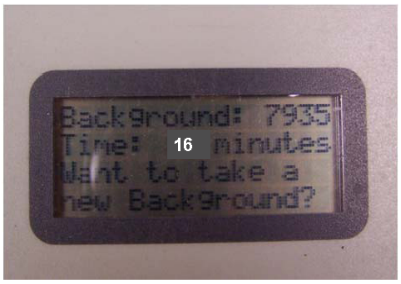
(a) Measured count on an empty drawer (16 minutes):

- Daily when in use.
- If the gauge is moved.
- When results appear wrong.

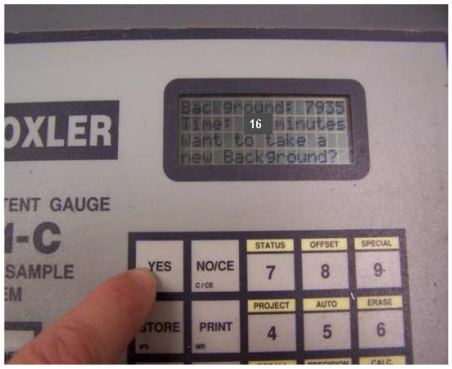
Background Count



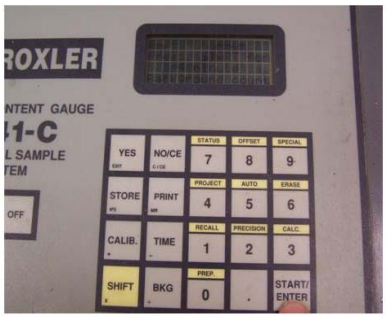
Background Count



Background Count



Background Count



(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).

BACKGROUND COUNTS

Date	Count	Ave.	Toler.	Time	Initials
6/08/10	2422				
	2413				
	2398				
	2385	2405	±12	5:48 a	JMH
6/09/10	2412	2402	±12	6:15 a	JMH
6/10/10	2392	2397	±12	5:19 a	JMH
6/11/10	2386	2394	±12	6:04 a	JMH

7
10
11

Background Counts

1) Daily when in use.
2) If the gauge is moved.
3) When results appear wrong.

JMH – Joseph M. Helms

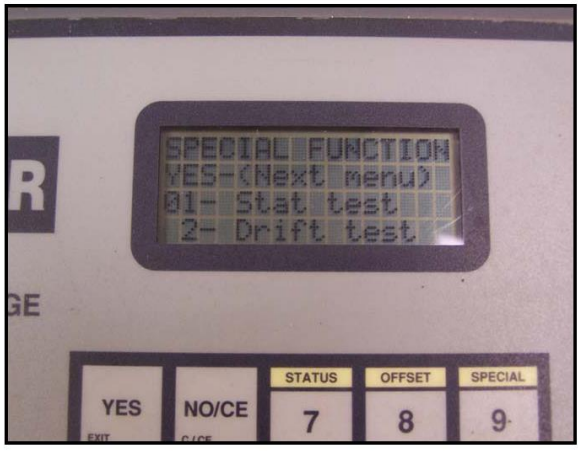
* See Page 6 for exact location of gauge

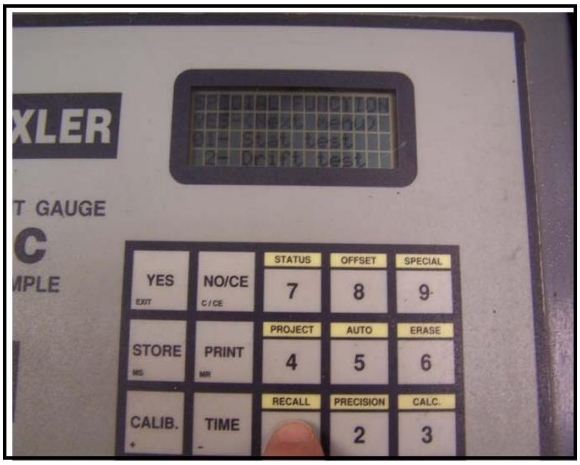
(3) Statistical analysis:

(a) One per week (when the gauge is in use).

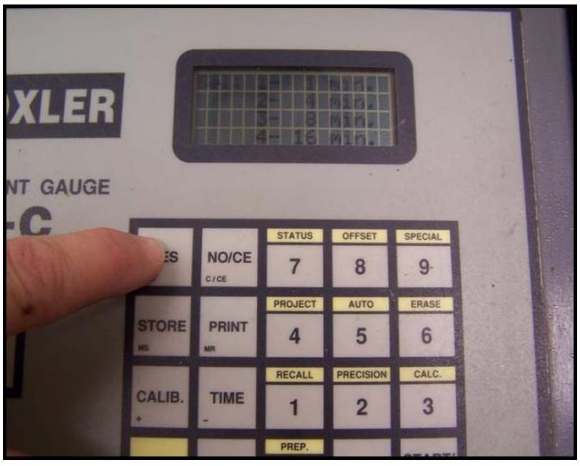
(b) When the gauge has been transported by vehicle.

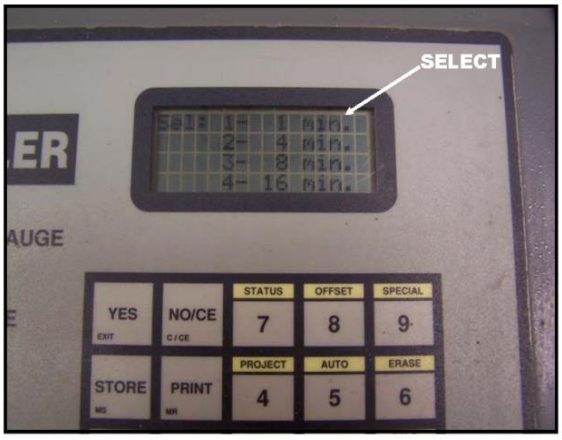
(c) When results appear wrong.

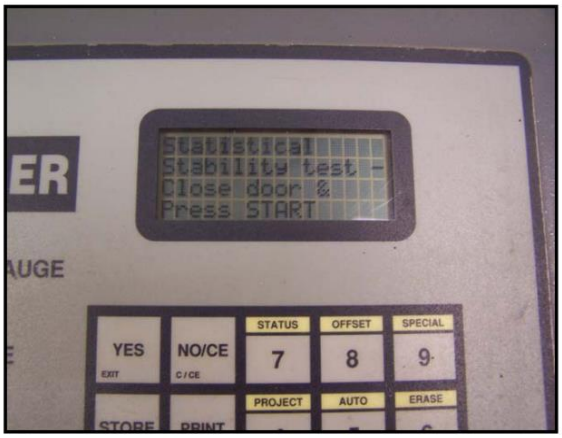


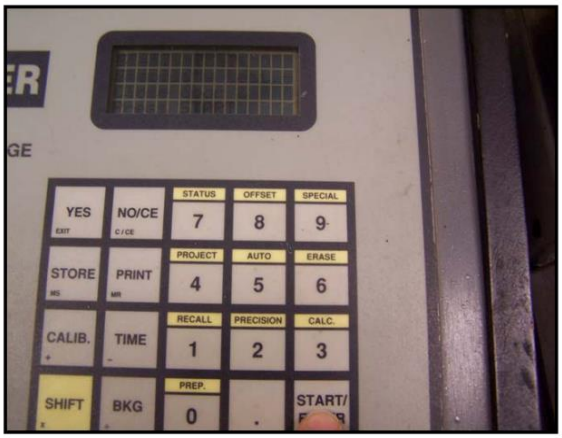

XLER
T GAUGE
C
MPLE
YES
EXIT
NO/CE
C/CE
STATUS
OFFSET
SPECIAL
7
8
9
STORE
PRINT
PROJECT
AUTO
ERASE
4
5
6
CALIB.
TIME
RECALL
PRECISION
CALC.
2
3


- STAT TEST -
Time: 4 min.
Do you want
to change?
ER
UGE
YES
EXIT
NO/CE
C/CE
STATUS
OFFSET
SPECIAL
7
8
9


XLER
NT GAUGE
NO/CE
C/CE
STATUS
OFFSET
SPECIAL
7
8
9
STORE
PRINT
PROJECT
AUTO
ERASE
4
5
6
CALIB.
TIME
RECALL
PRECISION
CALC.
1
2
3
PREP.


SELECT
Sel: 1- 1 min.
2- 4 min.
3- 8 min.
4- 16 min.
YES
NO/CE
STATUS
OFFSET
SPECIAL
7
8
9
STORE
PRINT
PROJECT
AUTO
ERASE
4
5
6


Statistical
Stability test -
Close door &
Press START
YES
NO/CE
STATUS
OFFSET
SPECIAL
7
8
9
PROJECT
AUTO
ERASE


YES
NO/CE
STATUS
OFFSET
SPECIAL
7
8
9
STORE
PRINT
PROJECT
AUTO
ERASE
4
5
6
CALIB.
TIME
RECALL
PRECISION
CALC.
1
2
3
SHIFT
BKG
PREP.
0
START/

Statistical Analysis				
Date	Ave. Count	Count Ratio	Time	Initials
6/1/00	2489	0.51	1 min.	GLA
6/14/00	2472	0.47	1 min.	GLA
6/15/00	2479	0.54	1 min.	GLA
6/22/00	2470	0.56	1 min.	GLA

10

Statistical Analysis

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 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

GLA = Glen L. Adams

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.

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.

D. Determine W_o, the total weight of sample:

Weigh empty pan.

D. Determine W_o, the total weight of sample:

(1) Place dry blended aggregate in a gauge pan in two layers.

D. Determine W_o, the total weight of sample:

(1) Place dry blended aggregate in a gauge pan in two layers.

D. Determine W_o, the total weight of sample:

(1) Place dry blended aggregate in a gauge pan in two layers.


D. Determine W_o, the total weight of sample:

(1) Place dry blended aggregate in a gauge pan in two layers.

D. Determine W_o, the total weight of sample:

(2) Raise and drop the pan 25 mm (1"), four times, striking the bottom evenly, after each layer.

(3) Do not compact.


Place second lift in pan filling to the top and repeat process of dropping four times.

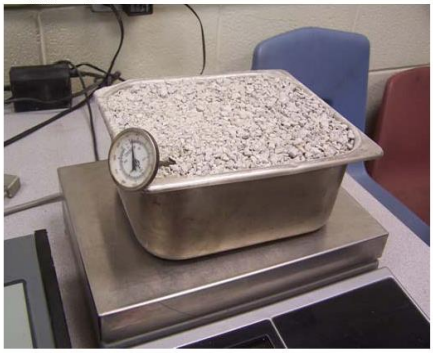
- After consolidating strike off the blended aggregate sample even with the top of the pan.

- Record the weight.

THIS IS THE Wo OF THE AGGREGATE

Definition of Wo = The weight of dry blended aggregate in a sample pan.

- Place a thermometer in the blended aggregate.



(7) Place the blended aggregate in an 82° - 143° C (180° - 290° F) oven.

(a) Blended aggregate sample must be 82° - 143° C (180° - 290° F) immediately prior to testing.

(b) Further calibration and testing shall be within 6° C (10° F) 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.

MIX DESIGN NUCLEAR CALIBRATION

20

Date	Plant	Bit.	Code	Wo/Cnt	Temp/CF	Slope	Int.	Pan 1 AC/Count	Pan 2 AC/Count	Pan 3 AC/Count	Cal. No.
6/16/00	918-01	7134	17552	7055g/2466	110C/0.998	3.384	-7.110	3.2/2698	4.2/2933	5.2/3218	1
6/16/00	918-01	7135	17552	6998g/2511	110C/ 1.000	4.454	-8.760	3.0/2638	4.0/2868	5.0/3088	2
6/22/00	918-01	7136	17554	6875g/2841	110C/0.999	3.446	-5.980	4.6/3052	5.6/3342	6.6/3629	3
6/22/00	918-01	7137	17551	7050g/2461	110C/0.997	3.673	-6.546	3.2/2664	4.2/2881	5.2/3162	4

CALIBRATION

A. Find the asphalt content determined in the design. (SEE FIGURE 5.3)

Figure 5.3

	% AC	d (G_{mb})	D (G_{mm})
Asphalt determined at 4.0% voids	5.42		
OPTIMUM DESIGN DATA:---	5.4	2.344	2.444
REMARKS:			

THIS IS THE Wo OF THE AGGREGATE

Definition of Wo = The weight of dry blended aggregate in a sample pan.

CALIBRATION

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:

(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.

Fill pan to Wo weight – 6856 g

547 g of Asphalt Binder per batch

(6) Place the gauge pan in an 82° - 143° C (180° - 290° F) oven until the temperature stabilizes and can be determined. *

(7) Record temperature.

(8) Place calibration point 1 in the gauge:

(9) Enter asphalt content.

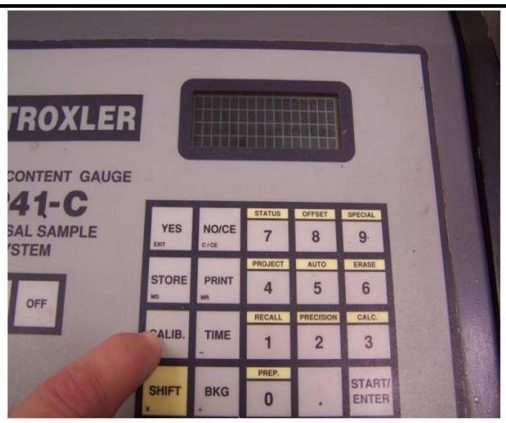
(10) Start calibration (16 minutes)

(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.**

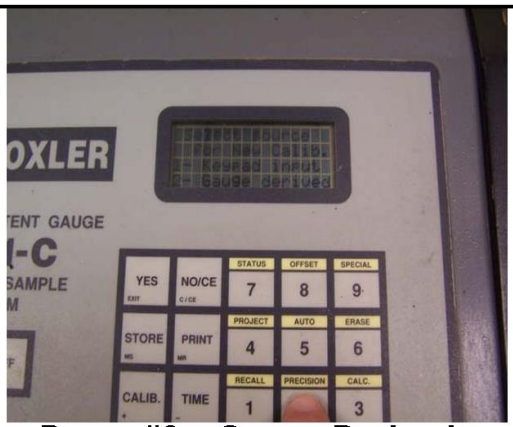
Steps for Calibration of Nuclear Content Gauge

Press the Calibration Button

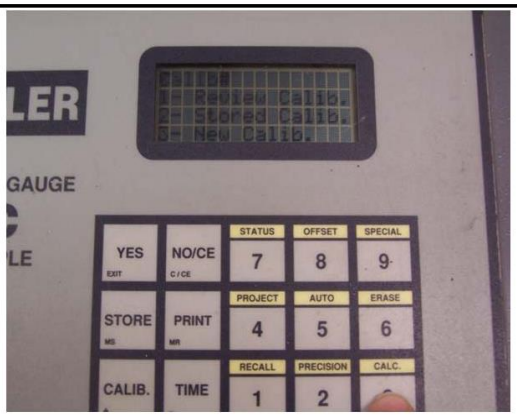


Press the Calibration Button

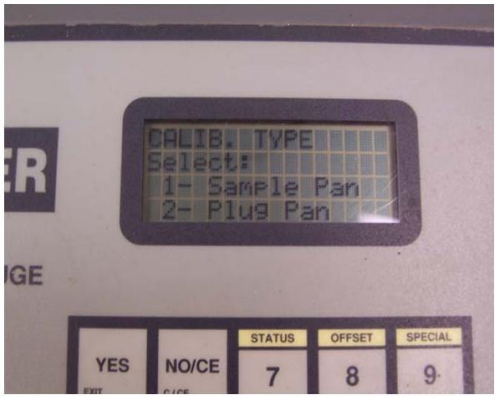
Select #2 – Gauge Derived



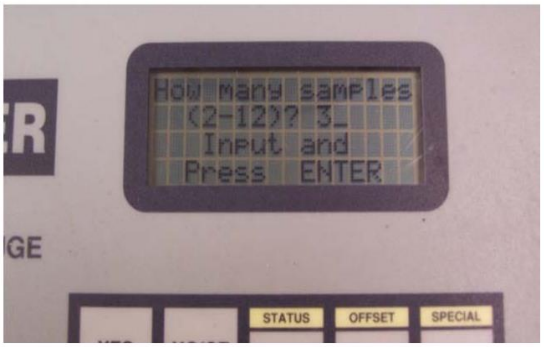
Press #2 – Gauge Derived



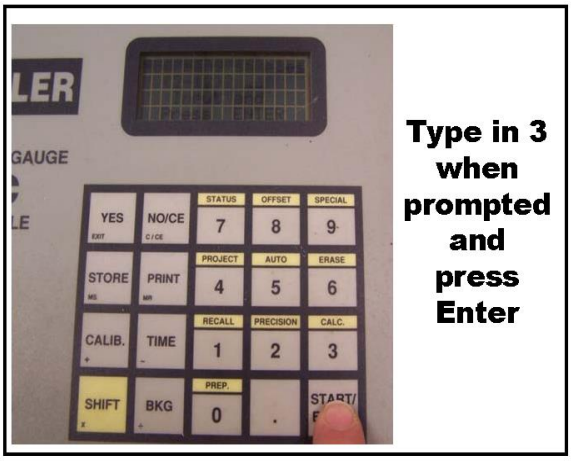
Press #3 - New Calibration

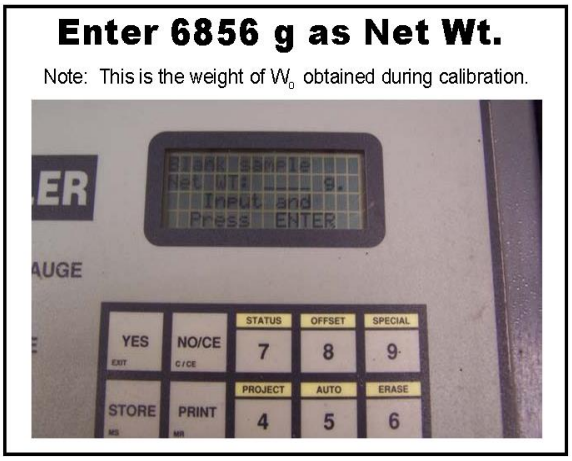


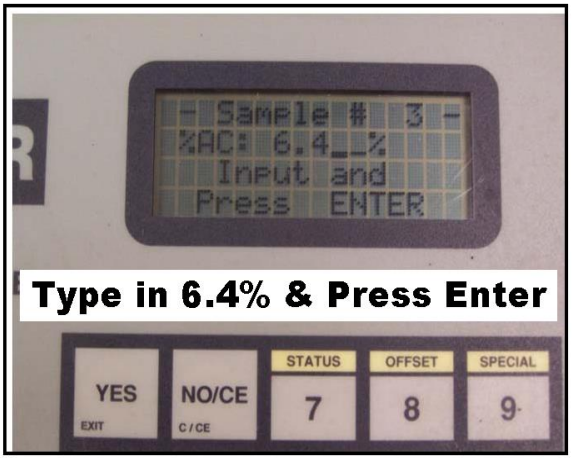
Press #1 - sample pan

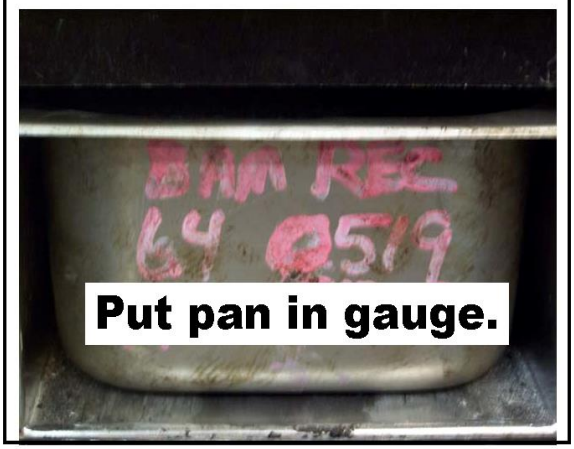


How many calibration samples?

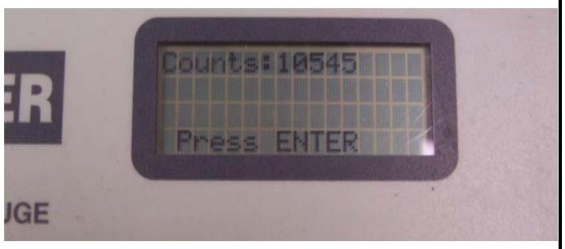

GAUGE
YES
NO/CE
STATUS
OFFSET
SPECIAL
7
8
9
STORE
PRINT
PROJECT
AUTO
ERASE
4
5
6
CALIB.
TIME
RECALL
PRECISION
CALC.
1
2
3
SHIFT
BKG
PREP.
0
.
Type in 3 when prompted and press Enter


Enter 6856 g as Net Wt.
Note: This is the weight of W_o obtained during calibration.
Input and
Press ENTER
YES
NO/CE
STATUS
OFFSET
SPECIAL
7
8
9
STORE
PRINT
PROJECT
AUTO
ERASE
4
5
6


Sample # 3
%AC: 6.4_%
Input and
Press ENTER
Type in 6.4% & Press Enter
YES
NO/CE
STATUS
OFFSET
SPECIAL
7
8
9



Gauge Counts 16 min. & gives you a count



Record Result in Diary

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:

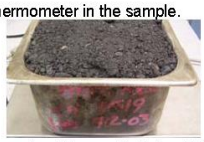
(1) Place material in a gauge pan in two layers totaling the weight equal to W_o.

(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.



457 g of Asphalt Binder per batch

Fill pan to W_o weight – 6856 g

(6) Place the gauge pan in an 82°-143° C (180°-290° F) oven until the temperature stabilizes and is within 6° C (10° F) of predetermined temperature.

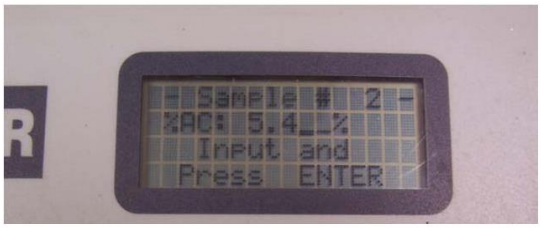
(7) Record temperature.

(8) Place calibration point 2 in the gauge.

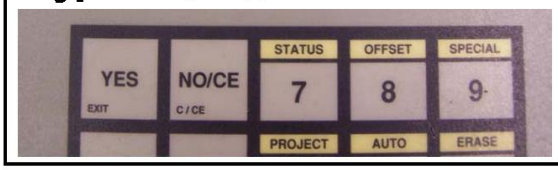
(9) Enter asphalt content.

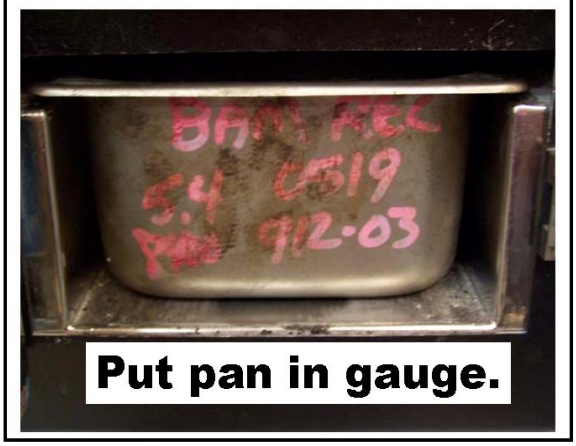
(10) Start calibration (16 minutes).

(11) Remove calibration point 2 from the gauge.



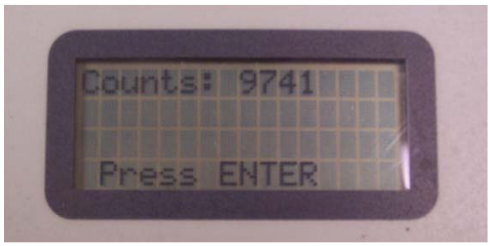
Type in 5.4% & Press Enter





Put pan in gauge.

Gauge Counts 16 min. & gives you a count



Record Result in Diary

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.

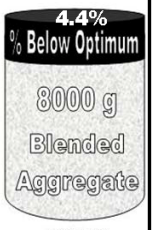
(2) Use scoop or spatula to rod into the corners.

(3) Do not compact.

(4) Flatten the top of the sample even with the top of pan with a wood or metal plate.

(5) Place a thermometer in the sample.

Fill pan to Wo weight – 6856 g



368 g of Asphalt Binder per batch

(6) Place the gauge pan in an 82° - 143° C (180° - 290° F) oven until the temperature stabilizes and is within 6° C (10° F) of predetermined temperature.

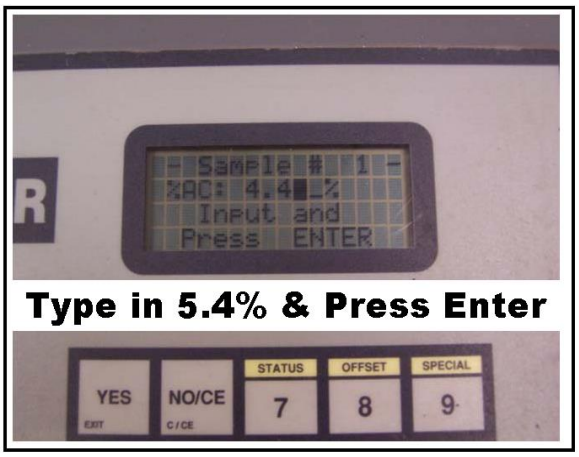
(7) Record temperature.

(8) Place calibration point 3 in the gauge.

(9) Enter asphalt content.

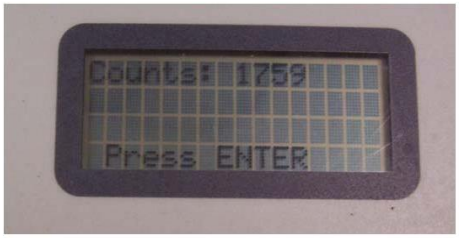
(10) Start calibration (16 minutes)

(11) Remove calibration point 3 from the gauge.



Type in 5.4% & Press Enter

Gauge Counts 16 min. & gives you a count



Record Result in Diary

(12) Record AC/count, slope/intercept, and correlation coefficient. A 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.

MIX DESIGN NUCLEAR CALIBRATION

(20)

Date	Plant	Bit.	Code	Wo/Cnt	Temp/CF	Slope	Int.	Pan 1 AC/Count	Pan 2 AC/Count	Pan 3 AC/Count	Cal. No.
6/16/00	918-01	7134	17552	7055g/2466	110C/0.998	3.384	-7.110	3.2/2698	4.2/2933	5.2/3218	1
6/16/00	918-01	7135	17552	6998g/2511	110C/ 1.000	4.454	-8.760	3.0/2638	4.0/2868	5.0/3088	2
6/22/00	918-01	7136	17554	6875g/2841	110C/0.999	3.446	-5.980	4.6/3052	5.6/3342	6.6/3629	3
6/22/00	918-01	7137	17551	7050g/2461	110C/0.997	3.673	-6.546	3.2/2664	4.2/2881	5.2/3162	4

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 110° ± 5° C. (230° ± 9° F.) 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 an 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 ofthe required test.

- Moisture content determination can be performed while the other sample is being tested for AC content.

TESTING THE PLANT MIXTURE FOR ASPHALT CONTENT:

TESTING THE PLANT MIXTURE FOR ASPHALT 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.

Fill sample pan to Wo

TESTING THE PLANT MIXTURE FOR ASPHALT CONTENT:

(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.

TESTING THE PLANT MIXTURE FOR ASPHALT CONTENT:

C. Place the gauge pan in an 82° - 143° C (180° - 290° F) oven.

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.

Reporting:

A. Date.

B. Equipment:

(1) Manufacturer of gauge.

(2) Model.

(3) Serial number.

C. Operators name.

D. Identification of mix.

Reporting:

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.

Reporting:

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.

This Page Is Reserved

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: January 1, 2017

Standard Method of Test
For
Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method

Reference AASHTO T 287-14

AASHTO Section	***Illinois Modification***
2.1	Replace the individual AASHTO Standards with the appropriate Illinois modified AASHTO Standards:
2.1	Replace AASHTO Standard T 2, T 11, T 27 with the following and add Illinois Test Procedure 248: • Illinois Test Procedure 2 • Illinois Test Procedure 11 • Illinois Test Procedure 27
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.

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: January 1, 2017

Standard Method of Test
For
Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method

Reference AASHTO T 287-14

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, metal-stemmed, armored type, with a temperature range 10 to 260 °C (50 to 500 °F), readable to 3 °C (5 °F).
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.
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**

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: January 1, 2017

Standard Method of Test
For
Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method

Reference AASHTO T 287-14

AASHTO Section	***Illinois Modification***
8.1	Replace with the following: Obtain samples of freshly produced asphalt concrete according to Illinois Department of Transportation document, "HMA 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 1	Change to **Note 2**
8.6 New Note	Add New **Note 3**: **Note 3** - 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 last sentence: or according to the manufacturer's instructions.
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.
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 current QC/QA 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

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: January 1, 2017

Standard Method of Test
For
Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method

Reference AASHTO T 287-14

AASHTO Section	***Illinois Modification***
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.
A4.3.1	Delete.
A4.3.2	Delete.

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: January 1, 2017

Standard Method of Test
For
Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method

Reference AASHTO T 287-14

AASHTO Section	***Illinois Modification***
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**:

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: January 1, 2017

Standard Method of Test
For
Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method

Reference AASHTO T 287-14

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 287-14

Technical Section: 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.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 231, Weighing Devices Used in the Testing of Materials
- R 66, Sampling Asphalt Materials
- R 76, Reducing Samples of Aggregate to Testing Size
- T 2, Sampling of Aggregates
- 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 168, Sampling Bituminous Paving Mixtures
- T 255, Total Evaporable Moisture Content of Aggregate by Drying
- T 329, Moisture Content of Asphalt Mixtures by Oven Method

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).

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 T 168. 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 1—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 a 4-min count.

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 T 2. 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:

$$Z_n = \frac{X^2}{Y} \qquad (A3.2)$$

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:

$$B = (A)(P_{ba}) \quad (A4.4)$$

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 $\mathbf{N_{design}}$ 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 $\mathbf{N_{ini}}$, $\mathbf{N_{des}}$ and $\mathbf{N_{max}}$. 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.

$\mathbf{N_{ini}}$	simulates	--	density behind the paver screed
$\mathbf{N_{des}}$	simulates	--	density after several years of traffic
$\mathbf{N_{max}}$	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 T312 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.

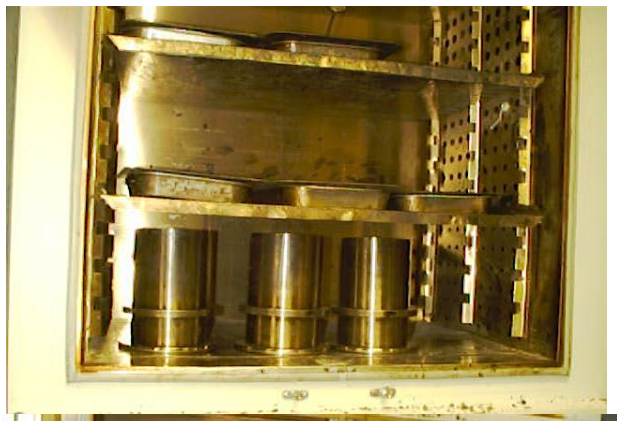
- Compaction Temperature – Heat to a compaction temperature of 295 ± 5°F (146 ± 3°C) for unmodified material and 305 ± 5°F (152 ± 3°C) for modified binders.

- 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 62 ± 2 mm.
  - I-FIT – Illinois Test Procedure 405, 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 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 ± 0.5%.
  - Hamburg – Test procedure AASHTO T-324, specified air void level is 7.0 ± 1.0%
  - I-FIT – Illinois Test Procedure 405, specified air void level is 7.0 ± 0.5%. Note: The voids are measured on disc(s) cut from the middle of each gyratory specimen.

(2) Approximately 30 minutes before compaction of the first sample, place the compaction molds and base/top plates in a forced draft oven at 310±5°F (154±3°C).

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 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.

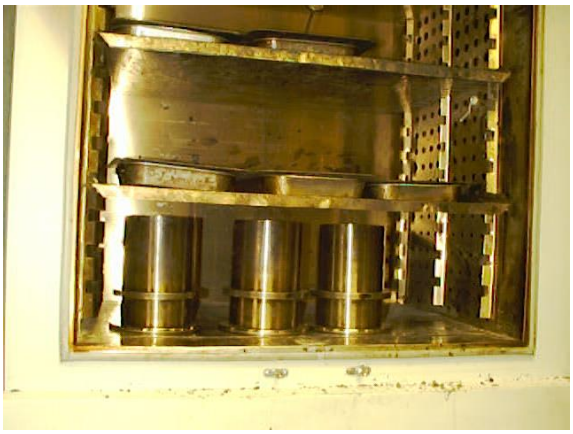
(11) Place the mold and base plate back in the 310° F oven at the compaction temperature for at least 5 minutes. This allows the mold to return to the proper temperature prior to reuse.

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 = $\mathbf{100} - \left(\frac{(\mathbf{Gmb})(\mathbf{100}-\mathbf{Pb})}{\mathbf{Design\ Gsb}}\right)$ **round to one decimal place (xx.x)**

Where: $\mathbf{G_{mb}}$ = Bulk specific gravity of the mix
$\mathbf{P_b}$ = Asphalt binder content of specimen
$\mathbf{G_{sb}}$ = Design bulk specific gravity of the combined dry aggregates of the mixture

Percent Density = $\frac{\mathbf{Gmb}}{\mathbf{Gmm}}\ \mathbf{x\ 100}$ **round to one decimal place (xx.x)**

Where: $\mathbf{G_{mb}}$ = Bulk Specific Gravity of the mixture
$\mathbf{G_{mm}}$ = Maximum Specific Gravity of the mixture

Percent Air Voids = $\left(\mathbf{1.0} - \frac{\mathbf{Gmb}}{\mathbf{Gmm}}\right)\ \mathbf{x\ 100}$ **round to one decimal place (x.x)**

Where: $\mathbf{G_{mb}}$ = Bulk Specific Gravity of the mixture
$\mathbf{G_{mm}}$ = 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	$\frac{A}{(B-C)}$	G_{mb}			
% Voids	$\left(1.0 - \frac{Gmb}{Gmm}\right) x\ 100$				
VMA	$100 - \left(\frac{(Gmb)(100-Pb)}{Design\ Gsb}\right)$	VMA			
Max. SG		G_{mm}			
Density	$\frac{Gmb}{Gmm} x\ 100$				

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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	$\left(\mathbf{1.0} - \frac{\mathbf{Gmb}}{\mathbf{Gmm}}\right)\mathbf{x\ 100}$				
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 an target air void level of 7.0±1.0%. 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}:

$$\text{Corrected } G_{mb} = \frac{100 - V}{100} \times G_{mm} \qquad \text{Where: } V = \text{target void level}$$

$$= \frac{100 - 7.0}{100} \times G_{mm}$$

2. Assume a Correction Factor "C":

   Assuming a Correction Factor "C" of 1.0180 should suffice in most cases.

3. Determine estimated G_{mb}:

$$\text{Estimated } G_{mb} = \frac{\text{Corrected } G_{mb}}{C} \qquad \text{Where: } C = \text{Correction Factor from step \#2}$$

$$= \frac{\text{Corrected } G_{mb}}{1.0180}$$

4. Determine weight of SGC sample needed:

$$\text{Specimen Weight} = \text{estimated } G_{mb} \times 17.67 \times h \qquad \text{Where: } h = \text{target height}$$

$$17.67 = \frac{\pi (150)^2}{4000}$$

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.

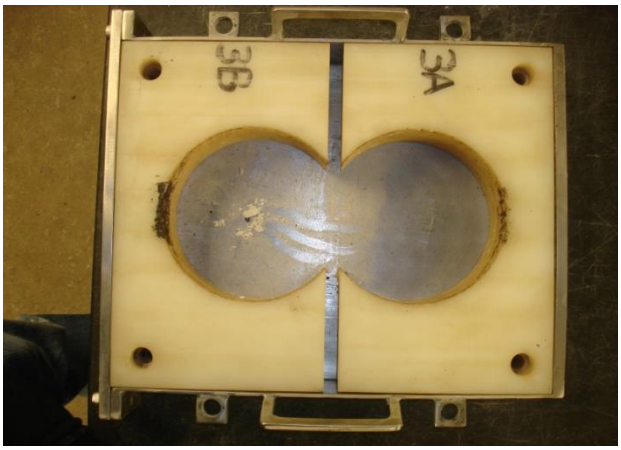
The Hamburg Wheel unit is a large temperature controlled water bath that runs a weighted wheel back and forth on submerged samples at a determined number of passes for each mixture. The test uses a total of four gyratory samples, two samples per mold. Samples are created in the lab using the method described on page 6-14 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:

PG Grade	No. of Passes
PG 76-xx (or higher)	20,000
PG 70-xx	15,000
PG 64-xx	7,500
PG 58-xx or lower	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

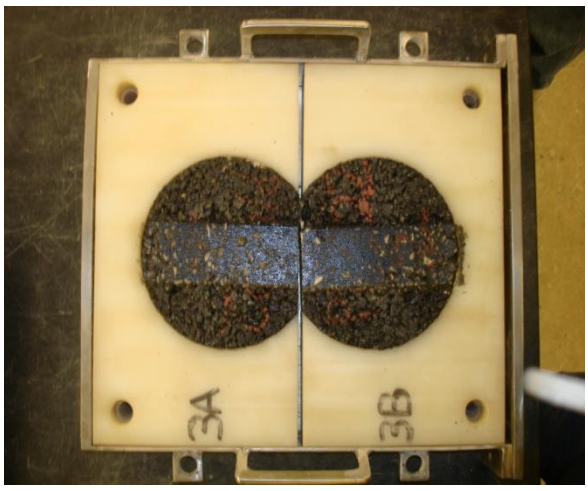
The unit can run two tests at one time



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

Illinois Test Procedure 405
Determining the Fracture Potential of Asphalt Mixtures Using the Illinois Flexibility Test (I-FIT)

INTRODUCTION

The objective of this section is to introduce Illinois Test Procedure 405: *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 Test Procedure 405 and this test method should be referenced for all details.

DEFINITIONS

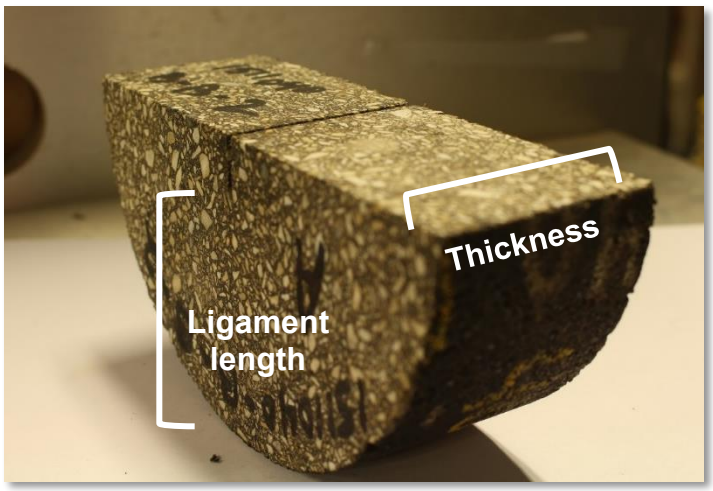
The flexibility index is a quantification of an asphalt mixture's damage resistance and cracking potential. The higher the flexibility index, the more resistant the material is to damage. Each mix design subject to the I-FIT requirement must have at least the minimum flexibility index specified in order to pass. The flexibility index is calculated using the fracture energy, the post-peak slope, and the ligament area. Currently, the minimum flexibility index specified by IDOT is 8.0.

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

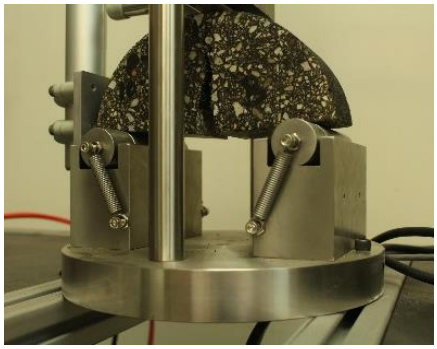
The I-FIT test method requires a testing setup comprised of a loading and data acquisition system. For loading specimens, it is preferred that a closed-loop servo-hydraulic axial loading device be used. An electromechanical screw driven loading device may also be used if it compares well to its closed-loop, servo-hydraulic counterpart. All loading devices must have a minimum capability of 10 N with a minimum resolution of 5 N.

Testing Fixture

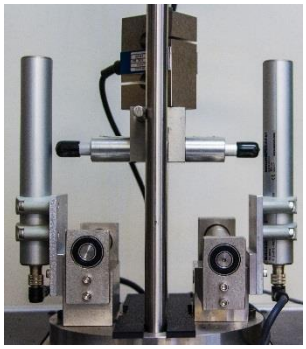
In addition to the loading device, a testing fixture is required. This must be comprised of a loading head, a steel base plate, and two 25 mm diameter steel rollers. The loading head must possess a contact curvature with a 12.5 mm radius. There are two approved setups for the rollers: Method A and Method 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.

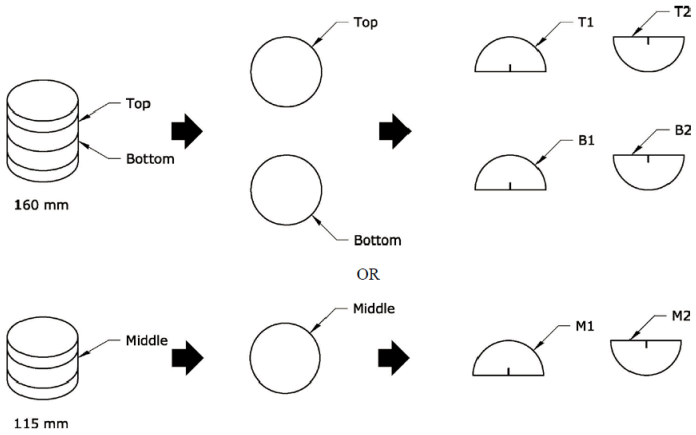
When compacting specimens, target air voids should be slightly higher than those desired in the final I-FIT specimen due to densification from cylinder to specimen. A typical starting weight for compaction of 160mm (Note 1) high specimens is 6800 g in order to target the recommended 8% voids. Upon compaction, 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.

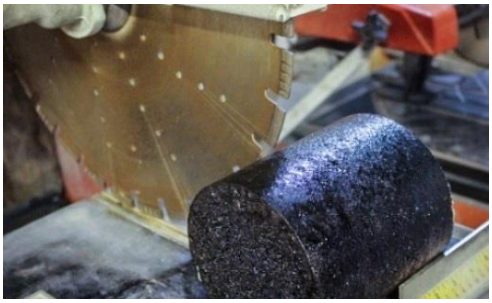
(Note 1) A compaction height of 115 mm is allowed if the gyratory machine cannot compact to 160 mm.

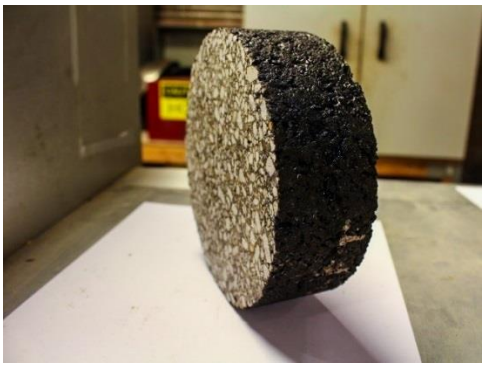
Fabrication

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 dried. Specimens are conventionally air-dried using a fan or vacuum-dried using the Core-Dry setup specified in ASTM D7227 and in equivalent Illinois Modified test procedures. The air void content is then verified to ensure compliance with the 7.0% ± 1.0% requirement in accordance with specification Illinois Modified AASHTO T269 and Illinois Modified AASHTO T166. If this tolerance is not met, 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

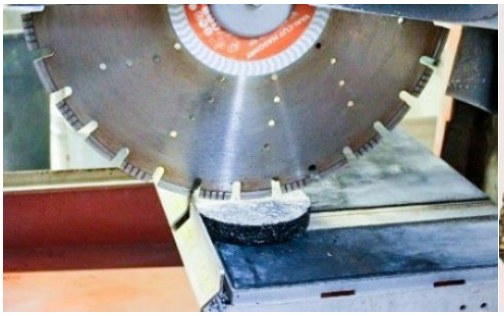
$$specimen\ weight = estimated\ G_{mb} * \frac{n * (150)^2 * h}{4000} = estimated\ G_{mb} * 17.67 * h$$

where: h = target height

Example: G_{mm} = 2.400 V = 8.0% h = 160 mm

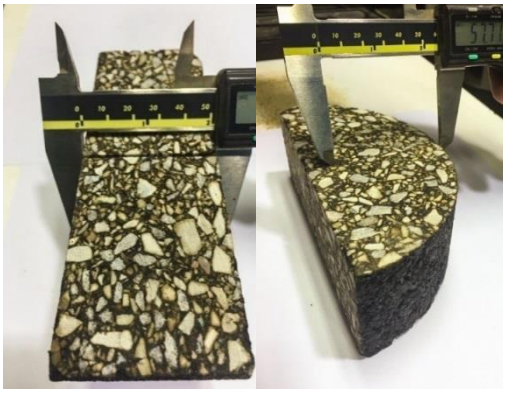
1. $corrected\ G_{mb} = \frac{100-8.0}{100} * 2.400 = 2.208$
2. $estimated\ G_{mb} = \frac{2.208}{1.0180} = 2.169$
3. $estimated\ weight = 2.169 * 17.67 * 160 = 6132.2\ grams$

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 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 1.5 mm ± 0.1 mm (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.

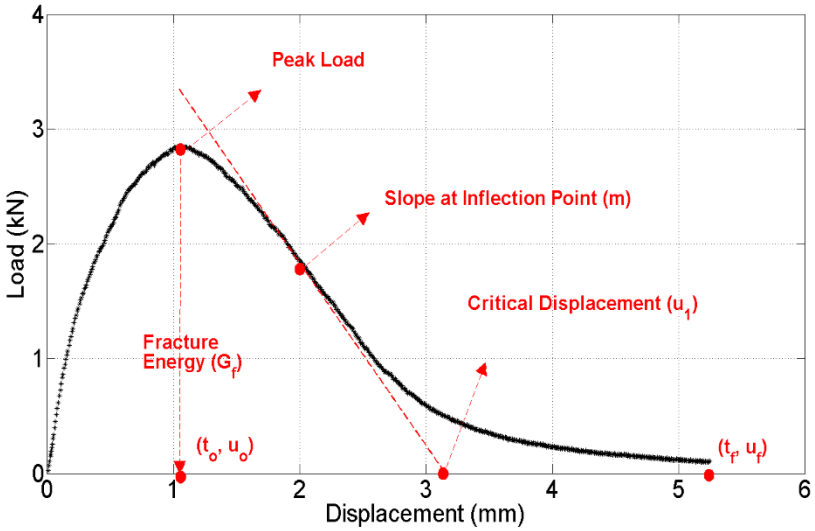
Once the specimen is aligned properly, loading of the specimen may be initiated. The machine software will typically prompt the user to verify that the contact load of 0.1 kN has been established before proceeding. Upon confirmation that this has occurred, the machine will automatically increase the 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:

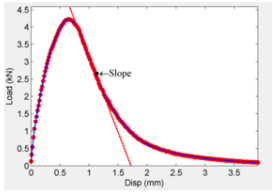
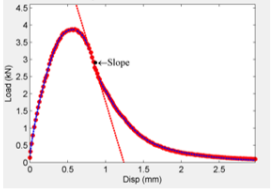
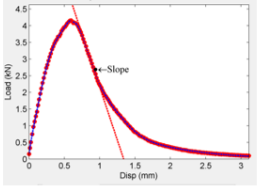
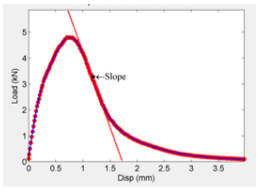
- Bulk specific gravity to the nearest 0.001
- Average air void content to the nearest 0.1
- Thickness and ligament length to the nearest 0.1 mm
- Peak load to the nearest 0.1 kN
- Post-peak slope to the nearest 0.1 kN/mm
- Fracture energy to the nearest 1 J/m^2
- Flexibility index to the nearest 0.1

The following is an example of a reporting template:

Chicago Testing Laboratory, Inc.

30 W. 114 Butterfield Road, Warrenville, IL 60555
I-FIT (Illinois-Flexibility Index Test)
Illinois Test Procedure 405
Method B

Mix Info	Project Name:			Date Tested:				
	Material Code/Mix Type:			CTL Job Number:				
	Mix Producer/Location:							
	Sampled/Tested By:							
		1609031-1-T-1		160903-1-T-2		1609031-1-B-1		1609031-1-B-2	
Volumetrics	Gyrations								
	Thickness (mm)								
	Ligament (mm)								
	Notch Length (mm)								
	Air voids (%)								
Testing Summary	Rate (mm/min)								
	Test Duration (sec)								
	Max Load (Psi)								
	Slope								
	Gf (J/m2)								
	Flexibility Index								
	STATISTICAL RESULTS:	Avg. FI	#DIV/0!	Avg. FE	#DIV/0!	Avg. Slope	#DIV/0!	Avg. Peak Load	#DIV/0!
		Std. Dev. FI	#DIV/0!	Std. Dev. FE	#DIV/0!	Std. Dev. Slope	#DIV/0!	Std. Peak Load	#DIV/0!
		COV FI	#DIV/0!	COV FE	#DIV/0!	COV Slope	#DIV/0!	COV Peak Load	#DIV/0!

1609031-1-T-1	160903-1-T-2
	
1609031-1-B-1	**1609031-1-B-2**
	

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 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 $_{mixture\ bulk}$) - 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 $_{mixture\ maximum}$) - 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: January 1, 2017

Standard Method
for
Preparing and Determining the Density of Hot-Mix Asphalt (HMA) Specimens by Means of the SHRP Gyratory Compactor

Reference AASHTO T 312-15

AASHTO Section	***Illinois Modification***
2.1	Replace with the following: *Referenced Illinois modified AASHTO Standards:* ▪ M 231, Weight Devices Used in the Testing of Materials ▪ R 30, Mixture Conditioning of Hot-Mix Asphalt (HMA) ▪ R 35, Superpave Volumetric Design for Hot-Mix Asphalt (HMA) ▪ T 166, Bulk Specific Gravity of Compacted Hot-Mix Asphalt Using Saturated Surface-Dry Specimens ▪ T 209, Theoretical Maximum Specific Gravity and Density of Hot-Mix Asphalt Paving Mixtures ▪
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 ± 0.35 mrad) determined by the Illinois Procedure for Internal Angle Calibration of the Superpave Gyratory Compactor using the Dynamic Angle Validator (DAV-2).
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 ot 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.

Illinois Modified Test Procedure
Effective Date: May 1, 2007
Revised Date: January 1, 2017

Standard Method
for
Preparing and Determining the Density of Hot-Mix Asphalt (HMA) Specimens by Means of the SHRP Gyratory Compactor

Reference AASHTO T 312-15

AASHTO Section	***Illinois Modification***
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.
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 may be lightly coated with an approved asphalt release agent to prevent a buildup and loss of asphalt binder and fines. The release agent shall not contain any solvents or petroleum-based products that could affect 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.

Illinois Modified Test Procedure
Effective Date: May 1, 2007
Revised Date: January 1, 2017

Standard Method
for
Preparing and Determining the Density of Hot-Mix Asphalt (HMA) Specimens by Means of the SHRP Gyratory Compactor

Reference AASHTO T 312-15

AASHTO Section	***Illinois Modification***
8.2.3	Replace with the following: 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 may be lightly coated with an approved asphalt release agent to prevent a buildup and loss of asphalt binder and fines. The release agent shall not contain any solvents or petroleum-based products that could affect binder properties.
8.2.5	Replace 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.
9.5	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.
A2.1	Replace with the following: Internal Bore Gauge – Minimum resolution shall be 0.0025 mm (0.0001 in).

Illinois Modified Test Procedure
Effective Date: May 1, 2007
Revised Date: January 1, 2015

Standard Method
for
Preparing and Determining the Density of Hot-Mix Asphalt (HMA) Specimens by Means of the SHRP Gyratory Compactor

Reference AASHTO T 312-12

AASHTO Section	***Illinois Modification***
A1.2 New Section	Each district shall own and operate an Internal Bore Gauge. A Three-Pint 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 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.
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.

Illinois Modified Test Procedure
Effective Date: May 1, 2007
Revised Date: January 1, 2015

Standard Method
for
Preparing and Determining the Density of Hot-Mix Asphalt (HMA) Specimens by Means of the SHRP Gyratory Compactor

Reference AASHTO T 312-12

AASHTO Section	***Illinois Modification***
A4.3	Replace 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 312-15

AASHTO

Technical Section: 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.*

2. REFERENCED DOCUMENTS

2.1. *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
- R 47, Reducing Samples of Hot Mix Asphalt (HMA) to Testing Size
- T 166, Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
- T 168, Sampling Bituminous Paving Mixtures
- T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA)
- 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. *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*—Armored, glass, or dial-type thermometers with metal stems for determining the temperature of aggregates, binder, and HMA between 10 and 232°C.

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. HMA 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 3—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 4—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) and base plate(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).

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 4.)

8.2. *Plant Produced*:

8.2.1. Place the compaction mold(s) and base plates(s) in an oven at the required compaction temperature (see Section 8.1.7.1).

8.2.2. Obtain the sample in accordance with T 168.

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 HMA 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, base plate, and upper plate (if required) 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 and upper plate (if required) on top of the leveled material.

9.3. Load the charged mold into the compactor, and center the loading ram.

9.4. Apply a pressure of 600 ± 18 kPa on the specimen.

9.5. Apply a 20.2 ± 0.35 mrad (1.16 ± 0.02 degrees) average internal angle to the mold assembly, and begin the gyratory compaction.

9.6. Allow the compaction to proceed until the desired number of gyrations specified in R 35 is reached and the gyratory mechanism shuts off.

9.7. 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 5—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 6—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.

9.8. Remove the paper disks from the top and bottom of the specimens.

Note 7—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 8—This formula gives the volume in cm^3 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. *Multilaboratory Precision*—The multilaboratory 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 multilaboratory 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
Multilaboratory 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.

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.

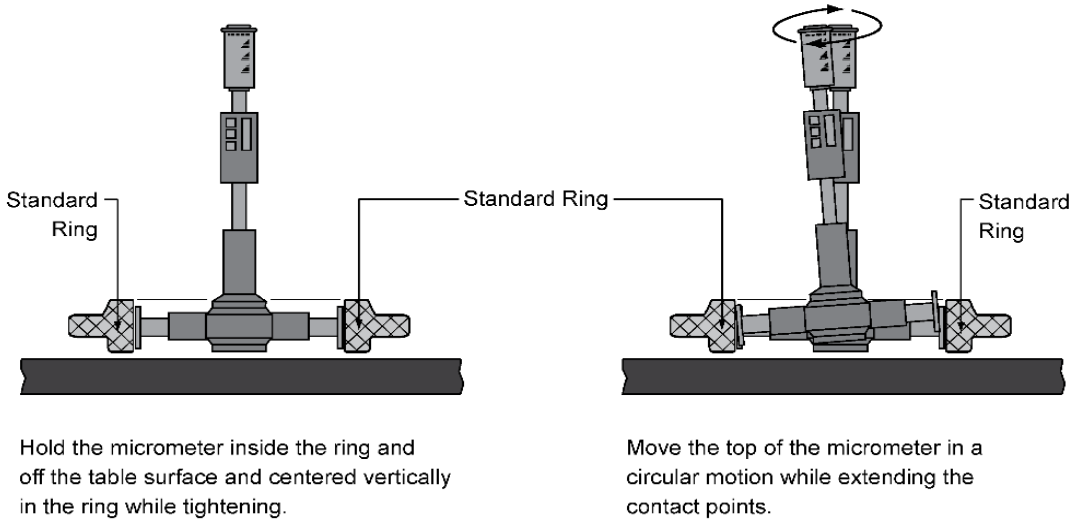

Figure A4.1—Techniques for Using the Three-Point Bore Gauge with the Calibrated Master Ring

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.

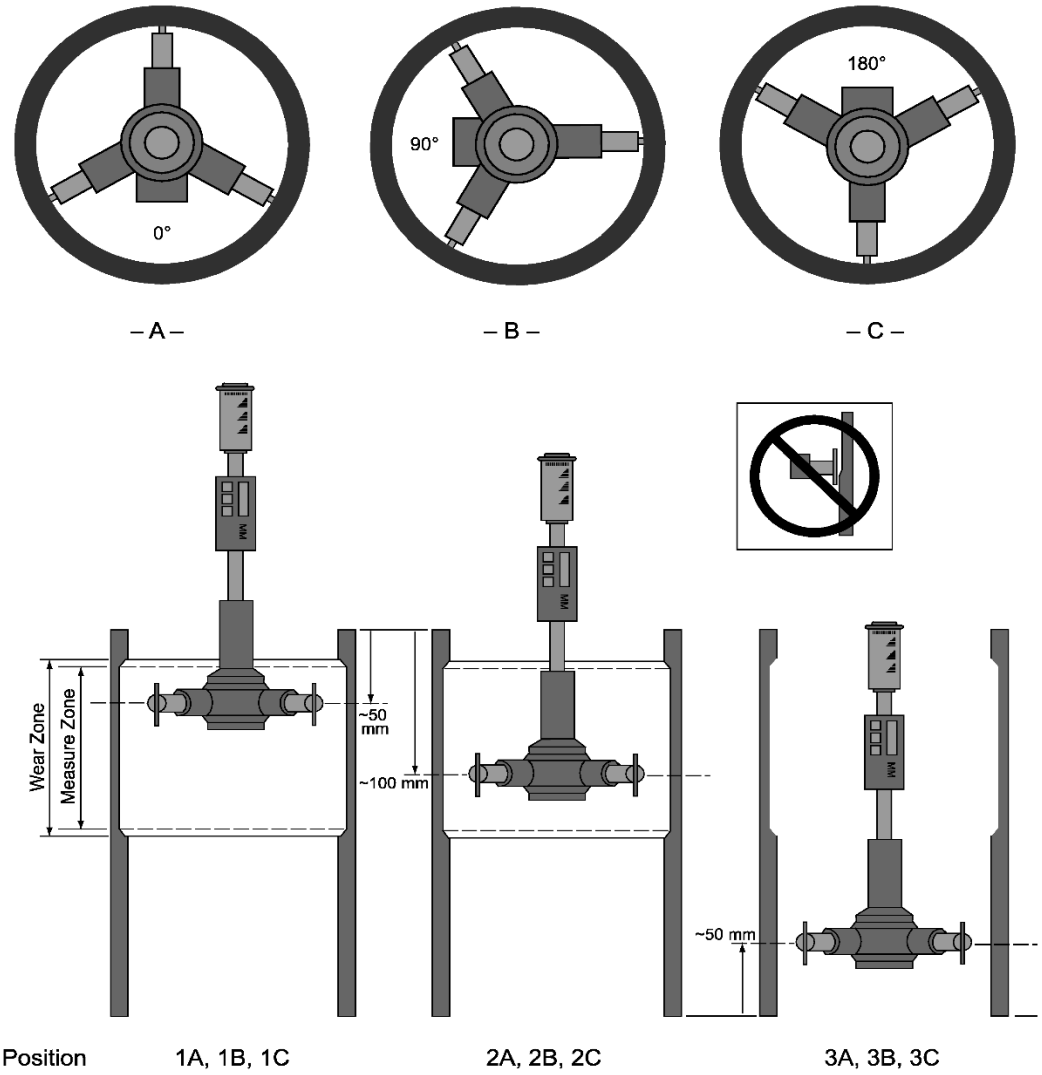

Figure A4.2—Bore Gauge Measurement Positions within the Mold Bore

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:

measurement = $M + D$ *(A1.1)*

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:

mm = in. × 25.40 *(A1.2)*

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.).

This Page Is Reserved

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised: December 1, 2017

Standard Method of Test
for
Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens

Reference AASHTO T 166-16, 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 (1) required that the minimum diameter of the gyratory compacted specimens be 149.90 mm (5.90 inches), (2) required that the minimum diameter of the cored specimens be 92.1 mm (3 5/8 inches), and (3) recommended that the thickness of specimens be at least one and one half times the maximum size of the aggregate.
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, 2017

Standard Method of Test
for
Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens

Reference AASHTO T 166-16, 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, “Bituminous Concrete QC/QA Laboratory Equipment”.
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.
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.
13.1.1	Replace with the following: The method used (A or C).
Footnote[1]	Delete

Standard Method of Test for

Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens

AASHTO Designation: T 166-16[1]

AASHTO

Technical Section: 2c, Asphalt–Aggregate Mixtures

Release: Group 3 (August 2016)

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 samples 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 sample 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.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 231, Weighing Devices Used in the Testing of Materials
- 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

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 sample 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 sample 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.

6. PROCEDURE

6.1. Dry the specimen to a constant mass at a temperature of 52 ± 3°C (125 ± 5°F). Samples saturated with water shall initially be dried overnight and then weighed at 2-h drying intervals. Recently compacted laboratory samples, which have not been exposed to moisture, do not require drying. As an alternative to oven drying to constant mass, drying the sample 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 2). Immerse each specimen in the water bath at 25 ± 1°C (77 ± 1.8°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 2—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 3—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.

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 sample mass or better, and conform to the requirements of M 231.

8.2. *Water Bath*—For immersing the specimen in water.

8.3. *Thermometer*—ASTM 17C (17F) as provided in ASTM E1, having a range of 19 to 27°C (66 to 80°F), graduated in 0.1°C (0.2°F) subdivisions.

8.4. *Volumeter*[2]—Calibrated to 1200 mL, or an appropriate capacity depending on the size of the test sample. The volumeter shall have a tapered lid with a capillary bore.

9. PROCEDURE

9.1. Dry the specimen to a constant mass at a temperature of 52 ± 3°C (125 ± 5°F). Samples saturated with water shall initially be dried overnight and then weighed at 2-h drying intervals. Recently compacted laboratory samples, 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 2). Immerse the specimen in the water bath at 25 ± 1°C (77 ± 1.8°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 ± 1.8°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 3) 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 ± 1.8°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 4). Record this weight as *E*.

Note 4—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 5—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 ± 1.8°F), g; and
E = mass of the volumeter filled with the specimen and water at 25 ± 1°C (77 ± 1.8°F), g.

10.2. Calculate the percent of water absorbed by the specimen (on a volume basis) as follows:

$$\text{percent of water absorbed by volume} = \frac{B - A}{B + D - E} \times 100 \quad (5)$$

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 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.

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.

[1] Minor editorial revisions have been made at the discretion of the authors responsible for standards on asphalt–aggregate mixtures (Technical Section 2c).

[2] 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.

Illinois Modified Test Procedure
Effective Date: May 1, 2007
Revised Date: December 1, 2017

Standard Method of Test
For
Superpave Volumetric Design for Asphalt Mixtures

Reference AASHTO R 35-17

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 or Illinois Test Procedure. • Replace all references to design air voids of 4.0% with the design air voids content specified in Illinois-modified M323.
3.9	Replace with the following: Dust-to-Binder Ratio ($P_{0.075}/P_b$)—By mass, the ratio between percent of aggregate passing the 75-□m (No. 200) sieve ($P_{0.075}$) and total asphalt content (P_b).
4.1 Note 3	Delete
6.1	Delete
6.2	Delete
6.5 New Note	Note 5a: Oven dry the mix design aggregates according to T 30.
6.5 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.
6.6	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.
6.6 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 "HMA Mix Design Procedure for Dust Correction Factor Determination."

Illinois Modified Test Procedure
Effective Date: May 1, 2007
Revised Date: December 1, 2017

Standard Method of Test
For
Superpave Volumetric Design for Asphalt Mixtures

Reference AASHTO R 35-17

<table>
<tr><th>AASHTO Section</th><th>Illinois Modification</th></tr>
<tr><td>6.8</td><td>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.</td></tr>
<tr><td>6.9</td><td>Delete</td></tr>
<tr><td>6.9
Note 6</td><td>Delete</td></tr>
<tr><td>8.1
New Note</td><td>Note 7a
The design number of gyrations will be determined by the Department and specified in the plans.</td></tr>
<tr><td>Table 1 and all footnotes</td><td>Replace with new Table 1 (below)

<table>
<tr><th colspan="3">Table 1 – N_{design} Table</th></tr>
<tr><th>Design ESALs (millions) Based on 20-year design</th><th>N_{des}</th><th>Typical Roadway Application</th></tr>
<tr><td>< 0.3</td><td>30</td><td>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.</td></tr>
<tr><td>0.3 to 3</td><td>50</td><td>Includes many collector roads or access streets. Medium-trafficked city streets and the majority of county roadways.</td></tr>
<tr><td>3 to 10</td><td>70</td><td>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.</td></tr>
<tr><td>≥ 10</td><td>90</td><td>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.</td></tr>
</table>
</td></tr>
</table>

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For
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Reference AASHTO R 35-17

AASHTO Section	***Illinois Modification***
8.3 Note 9	Delete
8.3 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-□m 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-□m 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 X5	Replace the last sentence with the following: Appropriate mixing times for bucket mixers should be established by evaluating the coating of HMA mixtures prepared at the mixing temperatures specified in T 312.
X2.4.2	Replace with the following: Estimate the planned production and field compaction temperatures.

Illinois Modified Test Procedure
Effective Date: May 1, 2007
Revised Date: December 1, 2017

Standard Method of Test
For
Superpave Volumetric Design for Asphalt Mixtures

Reference AASHTO R 35-17

AASHTO Section	***Illinois Modification***
X2.5.1	Delete the last sentence
X2.6.3	Delete
Note X8	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.
Note X11	Delete the first sentence.
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.

Standard Practice for

Superpave Volumetric Design for Asphalt Mixtures

AASHTO Designation: R 35-17[1]

AASHTO

Technical Section: 2d, Proportioning of Asphalt–Aggregate Mixtures

Release: Group 3 (August 2017)

1. SCOPE

1.1. This standard practice for mix design evaluation uses aggregate and mixture properties to produce a hot mix asphalt (HMA) 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).

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 that primarily use T 320 and T 322.

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
- R 83, Preparation of Cylindrical Performance Test Specimens Using the Superpave Gyratory Compactor (SGC)
- R 30, Mixture Conditioning of Hot Mix Asphalt (HMA)
- R 76, Reducing Samples of Aggregate to Testing Size
- T 2, Sampling of Aggregates
- 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 Hot Mix Asphalt (HMA)
- 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 320, Determining the Permanent Shear Strain and Stiffness of Asphalt Mixtures Using the Superpave Shear Tester (SST)
- T 322, Determining the Creep Compliance and Strength of Hot Mix Asphalt (HMA) Using the Indirect Tensile Test Device
- 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)

2.2. *Asphalt Institute Standard*:

- SP-2, Superpave Mix Design

2.3. *Other References*:

- LTPP Seasonal Asphalt Concrete Pavement Temperature Models, LTPPBind 3.1, http://www.ltppbind.com
- NCHRP Report 567: Volumetric Requirements for Superpave Mix Design

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 (Note 1).

Note 1—Term defined in Asphalt Institute Manual SP-2, Superpave Mix Design.

3.3. *binder content* (P_b)—the percent by mass of binder in the total mixture, including binder and aggregate.

3.4. *design ESALs*—design equivalent (80 kN) single-axle loads.

3.4.1. *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.

3.5. *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}).

3.6. *effective binder volume* (V_{be})—the volume of binder that is not absorbed into the aggregate.

3.7. *HMA*—hot mix asphalt.

3.8. *maximum aggregate size*—one size larger than the nominal maximum aggregate size (Note 2).

Note 2—The definitions given in Sections 3.10 and 3.11 apply to Superpave mixes only and differ from the definitions published in other AASHTO standards.

3.9. *nominal maximum aggregate size*—one size larger than the first sieve that retains more than 10 percent aggregate (Note 2).

3.10. *primary control sieve (PCS)*—the sieve defining the break point between fine and coarse-graded mixtures for each nominal maximum aggregate size.

3.11. *reclaimed asphalt pavement (RAP)*—removed and/or processed pavement materials containing asphalt binder and aggregate.

3.12. *voids filled with asphalt (VFA)*—the percentage of the VMA filled with binder (the effective binder volume divided by the VMA).

3.13. *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 (Note 1).

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.

6. PREPARING AGGREGATE TRIAL BLEND GRADATIONS

6.1. Select a binder in accordance with the requirements of M 323 and 320.

6.2. Determine the specific gravity of the binder according to T 228.

6.3. Obtain samples of aggregates proposed to be used for the project from the aggregate stockpiles in accordance with T 2.

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. Wash and grade each aggregate sample according to T 11 and T 27 for the purpose of materials characterization of the aggregates.

6.6. 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.

6.7. Blend the aggregate fractions for design purposes 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.

6.8. 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 4.75- or 2.36-mm sieve, 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.

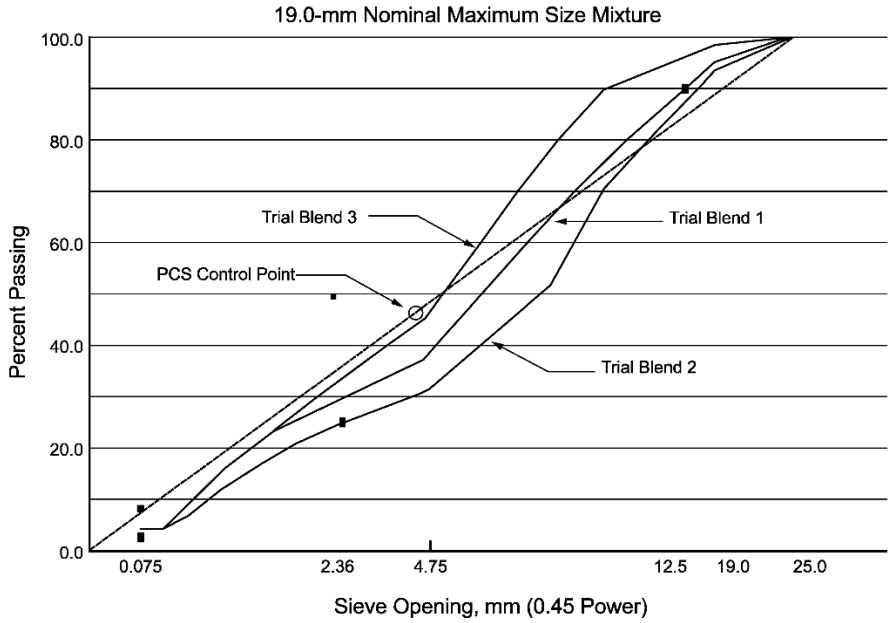


Figure 1—Evaluation of the Gradations of Three Trial Blends (Example)

6.9. Obtain a test specimen from each of the trial blends according to R 76, 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 asphalt content should be reduced by an amount equal to that provided by the RAP.

8. COMPACTING SPECIMENS OF EACH TRIAL GRADATION

8.1. 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.

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.

8.2. 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.

8.3. Determine the bulk specific gravity (G_{mb}) of each of the compacted specimens in accordance with T 166 or T 275 as appropriate.

Table 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*, 2004, 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.

8.4. 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 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:

$$V_a = 100\left(1 - \left(\frac{G_{mb}}{G_{mm}}\right)\right) \quad (2)$$

$$VMA = 100 - \frac{G_{mb}P_s}{G_{sb}} \quad (3)$$

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 a design air void content of 4.0 percent, the actual air void content of the compacted specimen is unlikely to be exactly 4.0 percent. Therefore, the change in binder content needed to obtain a 4.0 percent 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, 4.0 percent.

9.3. Estimate the volumetric properties at 4.0 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 level of 4.0 percent using Equation 4:

$$\Delta V_a = 4.0 - V_a \quad (4)$$

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 4.0 percent using Equation 5:

$$\Delta P_b = -0.4(\Delta V_a) \quad (5)$$

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.

$$\Delta VMA = 0.2(\Delta V_a) \quad \text{if} \quad V_a > 4.0 \quad (6)$$

$$\Delta VMA = -0.1(\Delta V_a) \quad \text{if} \quad V_a < 4.0 \quad (7)$$

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 4.0 percent air voids using Equation 8:

$$VMA_{design} = VMA_{trial} + \Delta VMA \quad (8)$$

where:

VMA_{design} = VMA estimated at a design air void content of 4.0 percent; 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 4.0 percent at N_{design}:

$$\%G_{mm_{initial}} = 100\left(\frac{G_{mb}h_d}{G_{mm}h_i}\right) - \Delta V_a \quad (9)$$

where:

$\%G_{mm_{initial}}$ = 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:

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}} \quad (10)$$

$$P_{be_{est}} = -\left(P_s \times G_b\right)\left(\frac{\left(G_{se} - G_{sb}\right)}{\left(G_{se} \times G_{sb}\right)}\right) + P_{b_{est}} \quad (11)$$

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
$P_{b_{est}}$ = estimated binder content at 4 percent air voids.

$$P_{0.075} / P_{be} = \frac{P_{0.075}}{P_{be_{est}}} \quad (12)$$

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.

Note 15—Many trial aggregate blend gradations will fail the VMA criterion. Generally, the $\%G_{mm_{initial}}$ 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 (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	
$\%G_{mm_{initial}}$ (trial)	88.3	88.0	87.3	
$\%G_{mm_{design}}$ (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
$\%G_{mm_{initial}}$ (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 air void content (V_a) of 4.0 percent 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:

$$VFA = 100\left(\frac{VMA - V_a}{VMA}\right) \quad (13)$$

10.5.2. Calculate the dust-to-binder ratio using Equation 14:

$$P_{0.075} / P_{be} = \frac{P_{0.075}}{P_{be}} \quad (14)$$

where:

P_{be} = effective binder content.

10.5.3. For each of the four mixtures, determine the average corrected specimen relative densities at $N_{initial}$ $\left(\%G_{mm_{initial}}\right)$, using Equation 15:

$$\%G_{mm_{initial}} = 100\left(\frac{G_{mb}h_d}{G_{mm}h_i}\right) \quad (15)$$

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 4.0 percent. This is the design binder content (P_b) at N_{design}.

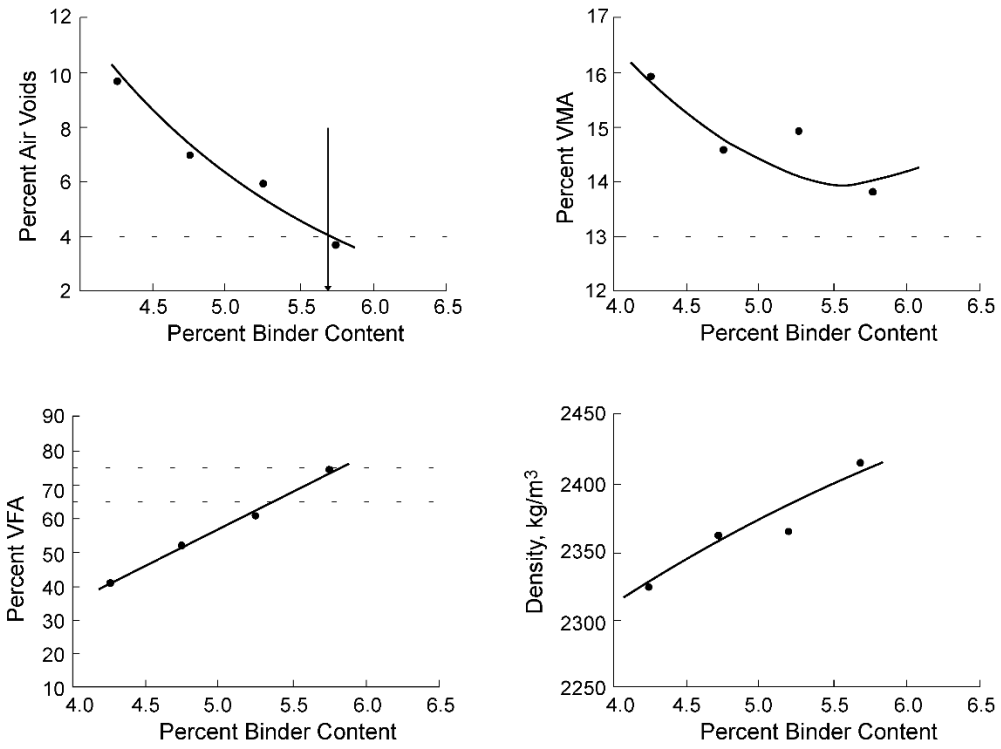
10.5.6. By interpolation (Figure 2), verify that the volumetric requirements specified in M 323 are met at the design binder content.

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 4.0 percent 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 at N_{design}

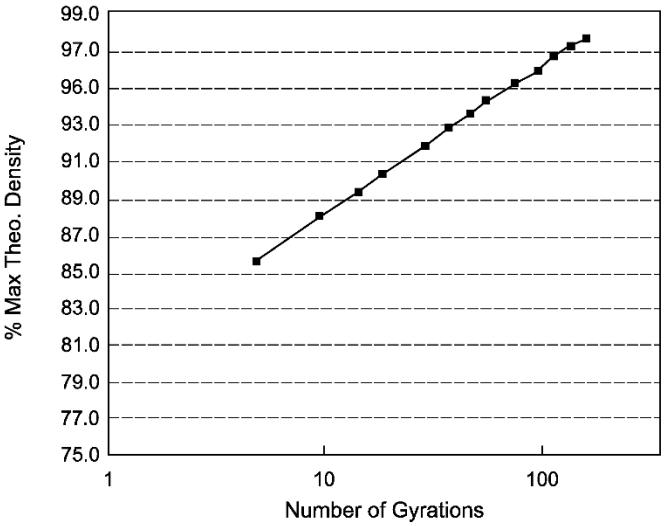


Figure 3—Sample Densification Curve

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.

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.

$$\%G_{mm_{max}} = 100\left(\frac{G_{mb}}{G_{mm}}\right) \qquad (16)$$

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 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 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 19—Changing gradation may not be an option if the trial aggregate blend gradation analysis includes the full spectrum of the gradation control area.

Note 20—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 21—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 4.0 percent air voids 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 include information on the design aggregate structure including the source of aggregate, kind of aggregate, required quality characteristics, and gradation.

13.3. The report shall contain information about the design binder including the source of binder and the performance grade.

13.4. The report shall contain information about the HMA including the 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; volumetric mix design.

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:

$$G_{sb} = \frac{P_1 + P_2 + \ldots + P_n}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \ldots + \frac{P_n}{G_n}} \quad (X1.1)$$

$$G_{sa} = \frac{P_1 + P_2 + \ldots + P_n}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \ldots + \frac{P_n}{G_n}} \quad (X1.2)$$

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:

$$G_{se} = G_{sb} + 0.8(G_{sa} - G_{sb}) \quad (X1.3)$$

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:

$$V_{ba} = W_s\left(\frac{1}{G_{sb}} - \frac{1}{G_{se}}\right) \quad (X1.4)$$

where:

W_s, the mass of aggregate in 1 cm^3 of mix, g, is calculated as:

$$W_s = \frac{P_s\left(1 - V_a\right)}{\frac{P_b}{G_b} + \frac{P_s}{G_{se}}} \quad (X1.5)$$

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;

P_b = mass percent of binder, in decimal equivalent, assumed to be 0.05; and

G_b = specific gravity of the binder.

Note X3—This estimate calculates the volume of binder absorbed into the aggregate, V_{ba}, and subsequently the initial, trial binder content at a target air void content of 4.0 percent.

X1.4. Estimate the volume of effective binder using Equation X1.6:

$$V_{be} = 0.176 - \left[0.0675 \log\left(S_n\right)\right] \quad (X1.6)$$

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 X4—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 and (2) the relationship between VMA and the nominal maximum sieve size of the aggregate in M 323.

X1.5. Calculate the estimated initial trial binder (P_{bi}) content for the aggregate trial blend gradation using Equation X1.7:

$$P_{bi} = 100\left(\frac{G_b\left(V_{be} + V_{ba}\right)}{\left(G_b\left(V_{be} + V_{ba}\right)\right) + W_s}\right) \quad (X1.7)$$

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 X5—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 X6—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 X7—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 X8—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.

$$\%\text{RAP} = \frac{\left(T_{\text{blend}} - T_{\text{virgin}}\right)}{\left(T_{\text{RAP}} - T_{\text{virgin}}\right)} \times 100 \quad \text{(Eq. X1.12 from M 323)}$$

where:

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 X9—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 X10—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.

Note X11—The aggregate will require 2 to 4 h to reach the temperature of the oven. Aggregates may be placed in the oven overnight.

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 X12—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 X13—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 X14—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 X15—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 X16—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 X17—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:

$$w_t = \frac{w_i}{\left(1 - \frac{P_{b_{new}}}{100}\right)} \quad (X2.2)$$

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 X18—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 X19—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 X20—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 X21—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 X22—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:

$$w_t = \frac{w_i}{\left(1 - \frac{P_{b_{new}}}{100}\right)} \qquad (X2.5)$$

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 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 specimen, determine the number of gyrations needed to reach 92 percent relative density.

X2.8.3.9. Determine the average number of gyrations needed to reach 92 percent relative density at the planned field compaction temperature.

X2.8.3.10. Determine the average number of gyrations needed to reach 92 percent relative density at 30°C below the planned field compaction temperature.

X2.8.3.11. Determine the gyration ratio using Equation X2.7:

$$\text{ratio} = \frac{(N_{92})_{T-30}}{(N_{92})_T} \quad (X2.7)$$

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. The recommended compactability criterion is a gyration ratio less than or equal to 1.25.

Note X23—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. Compact test specimens to 7.0 ± 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 X24—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. Prepare the flow number test specimens to 7.0 ± 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 Version 3.1. 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 X25—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. 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;

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.

[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: January 1, 2017

Standard Method of Test
for
Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus

Reference AASHTO T 245-15

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.
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).
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.

This Page Is Reserved

Standard Method of Test for

Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus

AASHTO Designation: T 245-15

AASHTO

Technical Section: 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.

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standard*:

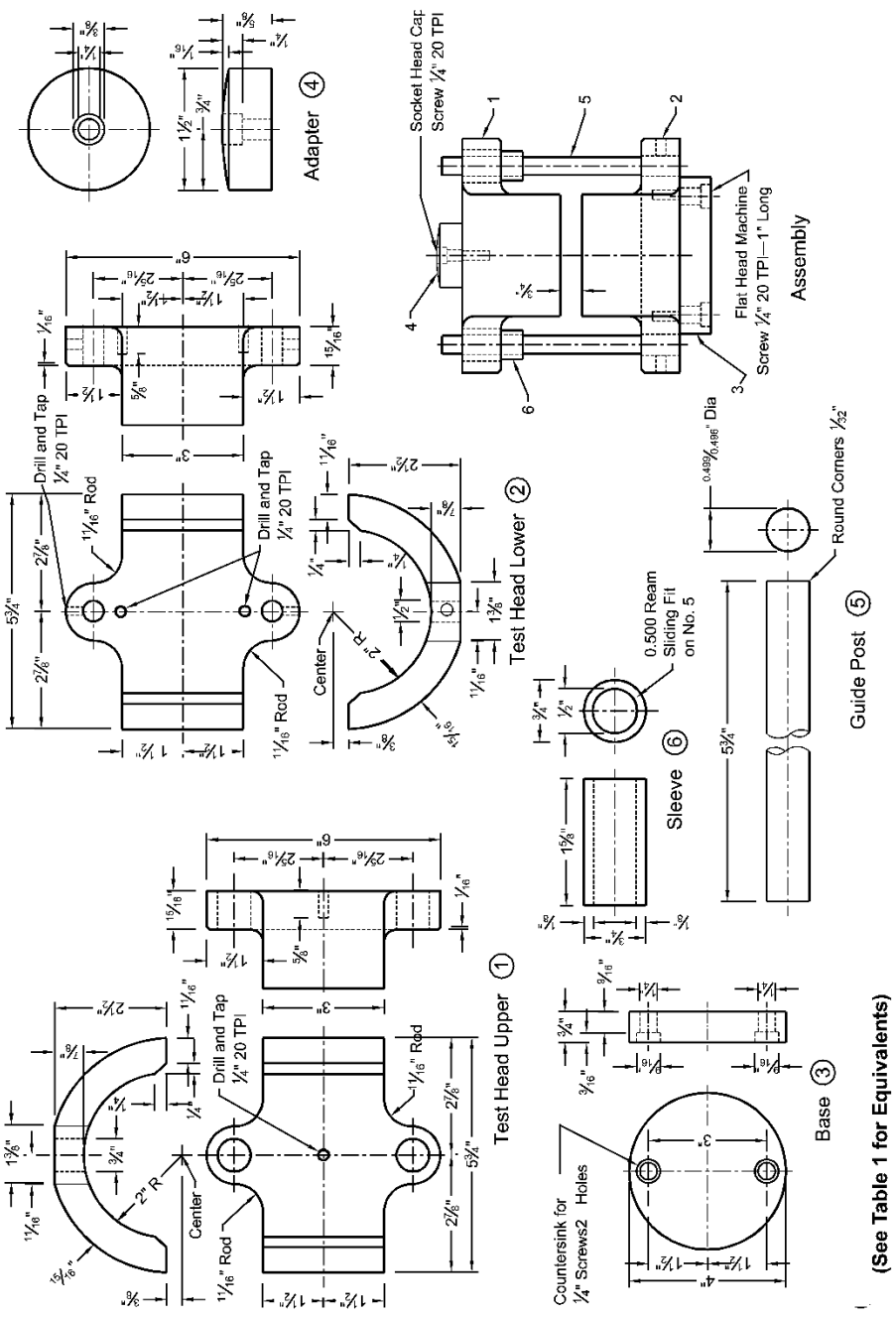
- R 68, Preparation of Asphalt Mixture Specimens by Means of the Marshall Compactor

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 Bituminous Paving Mixture Specimens

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.



(See Table 1 for Equivalents)

Figure 1—Breaking Head

Table 1—Table of Equivalents for Figure 1

Metric Equivalents, mm	U.S. Customary Units, in.	Metric Equivalents, mm	U.S. Customary Units, in.	Metric Equivalents, mm	U.S. Customary Units, in.	Metric Equivalents, 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.

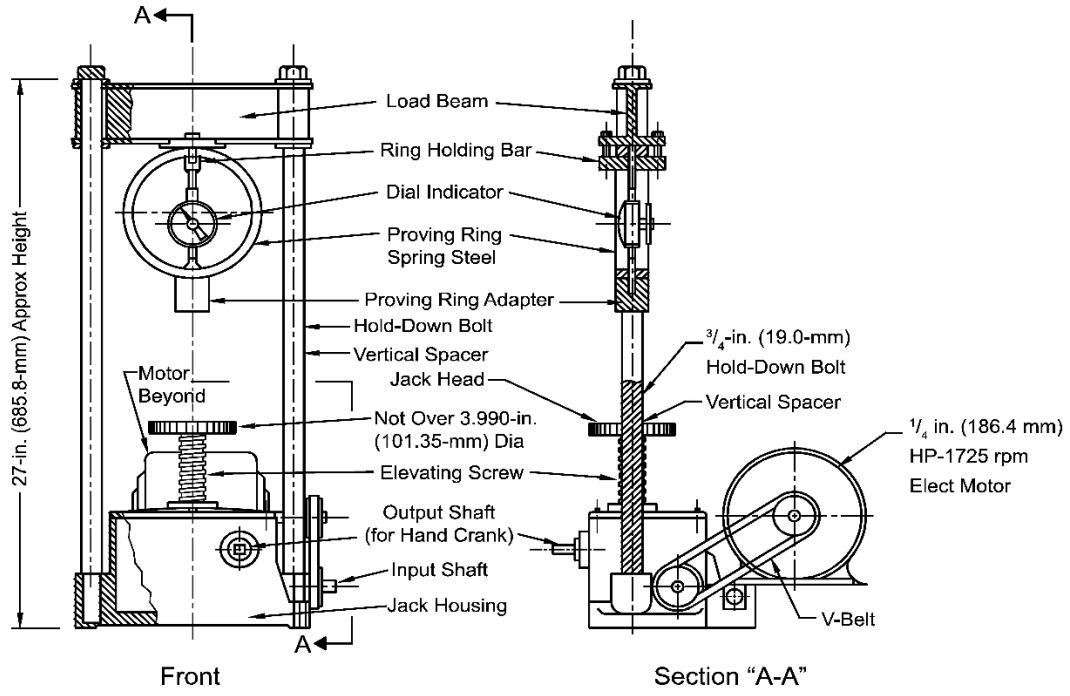


Figure 2—Loading Jack

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*—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. It is recommended that the heating units be thermostatically controlled so as to maintain the required temperature within 2.8°C (5°F). Suitable shields, baffle plates, or sand baths shall be used on the surfaces of the hot plates to minimize localized overheating.

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*—For water and air baths sensitive to 0.2°C (0.4°F) with a range sufficient to determine the specified bath temperature.

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 2—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 3—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. ASTM. D5361/D5361M, Standard Practice for Sampling Compacted Bituminous Mixtures for Laboratory Testing.

9.2. ASTM. E11, Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves.

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

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

9.5. AASHTO. T 331, Bulk Specific Gravity (G_{mb}) and Density of Compacted Asphalt Mixtures Using Automatic Vacuum Sealing Method.

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Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: December 1, 2017

Standard Method of Test
for
Hamburg Wheel-Track Testing of Compacted Hot Mix Asphalt (HMA)

Reference AASHTO T 324-17

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 and Density of Hot Mix Asphalt (HMA) ▪ T 312, Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
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).
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.

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: December 1, 2017

Standard Method of Test
for
Hamburg Wheel-Track Testing of Compacted Hot Mix Asphalt (HMA)
(continued)
Reference AASHTO T 324-17

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. A specimen thickness of 62±2 mm (2.4±0.1 in.) shall be used. The specimen thickness shall be at least twice the nominal maximum aggregate size. Two 150 mm (5.91 in.) diameter specimens are needed for each wheel. Compacted specimens shall be cooled at room temperature on a clean, flat surface until the specimen is cool to the touch. If compaction of a 62±2 mm specimen requires more than the design number of gyrations for that particular mix design, then a single specimen with a height larger than 62 mm, which can be compacted within the approximate design number of gyrations, may be fabricated. The top 62±2 mm shall be cut away using a wet-saw, kept, and tested, keeping the cut face down. The air voids of the top 62 mm shall meet the tolerance specified in Section 7.3. Discard the bottom material cut from the specimen.
6.3.2.2	Replace with the following: *Compacting SGC Cylindrical Specimens*—Material shall be compacted into specimens using an SGC according to IL Modified AASHTO T 312. A specimen thickness of 62±2 mm (2.4±0.1 in.) shall be used. The specimen thickness shall be at least twice the nominal maximum aggregate size. Compacted specimens shall be cooled at room temperature on a clean, flat surface until the specimen is cool to the touch. Two 150 mm (5.91 in.) diameter specimens are needed for each wheel. If compaction of a 62±2 mm specimen requires more than the design number of gyrations for that particular mix design, then a single specimen with a height larger than 62 mm, which can be compacted within the approximate design number of gyrations, may be fabricated. The top 62±2 mm shall be cut away using a wet-saw, kept, and tested, keeping the cut face down. The air voids of the top 62 mm shall meet the tolerance specified in Section 7.3. Discard the bottom material cut from the specimen.
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. Replace sentence five with the following: The height of a field core specimen may need to be adjusted to fit the specimen mounting system.

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: December 1, 2017

Standard Method of Test
for
Hamburg Wheel-Track Testing of Compacted Hot Mix Asphalt (HMA)
(continued)
Reference AASHTO T 324-17

AASHTO Section	***Illinois Modification***
Note 2	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).
7.3	Replace the second sentence with the following: For laboratory-compacted specimens, the target air void content shall be 6.0±1.0 percent for SMA mixes and 7.0±1.0 percent for all other mixes.
8.2	Replace with the following: SGC Cylindrical and Field Core Specimen Mounting – Place the HDPE molds in the mounting tray. Insert the cut specimens in the molds. Shim the molds in the mounting tray as necessary. Secure the molds into the mounting tray by hand-tightening the bolts of the edge plate.
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 (14.0 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 at the 0.5 in. (12.5 mm) rut depth criteria shall be selected based upon the PG Grade high temperature of the asphalt binder as specified in the mix requirements table of the plans. • PG 58-xx or lower 5,000 wheel passes • PG 64-xx 7,500 wheel passes • PG 70-xx 15,000 wheel passes • PG 76-xx or higher 20,000 wheel passes 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.

Illinois Modified Test Procedure
Effective Date: June 1, 2012
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Standard Method of Test
for
Hamburg Wheel-Track Testing of Compacted Hot Mix Asphalt (HMA)
(continued)
Reference AASHTO T 324-17

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 8.6.1.1 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 LVDT displacement is 14.0 mm (0.55 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, a passing test requires both wheels to have a rut depth less than or equal to 12.5 mm at the prescribed number of passes in section 8.6.1.1. The test result is reported as the average of the two rut depths. A test is considered as failing if one or both rut depths exceed 12.5 mm at, or less than, the prescribed number of passes in section 8.6.3. 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.
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
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 324-17

AASHTO

Technical Section: 2c, Asphalt–Aggregate Mixtures

Release: Group 3 (August 2017)

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 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 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.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- R 30, Mixture Conditioning of Hot Mix Asphalt (HMA)
- T 166, Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
- T 168, Sampling Bituminous Paving Mixtures
- T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA)
- 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 Standard*:

- D6027, Standard Test Method for Calibrating Linear Displacement Transducers for Geotechnical Purposes (withdrawn 2013)

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-mm (1.85-in.) wide steel wheel over the center (x and y axes) of the test specimen. The load on the wheel is 705 ± 4.5 N (158 ± 1.0 lb). The wheel reciprocates over the specimen, with the position varying sinusoidally over time. 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 approximately 0.305 m/s (1 ft/s).

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.

5.3. *Impression Measurement System*—A linear variable differential transducer (LVDT) device capable of measuring the depth of the impression (rut) of the wheel at the center $\pm^1/_2$ in. along the length of the wheel's path, to within 0.15 mm (0.006 in.), over a minimum range of 0 to 20 mm (0 to 0.8 in.). The system measures the rut depth, without stopping the wheel, at least every 400 passes. Rut depth is expressed as a function of the wheel passes.

Note 1—Users may require the capability of impression measurements at different intervals across the length of the wheel's path on the test specimen.

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.

5.6. *Cylindrical Specimen Mounting System*—An assembly consisting of two high-density polyethylene (HDPE) molds or plaster of paris, conforming to Section 8 to secure the specimen (as shown in Figures 1 and 2), placed in 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.

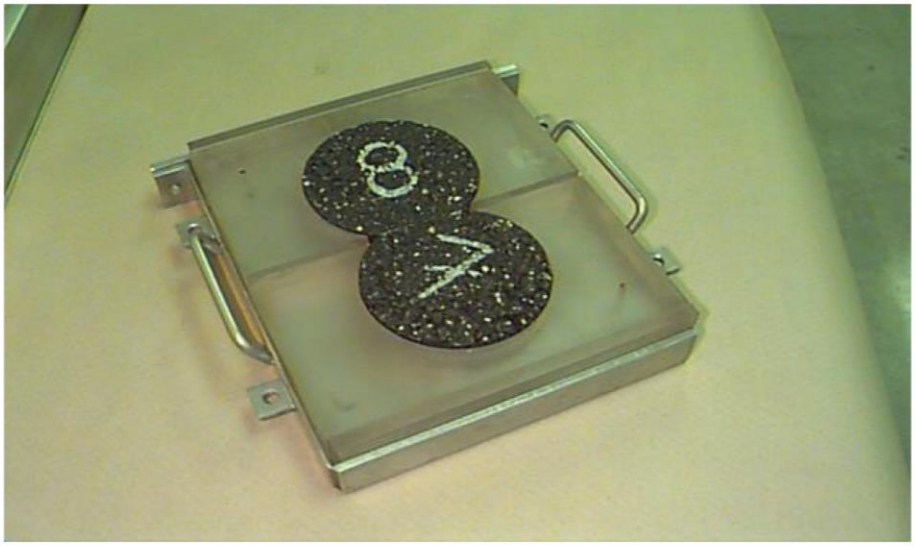
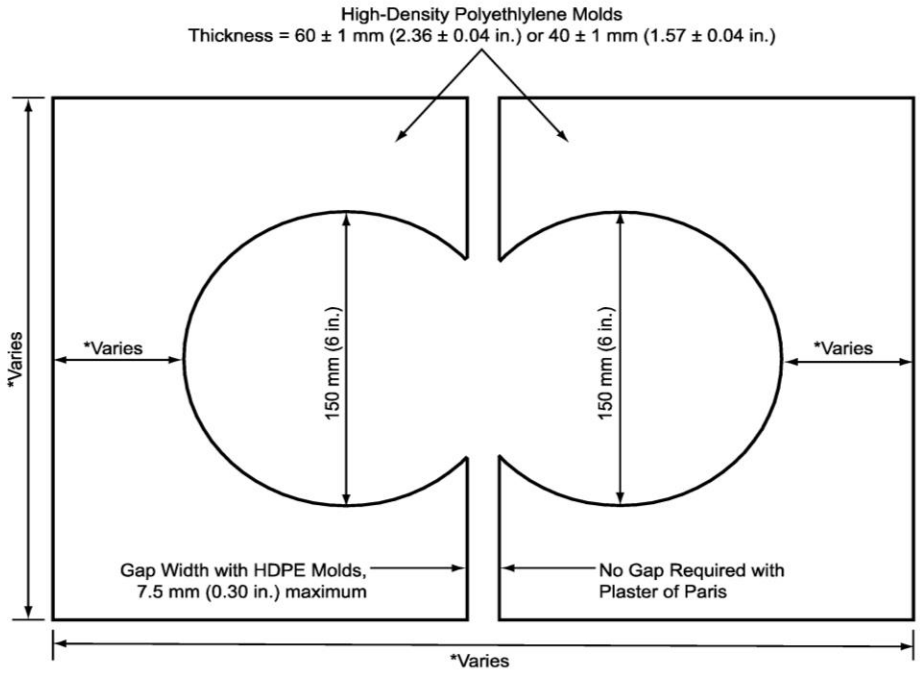


Figure 1—Cylindrical Specimen Mounting System



* Dimension may vary depending on 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. *Balance*—Of 12 000-g capacity, accurate to 0.1 g.

5.9. *Ovens*—For heating aggregate and asphalt binders.

5.10. *Superpave Gyratory Compactor (SGC)*—And molds conforming to T 312.

5.11. 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). 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 T 168.

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 2—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 705 N (158 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 3—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. The plaster underneath the specimen must not exceed 2 mm (0.08 in.). 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. The plaster underneath the specimen must not exceed 2 mm (0.08 in.) in thickness. Allow the plaster at least 1 h to set.

Note 4—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 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 computer 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 5—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 LVDT in accordance with the manufacturer's recommendations.

Note 6—The LVDT 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 7—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 8—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 LVDT reads between 10 and 18 mm (0.4 and 0.7 in.). Adjust the LVDT height to obtain this reading. Loosen the two screws on the LVDT mount and slide the LVDT 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. The device will also disengage if the average LVDT 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 LVDT reading from the total displacement.

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:

a) Two 320-mm (12.5-in.) long by 260-mm (10.25-in.) wide slab specimens, two 250-mm (10-in.) core specimens, or two 300-mm (12-in.) core specimens representing similar material run in the Hamburg Wheel-Tracking Device simultaneously; or

b) Four 150-mm (6-in.) diameter specimens grouped in pairs (1 and 1a) representing similar material run in the Hamburg Wheel-Tracking Device simultaneously.

The test results will be reported as the average value of both specimens (a) or both pairs of specimens (b).

9.2. Plot the rut depth versus number of passes for each test. Figure 3 shows a typical plot of the output produced by the Hamburg Wheel-Tracking Device. From this plot, obtain the following values:

- slope and intercept of the first steady-state portion of the curve, and
- slope and intercept of the second steady-state portion of the curve.

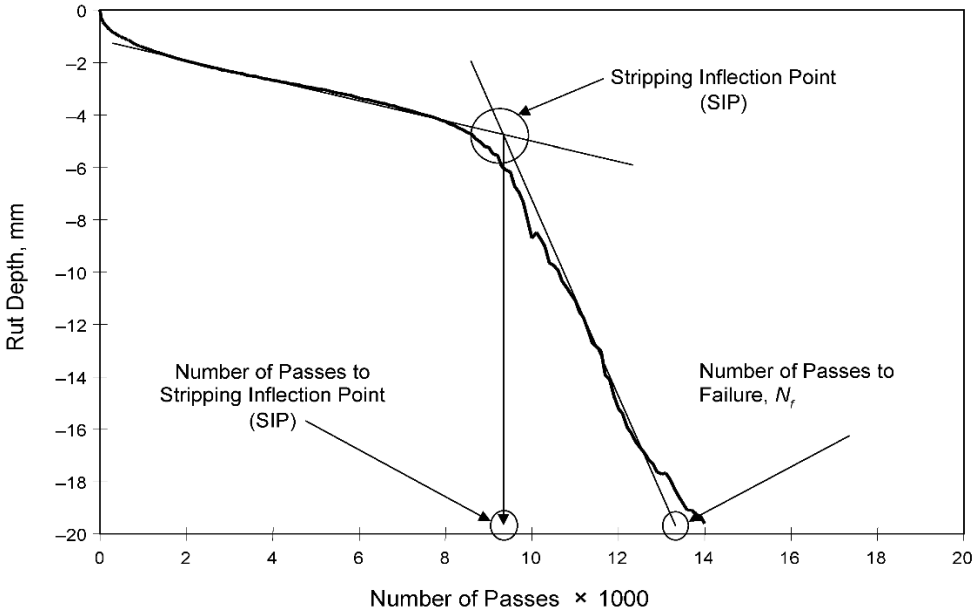


Figure 3—Hamburg Curve with Test Parameters

9.3. Calculate the following test parameters, all expressed in "Passes."

$$\text{stripping inflection point (SIP)} = \frac{\text{intercept (second portion)} - \text{intercept (first portion)}}{\text{slope (first portion)} - \text{slope (second portion)}} \quad (1)$$

where:

Failure rut depth is the specified maximum allowable rut depth for the test.

Note 9—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 must 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.

Note 10—Field-compacted samples have proven to be insufficiently controlled for inclusion in a precision and bias statement.

12. KEYWORDS

12.1. Compacted asphalt mixture; moisture-susceptibility; rutting; wheel-track testing.

ANNEX A—EVALUATING HAMBURG WHEEL DIMENSIONS

(Mandatory Information)

A1. SCOPE

A1.1. This Annex covers the evaluation of the steel wheel as a check for compliance with the requirements outlined in Section 5.1. Measurements of the wheel's diameter, as well as visual inspection of critical surface conditions, are included.

A1.2. Minimum frequency of this evaluation is 12 months.

A2. APPARATUS

A2.1. *Measurement Instrument (Calipers or Micrometer)*—With appropriate range and a minimum resolution of 0.1 mm (0.01 in.). The measurement instrument shall be standardized annually.

A3. PROCEDURE FOR 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 (0.01 in.).

A3.3. Measure the diameter at a 90-degree orientation to the maximum diameter. Record this diameter to the nearest 0.1 mm (0.01 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. INSPECTION REPORT

A4.1. *Record and report the following information*:

A4.1.1. Name of evaluator;

A4.1.2. Date;

A4.1.3. Equipment owner;

A4.1.4. Location of evaluation;

A4.1.5. Hamburg Wheel-Tracker model;

A4.1.6. Diameter measurements of the wheel to the nearest 0.1 mm (0.01 in.); and

A4.1.7. Width of the loading surface of the wheel to the nearest 0.1 mm (0.01 in.).

APPENDIXES

(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.

X2. CALIBRATION/EQUIPMENT VERIFICATION

X2.1. 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. Measure the water bath temperature at four locations per the manufacturer's recommendations. Average the four measurements and report this as the water bath verification temperature.

X2.2. Verify the LVDT calibration in accordance with ASTM D6027 or per the manufacturer's recommendations.

X2.3. Verify the load from the wheel loading assembly at the level position per the manufacturer's recommendations to be 705 ± 4.5 N (158 ± 1.0 lb). A calibrated load cell, accurate to 0.4 N (0.1 lb) is sufficient for this check.

X2.4. Verify that the wheel is reciprocating on the test sample at 52 ± 2 passes per minute.

Illinois Test Procedure 405
Effective Date: January 1, 2016
Modified Date: December 1, 2017

Determining the Fracture Potential of Asphalt Mixtures Using the Illinois Flexibility Index Test (I-FIT)

1. SCOPE

1.1. This test method covers the determination of fracture energy (G_f) and post peak slope of asphalt mixtures using semicircular specimens in the Illinois Flexibility Index Test (I-FIT) conducted at an intermediate test temperature. These parameters are used to calculate the Flexibility Index (FI) to predict the resistance to fracture of an asphalt mixture. The index is used as part of the asphalt mixture evaluation and approval process. The method also includes procedures for calculating other relevant parameters derived from the load-displacement curve.

1.2. These procedures apply to test specimens having a nominal maximum aggregate size (NMAS) of 19 mm or less. Lab compacted and field core specimens can be used. Lab compacted specimens shall be 150 ± 1 mm in diameter and 50 ± 1 mm thick. When field cores are used, specimens shall be 150 ± 8 mm in diameter and 25 to 50 mm thick. A thickness correction factor will need to be developed and applied for field cores tested at a thickness less than 45 mm.

1.3. The I-FIT specimen is a half disc with a notch cut parallel to the loading and the vertical axis of the semicircular disc.

1.4. *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.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- T 166, Bulk Specific Gravity (G_{mb}) of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens
- T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA)
- 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*:

- D 8, Standard Terminology Relating to Materials for Roads and Pavements
- D 3549/D 3549M, Standard Test Method for Thickness or Height of Compacted Bituminous Paving Mixture Specimens
- D 5361/D 5361M, Standard Practice for Sampling Compacted Bituminous Mixtures for Laboratory Testing

3. TERMINOLOGY

3.1. *Definitions:*

3.1.1. *critical displacement, u_1,* —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. *fracture energy, G_f*—the energy required to create a unit surface area of a crack.

3.1.4. *flexibility index*, *FI* — an index intended to characterize the damage resistance of asphalt mixtures.

3.1.5. *linear variable displacement transducer, LVDT*—sensor device for measuring linear displacement.

3.1.6. *ligament area, $Area_{lig}$*—cross-sectional area of the specimen through which the crack propagates, calculated by multiplying the test specimen thickness and ligament length.

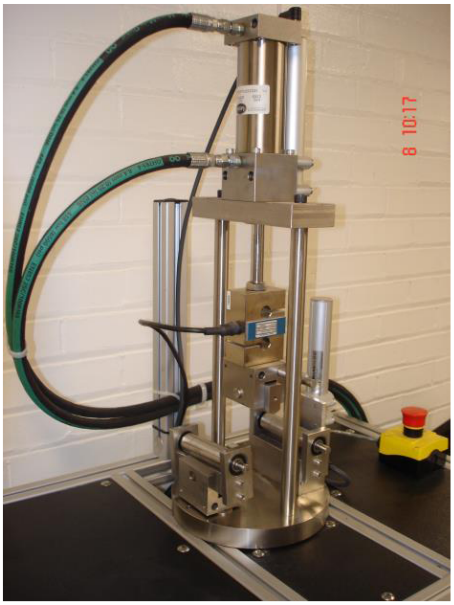
3.1.7. *load line displacement, LLD*—the displacement measured in the direction of the load application.

3.1.8. *post-peak slope, m,* —slope at the first inflection point of the load-displacement curve after the peak.

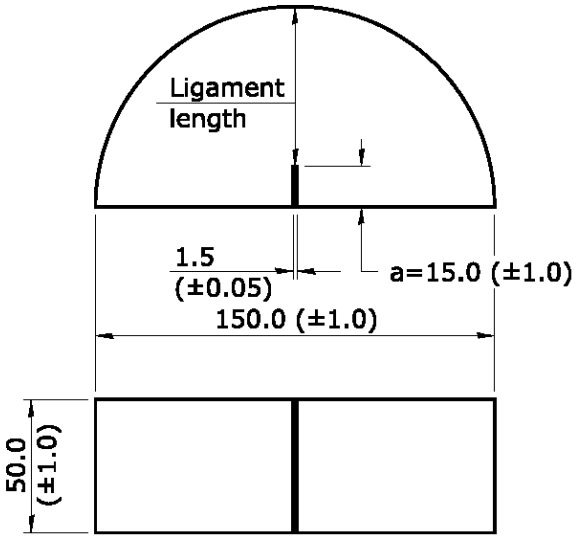
4. SUMMARY OF METHOD

4.1. An asphalt pavement core or Superpave Gyratory Compactor (SGC) compacted asphalt mixture specimen is trimmed and cut in half to create a semicircular shaped 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°C (77°F). 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 loads 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 test fixture and I-FIT specimen geometry are shown in Figure 1.

4.2. Fracture Energy (G_f), post-peak slope (m), displacement at peak load (u_0), strength, critical displacement (u_1), and a FI are calculated from the load and LLD results.



I-FIT Fixture



I-FIT Lab Compacted Specimen

Figure 1— I-FIT Fixture and test specimen and configuration (dimensions in millimeters)

5. SIGNIFICANCE AND USE

5.1. The I-FIT test is used to determine fracture resistance parameters of an asphalt mixture at an intermediate temperature. From the fracture parameters obtained at intermediate temperature, the FI of an asphalt mixture is calculated. The FI is calculated from the G_f and post-peak slope of load-displacement curve. The FI provides a means to identify brittle mixes that are prone to premature cracking. The range for an acceptable FI will vary according to local environmental conditions, application of the mixture, nominal maximum aggregate size (NMAS), asphalt performance grade (PG), air voids, and expectation of service life, etc.

5.2. The calculated G_f indicates an asphalt mixture's overall capacity to resist cracking related damage. Generally, a mixture with higher G_f can withstand greater stresses with higher damage resistance. The FI should not be directly used in structural design and analysis. FI values obtained using this procedure are used in ranking cracking resistance of alternative mixes for a given layer in a structural design. G_f is a specimen size, loading time, and temperature dependent property. Fracture mechanisms for viscoelastic materials are influenced by crack front viscoelasticity and bulk material (far from 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 and support points).

5.3. G_f is used as part of the FI to identify mixtures with increased fracture resistance.

5.4. This test method can be used to measure and evaluate 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 field cores with a diameter of 150 mm.

6. APPARATUS

6.1. *Testing Machine*—An I-FIT test 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 a minimum load of 10N in compression with a minimum resolution of 5N.

6.1.2. *Bend Test Fixture*—The fixture is composed of a loading head, a steel base plate, and two steel rollers with a diameter (D) of 25 mm. The tip of the loading head has a contact curvature with a radius of 12.5 mm. The horizontal loading head shall pivot relative to the vertical loading axis to conform to slight specimen variations. Illustrations of the loading and supports are shown in Figures 2 and 3.

6.1.2.1. *Method* A—Typically the two 25 mm steel rollers are mounted on bearings through their axis of rotation and attached to the steel base plate with brackets. One of the steel rollers pivots on an axis perpendicular to the axis of loading to conform to slight specimen variations. A distance of 120 mm between the two steel rollers is maintained throughout the test.

6.1.2.2. *Method B*—An alternate fixture design uses two 25 mm steel rollers 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 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) can be used (Figure 2 and Figure 3).

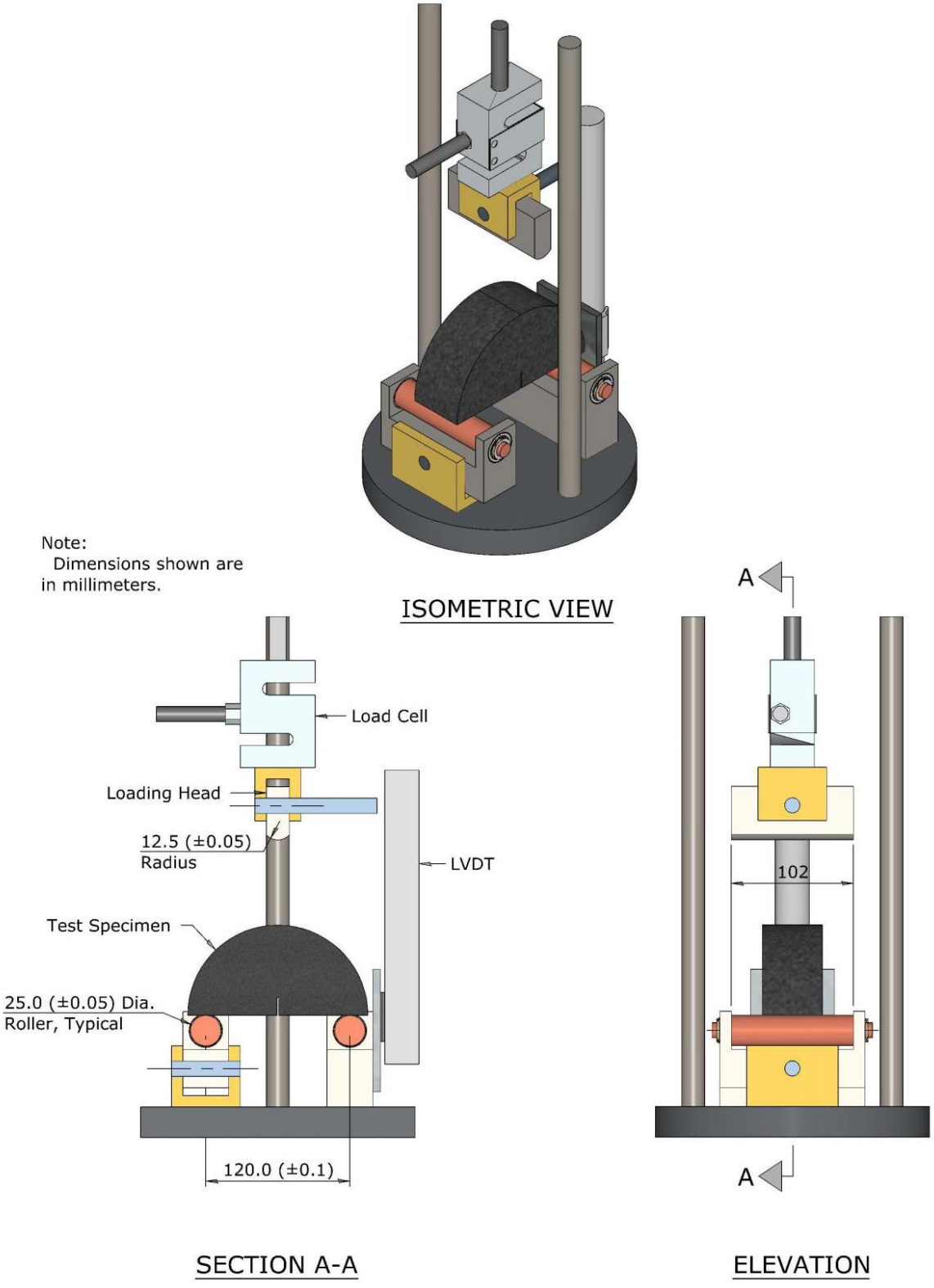


Figure 2— Method A

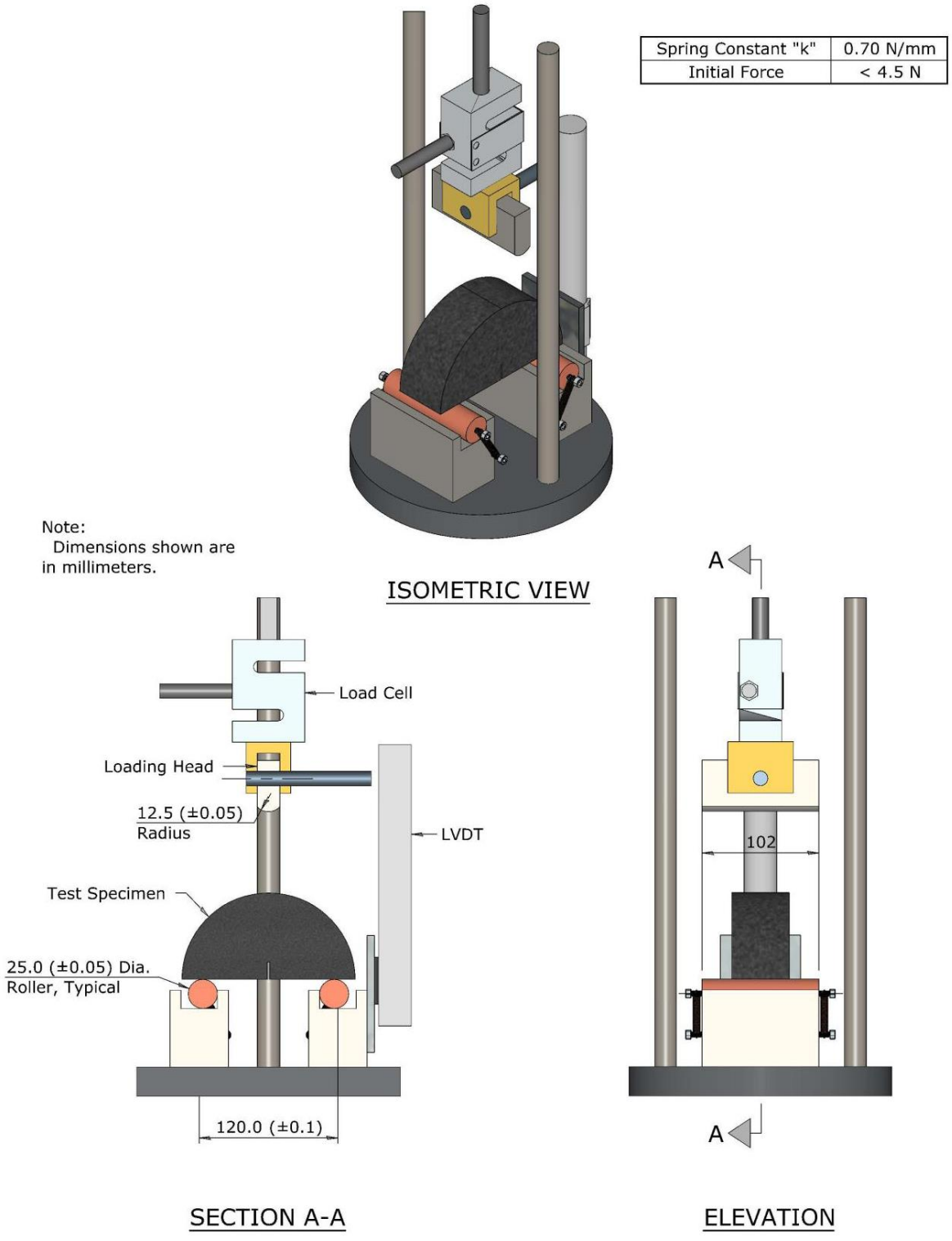


Figure 3—Method B

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-load line displacement curve.

7. HAZARDS

7.1. Standard laboratory caution should be used in handling, compacting and fabricating asphalt mixtures test specimens in accordance with AASHTO 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 will be used to maintain the specimen at a constant and uniform temperature. An environmental chamber may be used in lieu of a water bath.

Note 2— Caution should be used if an oven is selected for conditioning samples as this may result in variable sample conditioning and affect the test results.

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. *Specimen Size*—For mixtures with nominal maximum aggregate size of 19 mm or less, prepare the test specimens from a lab compacted SGC cylinder or from pavement cores. The final I-FIT test cylinders shall have smooth parallel faces with a thickness of 50 ± 1 mm and a diameter of 150 ± 1 mm (see Figure 4). If field specimens are used, the final test specimen dimensions shall be 150 ± 8 mm in diameter with smooth parallel faces 25 to 50 mm thick depending on available layer thickness.

Note 3—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 mm notch in the individual I-FIT test specimens. Diamond-impregnated cutting faces and water cooling are recommended to minimize damage to the specimen. When cutting the I-FIT specimens, 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 results.

SGC Specimens—Prepare a minimum of one laboratory SGC specimen according to T 312 in the SGC with a compaction height a minimum of 160 mm ± 1 mm. From the middle of each 160 mm ± 1 mm-tall specimen, obtain two cylindrical 50 ± 1 mm thick discs (see Figure 4). Cut each disc into two identical "halves" resulting in four individual I-FIT test specimens. **Note 4**—It is recommended that a greater number of SGC specimens (and therefore a greater number of individual test specimens) be fabricated

and tested to reduce the risk of a FI that is not representative of the mixture. This is especially important for marginal mixtures that have test results near the established pass/fail criteria.

Note 5—For laboratory compacted specimens, the air voids shall be determined for each of the two circular discs. The air voids for each disc shall be 7.0 +/- 1.0%. It is suggested that the minimum height of the gyratory compacted specimens shall be a minimum 160 ± 1 mm height to achieve the target 7.0 +/- 1.0% air voids in each of the top and bottom discs (see Figure 4). If target air voids cannot be achieved for each disc with 160 ± 1 mm height of the compacted specimens, then the specimen height can be increased. If specimen height cannot be increased or if a SGC has difficulty in compacting 160 mm tall specimens, then two SGC specimens, each at least 115 mm tall, may be compacted and used instead. A 50 mm thick disc will be cut from the middle of each gyratory specimen which will result in four individual I-FIT test specimens.

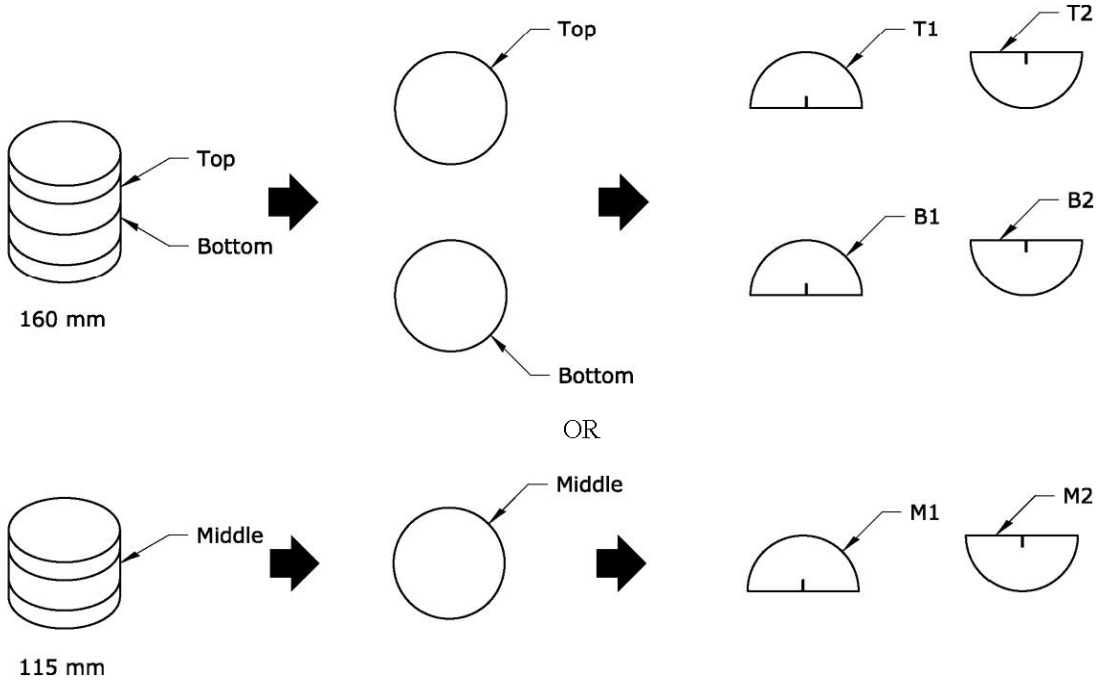


Figure 4— Specimen preparation from 160 mm or 115 mm SGC specimens

9.1.1. *Field Cores*—Obtain field cores from the pavement in accordance with ASTM D 5361. Obtain one 150 mm diameter pavement cores if the lift thickness is greater than 75 mm or two 150 mm diameter cores if the lift thickness is less than 75 mm.

9.1.1.1. *Field Specimens*—From the pavement cores, prepare four replicate I-FIT test specimens with smooth, parallel surfaces that conform to the height and diameter requirements specified herein. The thickness of test specimens in most cases for field cores may vary from 25 to 50 mm. If the lift thickness is less than 50 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 mm whichever is greater. If lift thickness is greater than 50 mm, a 50 mm slice shall be prepared. Cores from pavements with lifts greater than 75 mm may be sliced to provide two cylindrical specimens of equal thickness. Cut each cylindrical specimen exactly in half to produce two identical, semicircular I-FIT specimens. Each slice of the field core shall have parallel, smooth faces.

9.2. *Notch Cutting*— Cut a notch along the axis of symmetry of each individual I-FIT specimen to a depth of 15 ± 1 mm and 1.5 ± 0.1 mm (0.06 in.) in width (see Figure 1).

Note 6—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 (0.75 in.) 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.

9.4. *Determining the Bulk Specific Gravity*—Determine the bulk specific gravity on the discs obtained from SGC cylinders or field cores according to AASHTO T 166.

10. TEST PROCEDURE

10.1. *Conditioning*—Test specimens shall be conditioned in a water bath or an environmental chamber at 25 ± 0.5 °C for 2 ± 0.5 h.

10.1.1. *Temperature Control* —The temperature of the specimen shall be maintained within 0.5 °C of the desired 25 ± 0.5 °C test temperature throughout the conditioning and testing periods. Testing shall be completed within 5 ± 1 minutes after removal from the water bath or environmental chamber.

10.2. *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.

10.3. *Contact Load*— First, impose a small contact load of 0.1 ± 0.01 kN in stroke control with a loading rate of 0.05 kN/s.

10.3.1. *Record Contact Load*— Record the contact load to ensure it is achieved.

10.3.2. *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. PARAMETERS

11.1. *Determining Work of Fracture (W_f)*—The work of fracture is calculated as the area under the load vs. load line displacement curve (see Figure 5).

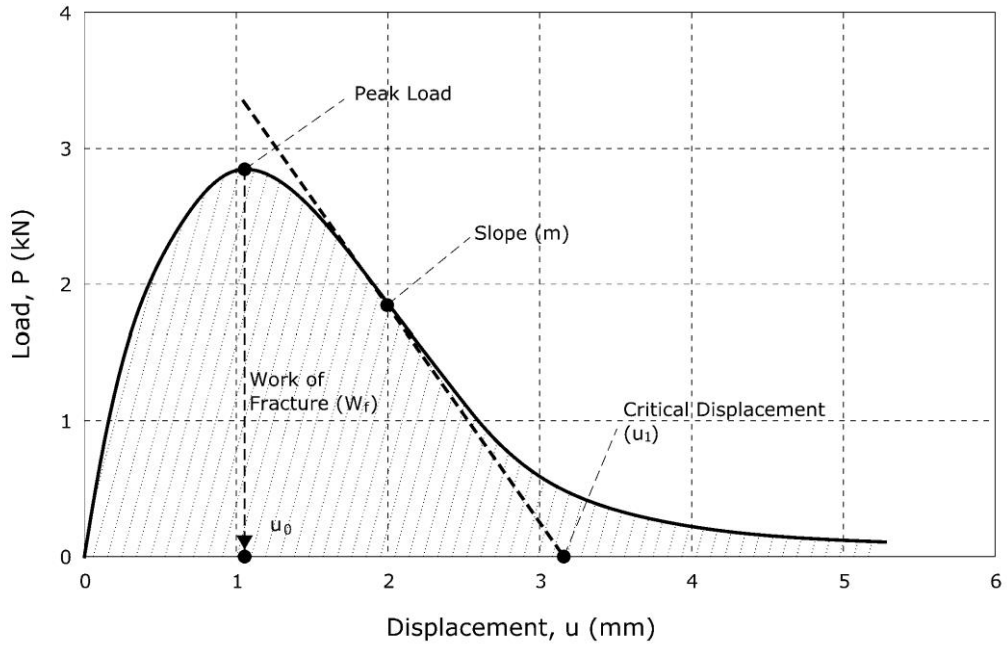


Figure 5—Recorded load (P) versus load line displacement (u) curve

11.2. *Fracture Energy (G_F)*— G_F is calculated by dividing the work of fracture (W_f) by the ligament area (the product of the ligament length and the thickness of the specimen) of the specimen measured prior to testing:

$$G_f = \frac{W_f}{Area_{lig}} \qquad \text{Equation 1}$$

where:

G_f = fracture energy (Joules/m^2);

W_f = work of fracture (Joules)

P = load (kN);

u = displacement (mm);

$Area_{lig}$ = ligament area = (r – a) *x* t, (mm^2)

r = specimen radius (mm);

a = notch length (mm);

t = specimen thickness (mm)

m = post-peak slope (kN/mm)

Note 7—G_f is a size dependent property. This specification does not aim at calculating size independent G_f. Therefore, cracking resistance of asphalt mixes quantified with G_f may vary when the notch length to radius ratio changes.

11.3. *Determining post-peak slope (m)* — The inflection point is determined on the load-displacement curve (Figure 5) after the peak load. The slope of the tangential curve drawn at the inflection point represents post-peak slope.

11.4. *Determining displacement at peak load (u_o)* — Find the displacement when peak load is reached.

11.5. *Determining critical displacement (u_1)* — Intersection of the tangential 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.

11.6. *Flexibility Index (FI)* — Flexibility Index can be calculated (by the software) from the parameters obtained using the load displacement curve. The factor A is used for unit conversion and scaling. "A" is equal to 0.01.

$$FI = \frac{G_f}{|m|} \times A \qquad \text{Equation 2}$$

where:

$|m|$= absolute value of m.

Note 8—When four individual I-FIT specimens are tested, the FI value that is farthest from the average of the four shall be discarded as an outlier to lower the variability of the average FI value that is reported.

12. CORRECTION FACTORS

12.1. *Shift factor from lab to field specimens* — Apply a shift factor between SGC and pavement core specimens based on the age of field specimens, different criteria based on design, plant mix, and aged for different times. This shift factor still needs to be determined.

13. REPORT

13.1. *Report the following information*:

13.1.1. Bulk specific gravity of each specimen tested, to the nearest 0.001;

13.1.2. Average air void content of each disc, to the nearest 0.1;

13.1.3. Thickness t and ligament length of each specimen tested, to the nearest 0.1 mm;

13.1.4. Initial notch length a, to the nearest 0.5 mm;

13.1.5. Peak load and coefficient of variation (COV) of peak load, to the nearest 0.1 kN;

13.1.6. Post-peak slope and COV of post-peak slope (m), to the nearest 0.1 kN/mm

13.1.7. G_f and COV of G_f to the nearest 1 J/m².

13.1.8. FI and COV of FI to the nearest 0.1.

14. PRECISION AND BIAS

14.1. *Precision*— The research required to develop precision estimates has not been conducted.

14.2. *Bias*— The research required to establish the bias of this method has not been conducted.

15. KEYWORDS

15.1. Fracture energy; asphalt mixture; Illinois flexibility index test (I-FIT); stiffness; work of fracture; flexibility index.

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 **(C)**.

EXAMPLES OF PYCNOMETER CALCULATIONS

What are the average pycnometer weights in the following examples?

Example 1	Example 2	Example 3
4001.5 4001.6 4001.9	4001.3 4001.9 4001.5	4001.2 4001.8 4001.5

SAMPLE PREPARATION

A. Split sample to size needed

   (1) For correct sample size see page 7-17, Section 7-Sampling, Table 7.2

   (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 **(B)**.

G. Calculate maximum specific gravity G_{mm} (D)

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

Where:

A = mass of oven-dry sample in air
B = mass of sample and pycnometer submerged in water at 77°± 1.8°F (25°±1°C)
C = mass of 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	Sample 2
1. Dry sample weight	(A)	_____	_____
2. Averaged calibrated Pycnometer weight (Pycnometer suspended in water bath)	(C)	_____	_____
3. Vacuumed sample weight (Pycnometer + sample suspended in water bath)	(B)	_____	_____
4. Maximum Specific Gravity (report to 3 places, **[2.xxx]**)		_____	_____

$$\frac{A}{A-(B-C)}$$

Average G_{mm}(D) _____ **(2.xxx)**

Pycnometer Calibration Weights

1. _____ _____
2. _____ _____
3. _____ _____

(A) = Oven dry sample weight

(C) = Calibrated Pycnometer weight

(B)= 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

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

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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 $_{mix\ bulk}$) - 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$_{mix\ maximum}$) - 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, 2017

Standard Method of Test
for
Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA)

Reference AASHTO T 209-12 (2016)

AASHTO *Section*	**Illinois Modification**
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.
4.1	Replace the second sentence with the following: Sufficient water at a temperature of 25 ± 1°C (77 ± 1.8°F) is added to completely submerge the sample. Delete the last sentence.
6.4.1	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.
6.8.1	Replace with the following: The water bath shall be maintained at a constant temperature of 25 ± 1°C (77 ± 1.8°F) during testing.
6.9	Replace with the following: *Drying Oven* – A thermostatically controlled drying oven capable of maintaining a temperature of 110 ± 5°C (230 ± 9°F).
8.1	Replace with the following: For the weighing-in-water method (Section 13.1), standardize the volumetric flasks or pycnometers by determining the mass of the container when submerged in water at 25 ± 1°C (77 ± 1.8°F). Complete the process three times and average the results for the proper calibration. Designate this mass as *C*.
Figure 2	Delete

Illinois Modified Test Procedure
Effective Date: February 5, 2008
Revised Date: December 1, 2017

Standard Method of Test
for
Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA)

Reference AASHTO T 209-12 (2016)

AASHTO *Section*	**Illinois Modification**
8.2	Replace with the following: For the weighing-in-air method (Section 13.2), calibrate the volumetric flasks or pycnometers by determining the mass of the container when filled with water at 25 ± 1°C (77 ± 1.8°F). Complete the process three times and average the results for the proper calibration. Designate this mass as *D*. Accurate filling may be ensured by the use of a glass cover plate.
Figure 3	Delete
8.3	Delete
8.3.1	Delete
8.3.2	Delete
8.3.3	Delete
Note 5	Delete
Figure 4	Delete (with definitions and explanations)
9.2	Replace the first two sentences with the following: Samples prepared in a laboratory shall be conditioned and dried in an oven according to IL-mod AASHTO R30. Longer drying time may be necessary for a sample to achieve 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.
Note 6	Replace the first sentence with the following: The minimum time in the oven is specified as short-term conditioning time for laboratory-prepared specimens.
13.1	Replace with the following: *Mass Determination in Water* - Suspend the container and contents in the 25 ± 1°C (77 ± 1.8°F) water bath and determine the mass after 10 ± 1 min immersion. Designate the mass of the container and the sample in water as *B.*

Illinois Modified Test Procedure
Effective Date: February 5, 2008
Revised Date: December 1, 2017

Standard Method of Test
for
Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA)

Reference AASHTO T 209-12 (2016)

AASHTO *Section*	**Illinois Modification**
Note 8	Delete
Note 9	Delete
14.1.1	Replace with the following: *Mass Determination in Water:* Theoretical Maximum Specific Gravity $= \frac{A}{A-(B-C)}$ where: *A* = mass of oven-dry sample in air, g; B = mass of sample and pycnometer submerged in water at 25°C (77°F), g; and C = mass of pycnometer submerged in water at 25°C (77°F), g.
14.1.3.1	Delete
14.1.3.2	Delete
Figure 5	Delete
Figure 6	Delete
Note 10	Delete
Note 11	Delete
15	This section shall be used only with approval of the Engineer.
Appendix	Delete

Standard Method of Test for

Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA)

AASHTO Designation: T 209-12 (2016)

AASHTO

Technical Section: 2c, Asphalt–Aggregate Mixtures

Release: Group 3 (August 2016)

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 hot mix asphalt (HMA) 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.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 231, Weighing Devices Used in the Testing of Materials
- R 47, Reducing Samples of Hot Mix Asphalt (HMA) to Testing Size
- R 61, Establishing Requirements for Equipment Calibrations, Standardizations, and Checks
- T 168, Sampling Bituminous Paving Mixtures

2.2. *ASTM Standards*:

- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- D4311/D4311M, Standard Practice for Determining Asphalt Volume Correction to a Base Temperature

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. SUMMARY OF TEST METHOD

4.1. A weighed sample of oven-dry HMA in the loose condition is placed in a tared vacuum container. Sufficient water at a temperature of 25 ± 0.5°C (77 ± 0.9°F) is added to completely submerge the sample. Vacuum is applied for 15 ± 2 min to gradually reduce the residual pressure in the vacuum container to 3.7 ± 0.3 kPa (27.5 ± 2.5 mmHg). At the end of the vacuum period, the vacuum is gradually released. The volume of the HMA sample is obtained either by immersing the vacuum container with the sample into a water bath and determining the mass (Section 13.1) or by filling the vacuum container level full of water and determining the mass in air (Section 13.2). At the time of weighing, the temperature is measured as well as the mass. From the mass and volume measurements, the specific gravity or density at 25°C (77°F) is calculated. If the temperature employed is different than 25°C (77°F), an appropriate correction is applied.

5. SIGNIFICANCE AND USE

5.1. The theoretical maximum specific gravities and densities of HMA are intrinsic properties whose values are influenced by the composition of the mixtures in terms of types and amounts of aggregates and asphalt materials.

5.1.1. These properties are used to calculate percent air voids in compacted HMA.

5.1.2. These properties provide target values for the compaction of HMA.

5.1.3. These properties are essential when calculating the amount of asphalt binder absorbed by the internal porosity of the individual aggregate particles in HMA.

6. APPARATUS

6.1. Follow the procedures for performing equipment calibrations, standardizations, and checks found in R 61.

6.2. *Vacuum Container*:

6.2.1. 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.

6.2.2. 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 7.2. Avoid using a small sample in a large container.

6.2.3. *Vacuum Bowl*—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.

6.2.4. *Vacuum Flask for Mass Determination in Air Only (Section 13.2)*—A thick-walled volumetric glass flask and a rubber stopper with a connection for the vacuum line.

6.2.5. *Pycnometer for Mass Determination in Air Only*—A glass, metal, or plastic pycnometer.

6.3. *Balance*—A balance conforming to the requirements of M 231, Class G 2. The balance shall be standardized at least every 12 months.

6.3.1. For the mass determination-in-water method (Section 13.1), 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.

6.4. *Vacuum Pump or Water Aspirator*—Capable of evacuating air from the vacuum container to a residual pressure of 4.0 kPa (30 mmHg).

6.4.1. When a 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.

6.5. *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 4.0 kPa (30 mmHg) or less (preferably to zero). The gauge shall be standardized at least annually and be accurate to 0.1 kPa (1 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.

Note 2—A residual pressure of 4.0 kPa (30 mmHg) absolute pressure is approximately equivalent to a 97 kPa (730 mmHg) reading on a vacuum gauge at sea level.

Note 3—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.

Note 4—An example of a correct 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. Insertion of a valve to isolate the line to each vacuum chamber can reduce wear on the bleeder valve atop each chamber and assist in tracing sealing leaks.

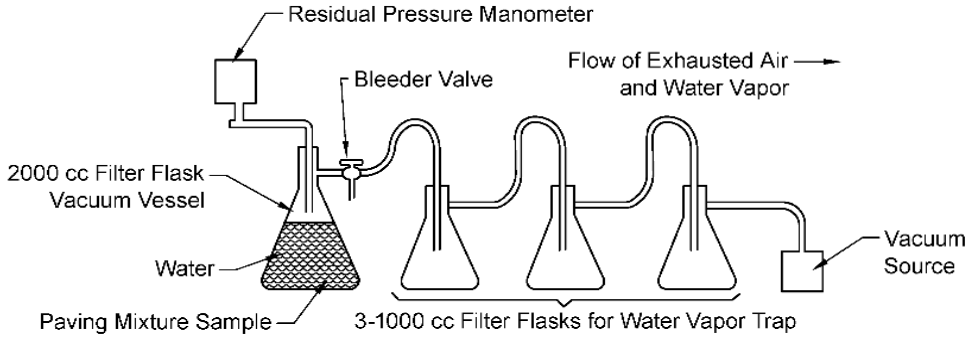

Figure 1—Example of Correct Arrangement of Testing Apparatus

6.6. *Bleeder Valve*—attached to the vacuum train to facilitate adjustment of the vacuum being applied to the vacuum container.

6.7. *Thermometric Device (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 thermometric device shall be standardized at the test temperature at least every 12 months.

6.8. *Water Bath*:

6.8.1. For vacuum bowls, a water bath capable of maintaining a constant temperature between 20 and 30°C (68 and 86°F) is required. [See Appendix X1 for a method for correcting the theoretical maximum specific gravity to 25°C (77°F) when measurements are made at temperatures other than 25°C (77°F)].

6.8.2. *Thermometric Device (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 thermometric device shall be standardized at least every 12 months.

6.8.3. 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.

6.9. *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).

6.9.1. *Thermometric Device*—A liquid-in-glass thermometer or other thermometric device accurate to 3°C (5°F) shall be used to measure the temperature of the oven. The thermometric device shall be standardized at least every 12 months.

6.10. *Protective Gloves*—Used when handling glass equipment under vacuum.

7. SAMPLING

7.1. Field samples shall be obtained in accordance with T 168. When necessary, reduce field samples or samples prepared or produced in a laboratory in accordance with R 47.

7.2. 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

8. STANDARDIZATION OF FLASKS, BOWLS, AND PYCNOMETERS

8.1. For the mass determination-in-water method (Section 13.1), standardize the vacuum bowls for temperature correction by determining the mass of each container when immersed in water over the range of water bath temperatures likely to be encountered in service (Figure 2).

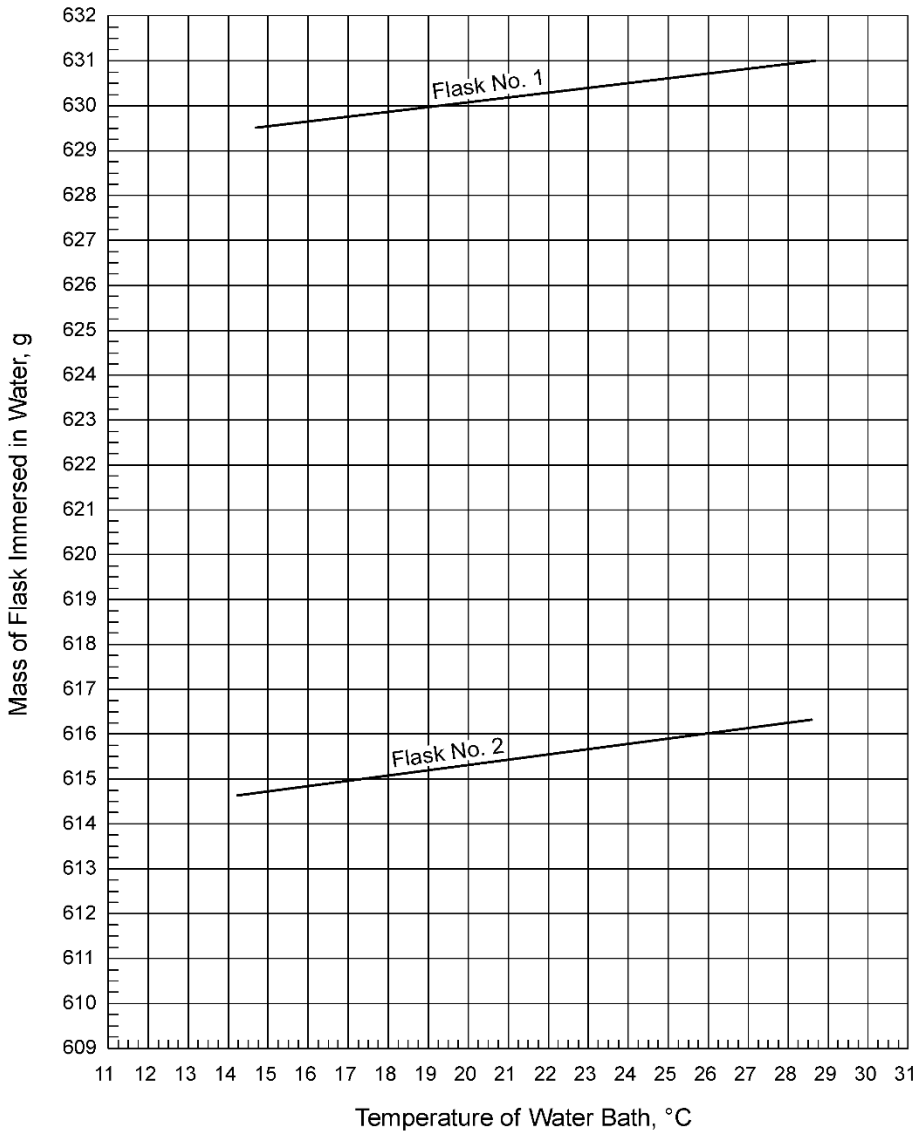

Figure 2—Example Standardization Curve for Volumetric Flask

8.2. For the mass determination-in-air method (Section 13.2), standardize the volumetric flasks or pycnometers for temperature correction by determining the mass of the container when filled with water over the range of water bath temperatures likely to be encountered in service (Figure 3). When standardized at 25 ± 0.5°C (77 ± 0.9°F), designate this mass as *D*. Accurate filling may be ensured by the use of a glass cover plate.

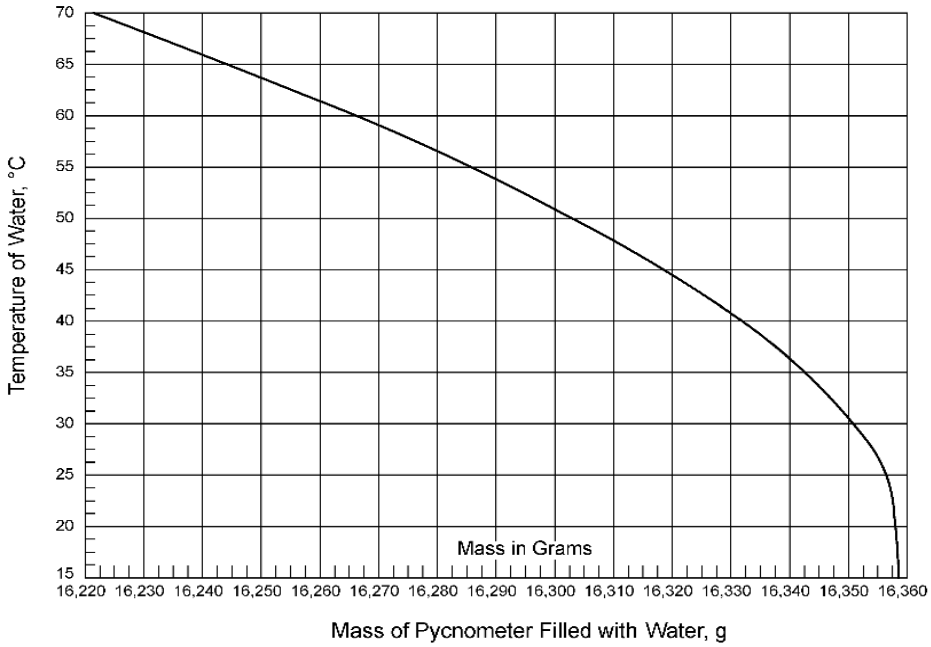

Figure 3—Example Standardization Curve for Pycnometer

8.3. Standardize the large-size plastic pycnometer by accurately determining the mass of water required to fill it over a temperature range from about 20 to 65°C (70 to 150°F), and construct a standardization curve of mass versus temperature as shown in Figure 3. Care should be taken to follow exactly the same procedure in standardization as in conducting a test.

8.3.1. The following filling procedure may be used for the model with a latched lid and vented stopper: The domed lid is latched in place and the pycnometer nearly filled with water. Leave about 50 mm (2 in.) empty. The release of air bubbles may be facilitated by applying vacuum and by dropping first one side then the other of the pycnometer about 10 mm ($^1/_2$ in.) above a hard, flat surface. This vacuum application and bubble release procedure should take about 10 min so that the temperature equilibrium between the shell and the water approximates that attained when performing a test. The final amount of water is then gently poured in until the level is about halfway up the neck. Any air bubbles caught against the dome that cannot be released by jarring or by swirling the water may be "pricked" or pushed to the surface with a bent wire or other suitable device. Insert the vented stopper using only enough force to just seat the stopper and immediately wipe the excess water off the top.

8.3.2. For models with a quick-disconnect vacuum line and unlatched lid, the filling procedure is as follows: With the inlet valve closed, apply a vacuum of about 30 kPa (225 mmHg). Open the inlet valve slowly, letting water in until the level reaches 25 mm (1 in.) below the top of the dome and close the valve. Continue applying vacuum and release the bubbles by jarring and rapping the vessel with a rubber mallet. Slowly open the inlet valve and allow more water in until the water overflows into the aspirator (vacuum) line and then close the valve. This vacuum application and bubble release procedure should take about 10 min so that the temperature equilibrium between the shell and the water approximates that attained when performing a test. Disconnect the vacuum line by pulling it out at the quick-disconnect joint below the gauge.

8.3.3. Wipe the outside of the pycnometer dry, determine the mass of the full pycnometer, and measure the water temperature.

Note 5—The shape of the standardization curve is a function of two opposing factors that can be rationally defined. As the temperature is increased, the container itself expands (adding mass—"Pycnometer" line in Figure 4) and the density of the contained water decreases (resulting in loss of mass—"Water" line in Figure 4). These relationships are shown in Figure 4 for a typical large-size pycnometer. The "Water" curve may be constructed by multiplying the volume at 25°C (77°F) by the difference between the density of water at 25°C (77°F), which is 0.9970, and the density of water at the standardization temperature (see Equation 1).

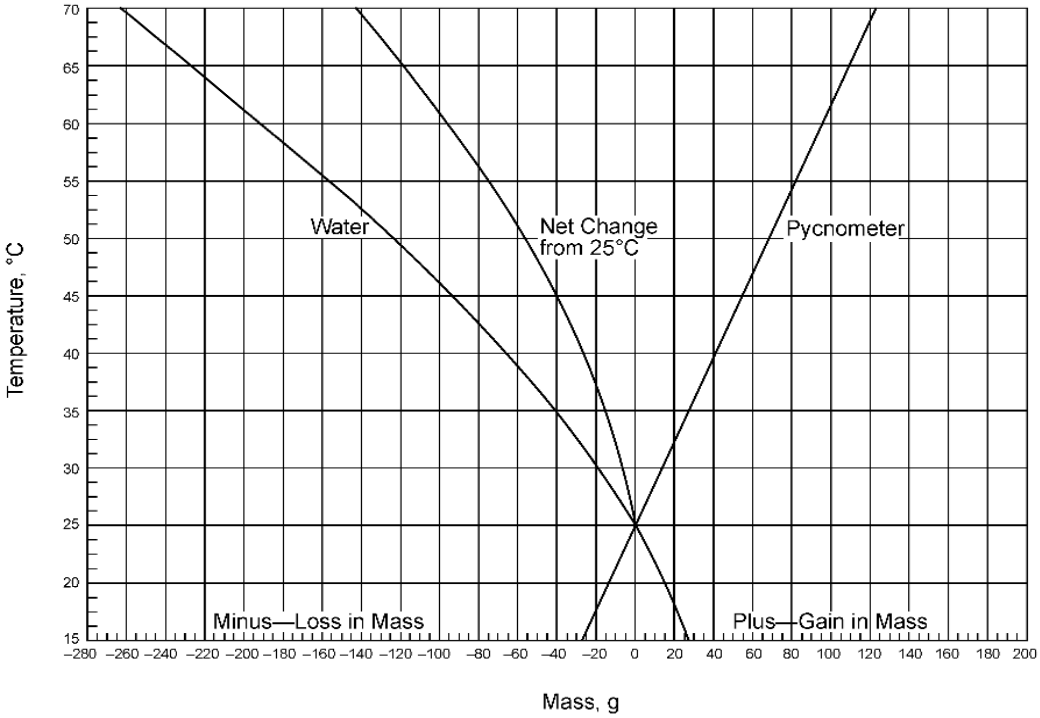

Figure 4—Effect of Change in Density of Water and Volume of Pycnometer with Change in Temperature

$$\text{difference due to water expansion} = V_{25}(0.9970 - dw)$$

Since $V_{25} = W_{25}/0.9970$,

$$V_{25}(0.9970 - dw) \text{ reduces to } W_{25}\left(1 - \frac{dw}{0.9970}\right) \qquad (1)$$

where:

V_{25} = volume of water to fill a container at 25°C (77°F), cm^3;
W_{25} = mass of water to fill a container at 25°C (77°F), g; and
dw = density of water at the standardization temperature, Mg/m^3.

The rate of change in capacity of the container due to thermal expansion of the pycnometer itself is essentially constant over the temperature range from 20 to 65°C (70 to 150°F). Thus, the "Pycnometer" line in Figure 4 can be drawn through the 0 at 25°C (77°F) point knowing only the slope of the straight line relationship. The slope can be established by averaging at least five standardization mass determinations at some elevated temperature, adding the loss due to water

expansion and subtracting the mass at 25°C (77°F), W_{25}, to give the gain in capacity due to expansion of the container. The difference in mass divided by the difference in temperature is the slope of the "Pycnometer" line. For a polycarbonate pycnometer of about 13,500-mL capacity, the slope thus established was 2.75 g/°C (1.53 g/°F). This value is believed to be typical and reasonably constant.

The bending of the standardization curve (Figure 3) due to these offsetting thermal factors thus minimizes experimental error due to temperature effects in the normal working range, 25°C (77°F), for both the volumetric flask and the pycnometer containers. Defining the standardization curve makes it possible to correct for temperature, rather than "bringing the container and sample to temperature," thereby eliminating the cost of a water bath and making it feasible to improve accuracy by testing larger samples and to materially reduce the testing time.

8.4. While standardization of the flask or either pycnometer needs to be performed only once, the standardization should be checked occasionally, particularly at 25°C (77°F). The equipment must be kept clean and free from any accumulation that would change the mass if the volume standardization is to remain constant. Care should be taken to use only neutral solvents, especially with plastic containers; glass vessels should not be subjected to high vacuum if they are scratched or damaged.

9. SAMPLE PREPARATION

9.1. Separate the particles of the HMA 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 HMA 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.

9.2. Samples prepared in a laboratory shall be conditioned and dried in an oven at 135 ± 5°C (275 ± 9°F) for a minimum of 2 h or as appropriate to match the mix design procedure being used. Longer drying time may be necessary for the sample to achieve a constant mass (mass repeats within 0.1 percent). HMA that has not been prepared in a laboratory with oven-dried aggregates shall be dried to a constant mass at a temperature of 105 ± 5°C (221 ± 9°F). This drying and conditioning operation shall be combined with any warming described in Section 9.1.

Note 6—The minimum 2 h time in the oven is specified as the short-term conditioning time for laboratory-prepared specimens. The 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 HMA should not be short-term conditioned because absorption takes place during production.

9.3. Cool the sample to room temperature, and place it in a tared and standardized flask, bowl, or pycnometer. The sample is to be placed directly into a vacuum container. A container within a container is not to be used. Determine the mass and designate the net mass of the sample as *A*. Add sufficient water at a temperature of approximately 25°C (77°F) to cover the sample completely.

Note 7—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

10. APPARATUS

10.1. In addition to the apparatus listed in Section 6, the following apparatus is required for Method A:

10.1.1. *Mechanical Shaker*—Shaker for removing air from asphalt mix.

11. PROCEDURE

11.1. Remove air trapped in the sample by applying gradually increased vacuum until the residual pressure manometer reads 3.7 ± 0.3 kPa (27.5 ± 2.5 mmHg). Maintain this residual pressure for 15 ± 2 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.

11.2. 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 13.

TEST METHOD B—MANUAL AGITATION

12. PROCEDURE

12.1. Remove air trapped in the sample by applying gradually increased vacuum until the residual pressure manometer reads 3.7 ± 0.3 kPa (27.5 ± 2.5 mmHg). Maintain this residual pressure for 15 ± 2 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.

12.2. 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 13.

13. MASS DETERMINATION

13.1. *Mass Determination in Water*—Suspend the container and contents in the water bath and determine the mass after a 10 ± 1 min immersion. Measure the water bath temperature, and if different from 25 ± 1°C (77 ± 2°F), correct the mass to 25°C (77°F) using the standardization temperature adjustment developed in Section 8.1. Designate the mass of the sample in water at 25°C (77°F) as *C*.

Note 8—Instead of using a chart like Figure 2 to establish the mass correction for the temperature of the vacuum vessel submerged by itself in the water bath, this correction can be easily established by rapidly and completely emptying the vacuum container immediately following the final mass determination, and then without delay, determining the mass of the vessel by itself when totally submerged in the water bath.

13.2. *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 the mass of the container and contents, completely filled, in accordance with Section 8.2 within 10 ± 1 min after completing Section 11.1 or 12.1. Designate this mass as *E*.

Note 9—See Appendix X1 for correcting the theoretical maximum specific gravity when measurements are made at temperatures other than 25°C (77°F).

14. CALCULATION

14.1. Calculate the theoretical maximum specific gravity (G_{mm}) of the sample at 25°C (77°F) as follows:

14.1.1. *Mass Determination in Water*:

$$\text{theoretical maximum specific gravity} = \frac{A}{A - C} \qquad (2)$$

where:

A = mass of the oven-dry sample in air, g; and
C = mass of the sample in water at 25°C (77°F), g.

14.1.2. *Mass Determination in Air*:

$$\text{theoretical maximum specific gravity} = \frac{A}{A + D - E} \qquad (3)$$

where:

A = mass of the oven-dry sample in air, g;
D = mass of the container filled with water at 25°C (77°F), g; and
E = mass of the container filled with the sample and water at 25°C (77°F), g.

14.1.3. *Large-Size Plastic Pycnometer Determinations*:

14.1.3.1. If the test temperature is between 22.2 and 26.7°C (72 and 80°F), Equation 3 may be used to calculate specific gravity (G_{mm}) within a minor amount of error due to thermal effects (0.001 points or less).

14.1.3.2. If the test temperature differs significantly from 25°C (77°F), correct for thermal effects as follows:

$$\text{specific gravity} = \frac{A}{(A + F) - (G + H)} \times \frac{dw}{0.9970} \qquad (4)$$

where:

A = mass of the oven-dry sample in air, g;
F = mass of the pycnometer filled with water at the test temperature (Figure 3), g;
G = mass of the pycnometer filled with water and the sample at the test temperature, g;
H = correction for thermal expansion of asphalt (Figure 5), g;
dw = density of water at the test temperature, Curve D in Figure 6, Mg/m^3; and
0.9970 = density of water at 25°C (77°F), Mg/m^3.

The ratio (dw/0.9970) is Curve R in Figure 6.

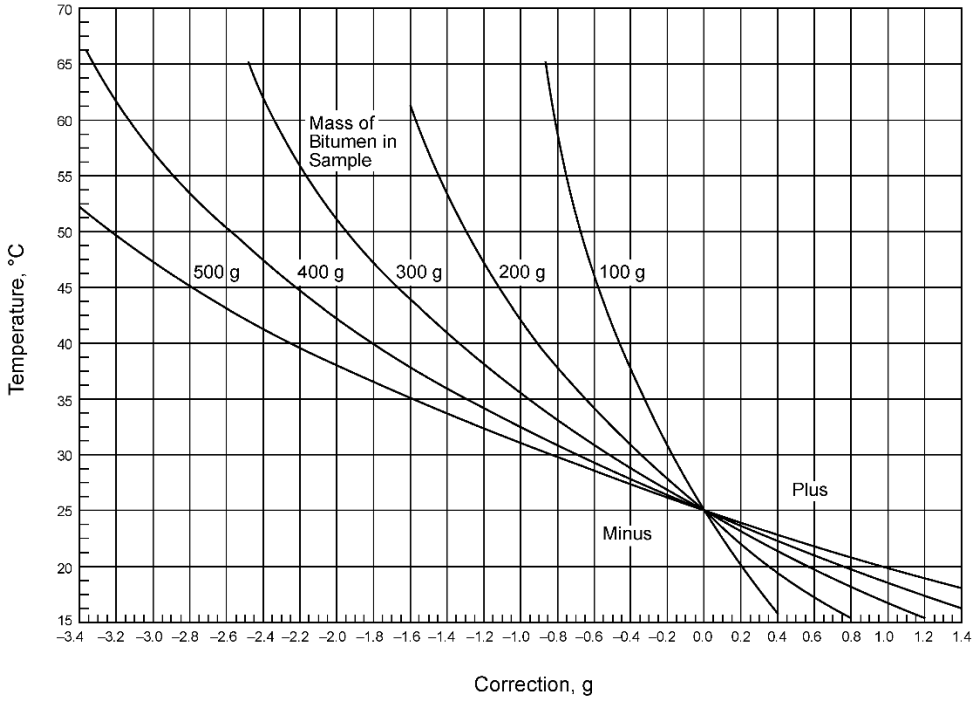

Figure 5—Correction Curves for Expansion of Asphalt, *H*, in Equation 4

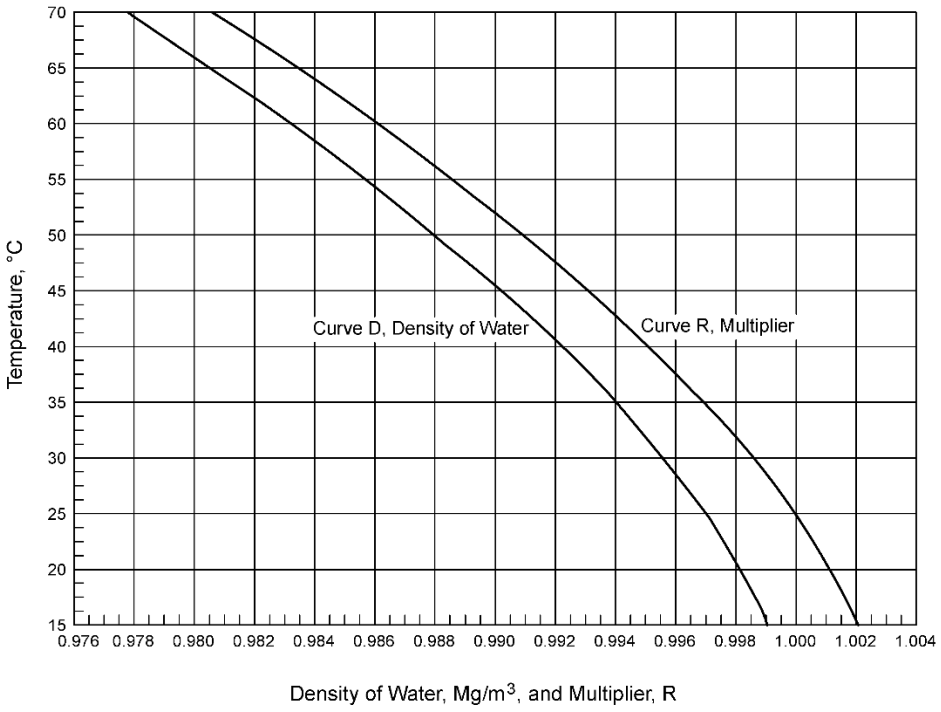

Figure 6—Curves D and R for Equation 4

Note 10—This general procedure for correcting for thermal effects should also be applicable to corresponding measurements made with other suitable containers.

Note 11—When samples are tested a portion at a time, differences between the maximum specific gravities for each portion should be within the precision statements listed in Section 17. If the values are within the precision statements, the specific gravities for each portion shall be averaged. If the values are outside the precision statements, the test shall be performed again.

14.2. *Theoretical maximum density (G_{mm}) at 25°C (77°F)*:

14.2.1. Calculate the corresponding theoretical maximum density (G_{mm}) 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.

15. SUPPLEMENTAL PROCEDURE FOR MIXTURES CONTAINING POROUS AGGREGATE

Note 12—Experiments indicate that this supplemental procedure has an insignificant effect on the test results if the HMA contains individual aggregate with a water absorption below 1.5 percent.

15.1. 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 13.1 or 13.2. 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.

15.2. If the aggregate has absorbed water, spread the sample before an electric fan to remove the surface moisture. Determine 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 HMA by hand. Take care to prevent loss of the HMA particles.

15.3. To calculate the specific gravity of the sample, substitute the final surface-dry mass determined in Section 15.2 for A in the denominator of Equation 2 or 3 as appropriate.

16. REPORT

16.1. *Report the following information*:

16.1.1. G_{mm} and density of the HMA 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);

16.1.2. Type of HMA;

16.1.3. Size of the sample;

16.1.4. Number of samples;

16.1.5. Type of container; and

16.1.6. Type of procedure.

17. PRECISION

17.1. 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		
Method A[a]		
Single-operator precision	0.0051	0.014
Multilaboratory precision	0.0084	0.024
Method B[b]		
Single-operator precision	0.0064	0.018
Multilaboratory precision	0.0103	0.029

[a] Basis of estimate: 1 replicate, 1 material, 344 laboratories.

[b] Basis of estimate: 1 replicate, 1 material, 134 laboratories.

17.2. 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.

17.3. 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: $0.004 \times 3.3 = 0.013$.

Additional guidance and background is given in ASTM C670.

18. KEYWORDS

18.1. Agitation; asphalt mixture; hot mix asphalt; maximum density; maximum specific gravity; pycnometer; vacuum.

APPENDIX

(Nonmandatory Information)

X1. THEORETICAL MAXIMUM SPECIFIC GRAVITY FOR LOOSE HMA

X1.1. *Scope*:

X1.1.1. This appendix has two objectives:

X1.1.1.1. To indicate a method for correcting the theoretical maximum specific gravity to 25°C (77°F) when measurements are made at temperatures other than 25°C (77°F).

X1.1.1.2. To indicate the range of temperature in °C above or below 25°C (77°F) within which no temperature correction is required, because the measured theoretical maximum specific gravity values are shown to be 0.0004 or less away from the value determined at 25°C (77°F).

X1.2. *Indicated Values*:

X1.2.1. The following example values are indicated for the theoretical maximum specific gravity of a loose HMA sample:

X1.2.1.1. Mass of the loose HMA sample = 1251.3 g.

X1.2.1.2. Volume of the loose HMA sample at 25°C (77°F) = 492.77 mL.

X1.2.1.3. Asphalt binder content = 5.0 percent of total mix.

X1.2.1.4. Specific gravity of the asphalt at 25°C (77°F) = 1.029.

X1.2.1.5. Combined bulk specific gravity of the aggregate = 2.714.

X1.2.1.6. Cubical coefficient of expansion of the asphalt binder at 20°C (68°F) = 6.2×10^{-4} mL/mL/°C (ASTM D4311/D4311M).

X1.2.1.7. Cubical coefficient of expansion of the aggregate at 20°C (68°F) = 2.2×10^{-5} mL/mL/°C.[2]

X1.3. *Basis of Calculation for 1 g of Loose HMA at 20°C (68°F)*:

X1.3.1. Mass of the asphalt binder = 0.05 g.

X1.3.2. Volume of the asphalt binder = 0.05/1.029 = 0.0486 mL.

X1.3.3. Mass of the aggregate = 0.95 g.

X1.3.4. Volume of the aggregate = 0.95/ 2.714 = 0.3500 mL.

X1.3.5. Volume of the asphalt binder plus aggregate in 1 g of loose HMA at 20°C (68°F) = 0.0486 + 0.3500 = 0.3986 mL.

X1.4. *Basis of Calculation for Volume Change of 1 g of Loose HMA for1°C (2°F) from 20°C (68°F)*:

X1.4.1. Volume change for the asphalt binder = $6.2 \times 10^{-4} \times 0.0486 = 0.3013 \times 10^{-4}$ mL = 3.0130×10^{-5} mL.

X1.4.2. Volume change for the aggregate = $2.2 \times 10^{-5} \times 0.3500 = 0.77 \times 10^{-5}$ mL.

X1.4.3. Volume change for 1 g of loose HMA for 1°C (2°F) change in temperature from 20°C (68°F) = $3.0130 \times 10^{-5} + 0.7700 \times 10^{-5} = 3.7830 \times 10^{-5}$ mL.

X1.5. *Volume Correction*:

X1.5.1. For a difference in water temperature of 1°C (2°F) above or below 20°C (68°F), a correction to the volume of water displaced by 1 g of loose HMA can be made by the following equation:

$$\text{correction} = \Delta T \times K_T \times V_T \text{ mL} \qquad (X1.1)$$

where:

ΔT = 1°C (2°F);

K_T = volume change of 1 g of loose HMA for a 1°C (2°F) change in temperature above or below 20°C (68°F) = 3.7830×10^{-5} mL; and

V_T = volume of water for a corresponding 1251.3-g mass of loose HMA at a test temperature of 20°C (68°F) = 492.77 mL.

Substituting these values into the equation gives the following:

Correction = $1 \times 3.7830 \times 10^{-5} \times 492.77 = 0.01864$ mL/g at 20°C (68°F).

X1.6. Table X1.1 illustrates an example of the influence of temperature corrections. For a measured volume and a given mass of HMA tested at specific temperatures, this table relates these influences to the specific gravity of the HMA.

Table X1.1—Influence of Temperature Corrections to a Measured Volume at 20°C of a Given Mass of Loose Paving Mixture, to Provide the Required Theoretical Maximum Specific Gravity at 25°C

Temperature, °C	Volume of HMA at 20°C (68°F), mL	Volume Correction for Temp Change	Corrected Volume of HMA at 20°C (68°F), mL	Mass of HMA, g	Specific Gravity of HMA
1	*2*	*3*	*4 = 2 + 3*	*5*	*6 = 5/4*
31	492.77	0.2046	492.975	1251.3	2.5383
30[a]	492.77	0.1860	492.956	1251.3	2.5384
29[a]	492.77	0.1674	492.937	1251.3	2.5385
28[a]	492.77	0.1488	492.919	1251.3	2.5386
27[a]	492.77	0.1302	492.900	1251.3	2.5386
26[a]	492.77	0.1116	492.882	1251.3	2.5387
25[a]	492.77	0.0930	492.863	1251.3	2.5388
24[a]	492.77	0.0744	492.844	1251.3	2.5389
23[a]	492.77	0.0558	492.826	1251.3	2.5390
22[a]	492.77	0.0372	492.807	1251.3	2.5391
21[a]	492.77	0.0186	492.789	1251.3	2.5392
20	492.77	0.0000	492.772	1251.3	2.5393
19	492.77	–0.0186	492.751	1251.3	2.5394

[a] Range less than 0.0005.

Notes: Strictly speaking, the above table shows that the specific gravity for this particular mix, as measured at 20°C (68°F), just fails to meet the corrected theoretical maximum specific gravity at 25°C (77°F), 2.5388 versus 2.5393, that is, by 0.0005, and that a temperature correction would be required. If the measurement for volume had been made at 21°C (70°F), the table indicates that no temperature correction would have been necessary, because the measurement at 21°C (70°F) would have satisfied the theoretical maximum specific gravity at 25°C (77°F), 2.5388 versus 2.5392, a difference of less than 0.0005.

[1] Sargent Welch, 39745 Gauge-Vacuum, Mercury Prefilled (or equivalent).
[2] Krebs and Walker, *Highway Materials*, McGraw-Hill, Inc., 1971, p. 274.

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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)**

EXAMPLES OF PYCNOMETER CALCULATIONS

What are the average pycnometer weights in the following examples?

Example 1	Example 2	Example 3
4001.5	4001.3	4001.2
4001.6	4001.9	4001.8
4001.9	4001.5	4001.5

SAMPLE PREPARATION

A. Split sample to size needed

   (1) For correct sample size see page 7-17, Section 7-Sampling, Table 7.2

   (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)**

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

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) = Dry sample weight

(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 insure 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 is 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. **Method C** (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. Bulk Specific Gravity = $\frac{\mathbf{A}}{\mathbf{B - C}}$

Example: **1359.7 (A)**
1376.1 (B)
794.4 (C)

$\frac{\mathbf{1359.7}}{\mathbf{1367.1 - 794.4}} = \mathbf{2.3741924}$ **or** $\mathbf{2.374}$

NOTE: Bulk Specific Gravity results are rounded to 3 decimal places.

B. Percent Density = $\frac{\textbf{Bulk Specific Gravity}}{\textbf{Maximum Specific Gravity}} \times \mathbf{100}$

Example: **2.374 (Bulk Sp. Gr.)**
2.546 (Max. Sp. Gr.)

$\frac{\mathbf{2.374}}{\mathbf{2.546}} \times \mathbf{100} = \mathbf{93.2443} = \mathbf{93.2\%}$

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/m^3

Example: **2.374 X 1000 kg/m^3 = 2374 kg/m^3**

NOTE: kg/m^3 results are rounded to a whole number.

Density = Bulk Specific Gravity X 62.4 results in $\#/ft^3$ (pcf)

Example: **2.374 X 62.4 $\#/ft^3$ = 148.1376 $\#/ft^3$ = 148.1 $\#/ft^3$**

NOTE: $\#/ft^3$ 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: January 1, 2017

Standard Method of Test
For
Resistance of Compacted Bituminous Mixture to Moisture-Induced Damage

Reference AASHTO T 283-14

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:* ▪ R30, 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 Marshal 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 B17, Procedure for Introducing Additives to Hot Mix Asphalt Mixtures and Testing in the Lab
2.2	Replace with the following: *ASTM Standards:* ▪ D 979, Sampling Bituminous Paving Mixtures ▪ D 2041, Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
3.1	Replace the first sentence with the following: As noted in the scope, this method is intended to evaluate the effects of saturation and accelerated water conditioning of compact 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 similar properties of dry specimens.

Illinois Modified Test Procedure
Effective Date: March 1, 2003
Revised: January 1, 2017

Standard Method of Test
For
Resistance of Compacted Bituminous Mixture to Moisture-Induced Damage

Reference AASHTO T 283-14

AASHTO ***Section***	***Illinois Modification***
4.1	Replace fourth sentence with the following: The other subset is subjected to vacuum saturation, followed by 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.
5.5	Delete.
5.6	Delete.
5.7	Delete.
5.11	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: 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 1).
6.2	Replace with the following: Specimens 150 mm (5.91 in.) diameter by 95 + 5 mm (3.75 + 0.20 in.) thick are used.
6.3	Replace with the following: Preparing Mixtures and Batching
6.3.1 New Section	If preparing a multi-specimen batch, split the batch into single-specimen quantities before placing in the oven.

Illinois Modified Test Procedure
Effective Date: March 1, 2003
Revised: January 1, 2017

Standard Method of Test
For
Resistance of Compacted Bituminous Mixture to Moisture-Induced Damage

Reference AASHTO T 283-14

AASHTO ***Section***	***Illinois Modification***
6.3.2 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.
6.3.3 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.
6.4	Delete
6.5	Replace the first sentence with the following: Short-term aging of laboratory prepared mixtures shall be done according to Illinois-modified AASHTO R 30. Compact the specimens according to the method in T312. The mixture shall be compacted to 7.0 ± 0.5 percent air voids except SMA mixtures which shall be compacted to 6.0 $\pm$ 0.5 percent air voids. 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 2).
6.6	Replace with the following: Allow the extracted specimens to cool to a room temperature 25 $\pm$ 5°C (77 $\pm$ 9 °F).
7.1	Replace with the following: Make a 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 1).
7.2	Replace with the following: Specimens 150 mm (5.91 in.) in diameter by 95 ± 5 mm (3.75 ± 0.20 in.) thick are used.

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Effective Date: March 1, 2003
Revised: January 1, 2017

Standard Method of Test
For
Resistance of Compacted Bituminous Mixture to Moisture-Induced Damage

Reference AASHTO T 283-14

7.4	Replace with the following: No loose-mix curing as described in Section 6.4 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 ± 0.5 percent air voids except SMA mixtures which shall be compacted to 6.0 $\pm$ 0.5 percent air voids. 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 2).
7.5	Replace with the following: Allow the extracted specimens to cool to room temperature of 25 $\pm$ 5°C (77 $\pm$ 9 °F).
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 the 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.
9.2	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 an recording the average of these measurements as the thickness of the specimen.
9.7	Replace the first sentence with the following: For those specimens to be subjected to vacuum saturation and warm-water soaking cycle, calculate the volume of air voids (V_a) in cubic centimeters using the following equation:
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.

Illinois Modified Test Procedure
Effective Date: March 1, 2003
Revised: January 1, 2017

Standard Method of Test
For
Resistance of Compacted Bituminous Mixture to Moisture-Induced Damage

Reference AASHTO T 283-14

AASHTO ***Section***	***Illinois Modification***
10.2	Replace the first sentence 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.
10.3.1	Replace with the following: Place the specimen 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. 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). Remove the vacuum and leave the specimen submerged in water for a short time (approximately 1 to 10 minutes).
Note 4	Delete.
10.3.7	Delete.
10.3.8	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.
10.3.9	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).

Illinois Modified Test Procedure
Effective Date: March 1, 2003
Revised: January 1, 2017

Standard Method of Test
For
Resistance of Compacted Bituminous Mixture to Moisture-Induced Damage

Reference AASHTO T 283-14

AASHTO ***Section***	***Illinois Modification***
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 4: 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 Bituminous Mixtures Visual Identification and Classification" and record the observations.
12.1 New Notes	Add the following at the end: Note 5. The actual diameter of a gyratory specimen is 150 mm (5.91 in.) Note 6: If the strength is converted from metric to English units, use the factor: 1 kPa = 0.14504 psi (1 psi = 6.895 kPa). The minimum acceptable tensile strength shall be 60 psi for unmodified asphalt binders and 80 psi for modified asphalt binders.
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 TSR for 150 mm (5.91 in.) specimens shall be 0.85. The minimum TSR for 4-inch (100 mm) field mixed, field-compacted pavement cores only shall be 0.75.

Standard Method of Test for

Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage

AASHTO Designation: T 283-14

AASHTO

Technical Section: 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.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- R 47, Reducing Samples of Hot Mix Asphalt (HMA) to Testing Size
- 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 168, Sampling Bituminous Paving Mixtures
- T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA)
- 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 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*:

- 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)

- D3549/D3549M, Standard Test Method for Thickness or Height of Compacted Bituminous Paving Mixture Specimens

3. SIGNIFICANCE AND USE

3.1. As noted in the scope, 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: T 167, T 245, 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 bath capable of maintaining a temperature of 60 ± 1°C (140 ± 2°F).

5.5. Freezer maintained at –18 ± 3°C (0 ± 5°F).

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 approximately 25 mm (1 in.).

5.9. Forced-draft oven, thermostatically controlled, capable of maintaining any desired temperature setting from room temperature to 176°C (350°F) within ±3°C (±5°F).

5.10. 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).

5.11. 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. 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 1).

Note 1—It is recommended that two additional specimens for the set be prepared. These specimens can then be used to establish compaction procedures as given in Section 6.5 or 7.4 and the vacuum saturation technique as given in Section 10.3.

6.2. 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.

6.3. 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.

6.4. After mixing, the mixture shall be placed in a pan having a surface area of 48 400 to 129 000 mm^2 (75 to 200 $in.^2$) in the bottom and a depth of approximately 25 mm (1 in.) and cooled at room temperature for 2 ± 0.5 h. Then the mixture shall be placed 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.

6.5. After curing, place the mixture in an oven for 2 h ± 10 min at the compaction temperature ±3°C (5°F) prior to compaction. Compact the specimens according to one of the following methods: T 167, T 245, T 247, T 312, or ASTM D3387. The mixture shall be compacted to 7.0 ± 0.5 percent air voids. This level of voids can be obtained by adjusting the number of blows in T 245; 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 2).

Note 2—Due to the elevated void content and potential instability of the specimens, ensure that each specimen is adequately cool and stable prior to removal from the mold.

6.6. After removal from the molds, the specimens shall be stored for 24 ± 3 h at room temperature.

7. PREPARATION OF FIELD-MIXED, LABORATORY-COMPACTED SPECIMENS

7.1. 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 1).

7.2. 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.

7.3. Field-mixed asphalt mixtures shall be sampled in accordance with T 168.

7.4. No loose-mix curing as described in Section 6.4 shall be performed on the field-mixed samples. After sampling, divide the sample to obtain the desired size in accordance with R 47. Next, place the mixture in an oven until it reaches the compaction temperature ±3°C (5°F). Then compact the specimen according to one of the following methods: T 167, T 245, T 247, T 312, or ASTM D3387. The mixture shall be compacted to 7.0 ± 0.5 percent air voids. This level of voids can be obtained by adjusting the number of blows in T 245; 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 2).

7.5. After removal from the molds, the specimens shall be stored for 24 ± 3 h at room temperature.

8. PREPARATION OF FIELD-MIXED, FIELD-COMPACTED SPECIMENS (CORES)

8.1. Select locations on the completed pavement to be sampled, and obtain cores. 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. The number of cores shall be at least six for each set of mix conditions.

8.2. 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.

8.3. No loose-mix curing (Section 6.4) 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. After curing, heating, or drying mixture samples or cores for the theoretical maximum specific gravity (G_{mm}) test as described in Sections 6.4 and 6.5, Section 7.4, or Section 8.2 as appropriate, determine the G_{mm} of those samples by T 209.

9.2. Determine each specimen thickness (t) in accordance with ASTM D3549/D3549M.

9.3. Record each specimen diameter (D) as defined in Section 6.2, 7.2, or 8.1, as appropriate.

9.4. 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.

9.5. Calculate the percentage of air voids (P_a) in accordance with T 269.

9.6. 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.

9.7. 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:

$$V_a = \frac{P_a E}{100} \quad (1)$$

where:

V_a = volume of air voids, cm^3;
P_a = air voids, percent; and
E = volume of the specimen, cm^3.

Note 3—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. The dry subset will be stored at room temperature as described in Section 6.6 or Section 7.5, as appropriate. At the end of the curing period from Section 6.6 or 7.5, as appropriate, the specimens shall be wrapped with plastic or placed in a heavy-duty, leakproof plastic bag. The specimens shall then be placed in a 25 ± 0.5°C (77 ± 1°F) water bath for 2 h ± 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. *The other subset shall be conditioned as follows*:

10.3.1. 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. Apply a vacuum of 13 to 67 kPa absolute pressure (10 to 26 in.Hg partial pressure) for a short time (approximately 5 to 10 min). Remove the vacuum and leave the specimen submerged in water for a short time (approximately 5 to 10 min).

Note 4—The time required for some specimens to achieve the correct degree of saturation (between 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).

10.3.2. Determine the mass of the saturated, surface-dry specimen after partial vacuum saturation (B') by Method A of T 166.

10.3.3. Calculate the volume of absorbed water (J') in cubic centimeters by use of the following equation:

$$J' = B' - A \quad (2)$$

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 9.4).

10.3.4. 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:

$$S' = \frac{100J'}{V_a} \quad (3)$$

where:

S' = degree of saturation, percent.

10.3.5. If the degree of saturation is between 70 and 80 percent, proceed to Section 10.3.7.

10.3.6. If the degree of saturation is less than 70 percent, repeat the procedure beginning with Section 10.3.1 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 10.3.1 using less vacuum and/or time.

10.3.7. 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.

10.3.8. 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.

10.3.9. After 24 ± 1 h in the 60 ± 1°C (140 ± 2°F) water bath, remove the specimens and place them 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). 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) by ASTM D3549/D3549M. 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:

$$S_t = \frac{2000P}{\pi tD} \quad (4)$$

where:

S_t = tensile strength, kPa;
P = maximum load, N;
t = specimen thickness, mm; and
D = specimen diameter, mm.

U.S. Customary units:

$$S_t = \frac{2P}{\pi tD} \quad (5)$$

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:

$$\text{tensile strength ratio (TSR)} = \frac{S_2}{S_1} \quad (6)$$

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 6-14 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 6.5%-7.5% 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° ± 5F° 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 minute. 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. Place conditioned bricks in 77°F±1.8°F bath for 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 shall 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: 406.10(d) 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.

Be aware that Warm Mix has its own tensile strength ratio specification and that RAP and RAS tensile strength maximum cannot exceed 200 PSI.

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 # :		DESIGN LAB:		INSPECTOR:	
MIX #:		MATL. CODE:		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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NUCLEAR DENSITY TEST
(QC/QA & Process Control)

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/m³ (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 insure 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

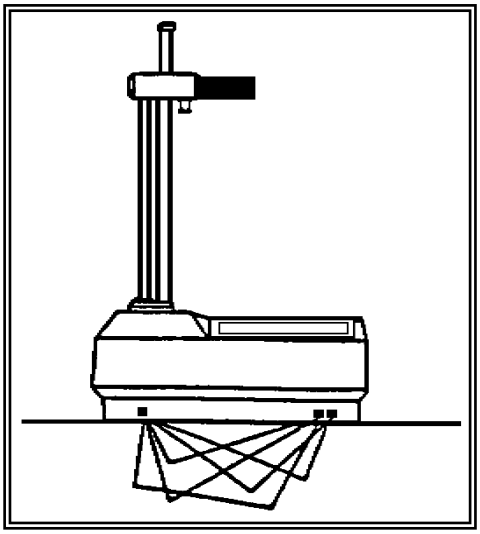
(1) Selecting Count Time - Most nuclear density gauges will allow the time for *test counts* to be set for 15 seconds, 1 minute, or 4 minutes. The confidence level of the gauge is affected by the length of time a *test count* is run. A 15 second *test count* will only provide a 37% confidence level. 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.

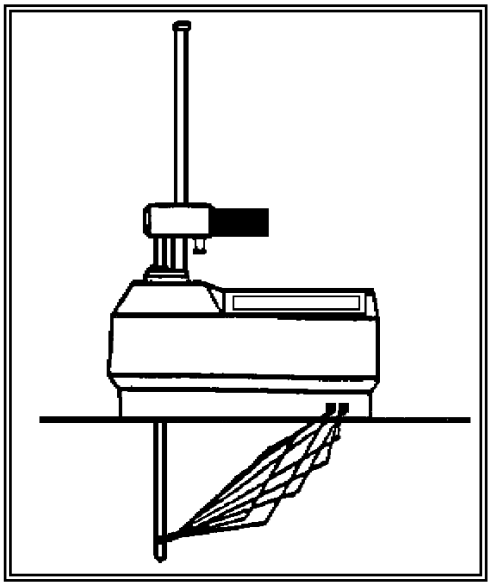
This method involves placing the density gauge on the surface and lowering the probe so that is resting on the material to be tested. The probe does not penetrate the surface of the material.



BACKSCATTER GEOMETRY

Direct transmission is required for layers of asphalt equal to, or greater than 4 inches (100 mm) thick.

Direct transmission involves lowering the probe below the bottom of the gauge into a hole drilled into the asphalt concrete. When the probe is lowered below the bottom of the gauge, the gauge will automatically switch to the direct transmission mode. The gauge can be set to automatically read the depth of the probe, or it can be set so the depth can be entered manually.



DIRECT TRANSMISSION

(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.

If direct transmission method is used, a smooth hole, slightly larger than the probe, should be drilled into the pavement.

(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.

If direct transmission is used, the probe shall be inserted so the side of the probe, facing the center of the gauge, is in intimate contact with the side of the hole.

(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 10-44 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 "Hot-Mix Asphalt – Density Testing of Longitudinal Joints" (BDE) document that was effective January 1, 2010, Revised April 1, 2016.

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", in Appendix H, 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.

MATERIAL CODES

Code	Mix	Grad./Frict.	# Gyrations	Individual Specifications
19502	Binder	IL 19.0	N30	
19503	Surface	C	N30	IL-19.0 & IL-19.0L, Ndesign <90 93.0% - 97.4%
19512	Binder	IL 19.0	N50	
19513	Surface	C	N50	
19514	Surface	D	N50	
19515	Surface	E	N50	IL-9.5 & IL 9.5L, Ndesign <90 92.5% - 97.4%
19516	Surface	F	N50	
19522	Binder	IL 19.0	N70	
19523	Surface	C	N70	
19524	Surface	D	N70	IL-19.0, Ndesign = 90 93.0% - 96.0%
19525	Surface	E	N70	
19526	Surface	F	N70	
19532	Binder	IL 19.0	N90	
19533	Surface	C	N90	IL-9.5, Ndesign = 90 92.0% - 96.0%
19534	Surface	D	N90	
19535	Surface	E	N90	
19536	Surface	F	N90	

Notes:

For recycled mixes add an "R" after 5 digit code.
Example: 19534R

For metric mixes add an "M" after 5 digit code.
Example: 19534M

For metric-recycle mixes add an "MR" after 5 digit code.
Example: 19534MR

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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 #:	87BIT1015
Lift Number:	.1

Route:	IL 32
Section:	(1,2) RS-3
County:	Moultrie
Job No:	C9701416
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:	**July 22, 2016**		
CONTRACT:	**74226**	**Gauge #**	**28769**
JOB #:	**C9701416**	**Layer Thickness**	**2.5”**
ROUTE:	**IL 32**	**Gmm**	**2.444**
BASE MATERIAL:	**Milled Surface**	(milled, binder, aggregate)	
MIX #:	**87BIT1015**	**Nuclear**	
MIX CODE:	**19523**	**Densities**	
USE:	**Surface**	(surf., 1st lift binder...)	

Reading 1

STATION: **12+34**

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. _____ 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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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 BITUMINOUS 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 BITUMINOUS 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 BITUMINOUS 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 BITUMINOUS 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**

THIS PAGE IS RESERVED.

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised Date: January 1, 2017

Standard Test Method
for
Determination of Density of Bituminous Concrete in Place by Nuclear Methods
Reference ASTM D 2950-14

AASHTO 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)
3.5	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 "Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities" 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.
3.6 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.

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised Date: January 1, 2017

Standard Test Method
for
Determination of Density of Bituminous Concrete in Place by Nuclear Methods
Reference ASTM D 2950-14

AASHTO Section	***Illinois Modification***
3.7	Definitions: 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.) • If one confined and one unconfined edge is present, two "individual test results" shall be reported for each density test location. o 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. o One "individual test result" representing the average of three density readings on the unconfined edge. • If two unconfined edges are present, three "individual test" results shall be reported for each density test location. o One "individual test result" representing the average of three density readings across the mat, excluding the unconfined edge density readings. o One "individual test result" representing the average of three density readings on the unconfined edge. o One "individual test result" representing the average of three density readings on the opposite unconfined edge. Daily Average Density Value: The "daily average density" is the average of the "density readings" of a given offset for the given days 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: January 1, 2017

Standard Test Method
for
Determination of Density of Bituminous Concrete in Place by Nuclear Methods
Reference ASTM D 2950-14

AASHTO Section	***Illinois Modification***
3.8 New Section	When the "Hot Mix Asphalt (HMA) Individual Density Site Modified QC/QA" special provision **is** included, "daily average density values" shall also be determined.
4.2.1	Add the following at the end: The user should recognize that density readings obtained on the surface of thin layers of bituminous concrete may be erroneous if the density of the underlying material differs significantly from that of the surface course.
4.2.2	Add the following at the end: Accuracy of the nuclear test modes (Backscatter vs. Direct Transmission) is not equal and is affected by the surface texture and thickness of the mixture under test. The nuclear test mode to be used and the number of tests required to determine a satisfactory factor are dependent on the conditions stated above.
4.5	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 "Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities" shall be used.
5.5 New Section	*Readout Instrument,* such as scaler or direct readout meter.
7.1	Add the following at the end: Dated inspection reports shall be kept and be made available to the Engineer upon request.
7.1.1 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.
7.1.2 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.

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised Date: January 1, 2017

Standard Test Method
for
Determination of Density of Bituminous Concrete in Place by Nuclear Methods
Reference ASTM D 2950-14

AASHTO Section	***Illinois Modification***
8.2.1	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.
8.2.2	Revise the first sentence as follows: Turn on the apparatus prior to standardization and allow it to stabilize, a minimum of 20 minutes.
8.2.3	Replace with the following: All reference standard counts shall consist of a 4-minute count.
8.2.4	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.
8.2.5 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.
8.2.6 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.
8.2.7 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.
8.3	Delete the first sentence.
9.1	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: January 1, 2017

Standard Test Method
for
Determination of Density of Bituminous Concrete in Place by Nuclear Methods
Reference ASTM D 2950-14

AASHTO Section	***Illinois Modification***
9.3	Replace with the following: Select a test location, using the Department's "Determination of Random Density Test Site 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 the lift thickness or a minimum of 2 in. (50 mm), from the edge of the mat, whichever is greater. • 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.
9.4	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.
9.5	Replace with the following: For the Direct Transmission Method use the guide/scraper plate and drive the steel rod to a depth of at least 50mm (2 in.) deeper than the desired measurement depth.
9.6	Add the following at the end: All other radioactive sources shall be kept at least 10 m (30 ft.) from the gauge so the readings will not be affected.
9.7	Delete.
9.8	Delete.
Note 6	Delete.
Note 7	Delete.

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised Date: January 1, 2017

Standard Test Method
for
Determination of Density of Bituminous Concrete in Place by Nuclear Methods
Reference ASTM D 2950-14

AASHTO Section	***Illinois Modification***
10.1	Delete.
10.1.1	Delete.
10.2	Delete.
11.1.1	Replace with the following: Gauge number,
11.1.2	Revise as follows: Date of calibration data,
11.1.5	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
11.1.6	Replace with the following: Layer (bottom lift = .1, second lift = .2, etc.) and thickness of layer,

Designation: D2950/D2950M – 14

Standard Test Method for Density of Bituminous Concrete 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 bituminous concrete 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 non-conformance with the standard.

1.4 *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.* For specific warning statements see Section 6 and Note 5.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

D1188 Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Coated Samples

D1559 Test Method for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus (Withdrawn 1998)[3]

D2041 Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures

D2726 Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures

D3665 Practice for Random Sampling of Construction Materials

D6752 Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Automatic Vacuum Sealing Method

D7013 Guide for Nuclear Surface Moisture and Density Gauge Calibration Facility Setup

D7759 Guide for Nuclear Surface Moisture and Density Gauge Calibration

3. Significance and Use

3.1 The test method described is useful as a rapid, nondestructive technique for determining the in-place density of compacted bituminous mixtures.

3.2 With proper calibration and confirmation testing, the test method is suitable for quality control and acceptance testing of compacted bituminous concrete.

3.3 The test method can be used to establish the proper rolling effort and pattern to achieve the required density.

3.4 The non-destructive nature of the test allows repetitive measurements to be made at a single test location between roller passes and to monitor changes in density.

3.5 The density results obtained by this test method are relative. Correlation with other test methods such as D1188 or D2726 are 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.

[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 June 1, 2014. Published August 2014. Originally approved in 1971. Last previous edition approved in 2011 as D2950/D2950M – 11. DOI: 10.1520/D2950_D2950M-14.

[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. Interferences

4.1 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.

4.2 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.

4.2.1 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.)

4.2.2 The surface roughness of the material being tested may cause lower than actual density determination.

4.3 Oversize aggregate particles in the source-detector path may cause higher than actual density determination.

4.4 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. In general, the higher the density the smaller the volume (Note 1).

NOTE 1—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.

4.5 If samples of the measured material are to be taken for purposes of correlation with other test methods such as D1188 or D2726, 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 2).

NOTE 2—If the layer of bituminous concrete 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.)

5. Apparatus

5.1 *Nuclear Device*—An electronic counting instrument, capable of being seated on the surface of the material under test, and which contains:

5.1.1 *Gamma Source*—A sealed high energy gamma source such as cesium or radium, and

5.1.2 *Gamma Detector*—Any type of gamma detector such as a Geiger-Mueller tube(s).

5.2 *Reference Standard*—A block of dense material used for checking instrument operation and to establish conditions for a reproducible reference-count rate.

5.3 *Site Preparation Device*—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.

5.4 *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.

6. Hazards

6.1 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.

6.2 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.

6.3 A regulatory agency radioactive materials license may be required to possess this equipment.

7. Calibration

7.1 Calibrate the instrument in accordance to Guide D7759 and Guide D7013.

7.2 *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. 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 D2726 or Test Method D6752) to establish a correlation.

8. Standardization and Reference Check

8.1 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.

8.2 Standardization of equipment should be performed at the start of each day's work, and a permanent record of this data retained.

8.2.1 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 3—The user is advised that the value given in section 8.2.1 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.

8.2.2 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.

8.2.3 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.

8.2.4 If the value obtained in 8.2.3 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:

$$| N_s - N_o | \leq 2.0 \sqrt{N_o/F} \quad (1)$$

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 4—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.

8.3 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.

9. Procedure

9.1 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 druing the day's testing.

9.2 Standardize the apparatus.

9.3 Select a test location in accordance wtih the project specifications, or, if not otherwise specified, in accordance with Practice D3665. If the instrument will be closer than 250 mm [10 in.] to any vertical mass that may influence the result, follow the instrument manufacturer's correction procedure.

9.4 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.

9.5 For the Direct Transmission Method use the guide/scraper plate and drive the steel rod to a depth of at least 25 mm [1 in.] deeper than the desired measurement depth.

NOTE 5—**Caution:** Extreme care must be taken when driving the rod into compacted bituminous concrete as it may cause a disturbance of the material which could cause errors in the measurement. Drilling may be more suitable.

9.6 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.

9.7 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 2)

9.8 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 6 and Note 7)

NOTE 6—Some instruments have built-in provisions to compute the ratio, bulk (or wet) density, and allow an adjustment bias.

NOTE 7—If the depth of the bituminous concrete layer under test is less than the depth of measurement of the instrument, the value obtained in 9.8 must be adjusted. (See Annex A1.)

NOTE 8—Do not leave the gauge on a hot surface for an extended period of time. Prolonged high temperatures may adversely affect the instrument's electronics. The gauge should be allowed to cool between measurements.

10. Calculation of Results

10.1 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.

10.1.1 An adjustment bias can be calculated by comparing the results from a number of instrument measurements to the results obtained using Test Method D2726.

10.2 Compare the results obtained to samples compacted by Test Method D1559 or with the results of test methods such as D2041 to determine acceptability (percentage of compaction).

11. Report

11.1 Report the following information:

11.1.1 Make, model, and serial number of the test apparatus,

11.1.2 Date and source of calibration data,

11.1.3 Date of test,

11.1.4 Standard count for the day of the test,

11.1.5 Test site description including project identification number, location and mixture type(s),

11.1.6 Thickness of layer tested and any adjustment bias,

11.1.7 Method of measurement (backscatter or direct transmission), depth, count rate, calculated density of each measurement and any adjustment data, and

11.1.8 Percentage of compaction, if required.

12. Precision and Bias[4]

12.1 *Precision:*

12.1.1 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 pounds per cubic foot with mean of 138.07 and standard deviation 3.900. 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.

12.1.2 *Single Operator Precision*—The single-operator standard deviation has been found to be 25.15 kgm^3 [1.57

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D04-1032.

lb/ft^3].[5] Therefore, results of two properly conducted tests by the same operator on the same material should not differ by more than 70.48 kgm^3 [4.4 lb/ft^3].[5]

12.1.3 *Multilaboratory Precision*—The multilaboratory standard deviation has been found to be 1.75 pounds per cubic foot [20.03 kgm^3].[5] Therefore, results of two properly conducted tests from two different laboratories on the same material should not differ by more than 78.49 kgm^3 [4.9 lb/ft^3].[5]

[5] These numbers represent, respectively, the (1s) and (d2s) limits as described in Practice C670, for Preparing Precision Statements for Test Methods for Construction Materials.

12.2 *Bias:*

12.2.1 There is no consensus on the most accurate method to determine the values of density against which this test can be compared. Accordingly, a statement of method bias cannot be made.

NOTE 9—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.

13. Keywords

13.1 bituminous-concrete density; density; in-place density; nuclear test method

ANNEX

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.

Illinois Department of Transportation
QC/QA PROCEDURE

Determination of Random Density Locations
Appendix B7

Effective: May 1, 1993
Revised: April 1, 2011

Density tests (core or nuclear gauge) shall be performed at randomly located sites based on the frequency specified in Section 1030 of the Standard Specifications. The random test locations shall be determined as follows:

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 units representing 2640-ft. (800-m) or 1320-ft. (400-m) frequency.

B. The length of each unit 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 QC/QA computer software. The number obtained shall be added to the beginning station number for the unit to determine the center of the test site location.

C. This process shall be repeated for the subsequent units for the day's production using a new random number for each location.

D. The partial unit at the end of each day shall be considered a whole unit, and the test location shall be determined by multiplying the partial distance by the next available random number.

Appendix B7
B41

Illinois Department of Transportation
QC/QA PROCEDURE

Determination of Random Density Locations
Appendix B7
(continued)
Effective: May 1, 1993
Revised: April 1, 2011

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 _____(Random) × _____(Length) feet = _____(Dist into Area) feet

_____(Dist into Area) feet +_____(Beg Sta of Area in feet) feet =_____(Total feet) =Sta_____

Area 2 _____(Random) × _____(Length) feet = _____(Dist into Area) feet

_____(Dist into Area) feet +_____(Beg Sta of Area in feet) feet =_____(Total feet) = Sta_____

Area 3 _____(Random) × _____(Length) feet = _____(Dist into Area) feet

_____(Dist into Area) fee t+ _____(Beg Sta of Area in feet) feet =_____(Total feet) = Sta_____

Area 4 _____(Random) × _____(Length) feet = _____(Dist into Area) feet

_____(Dist into Area) feet +_____(Beg Sta of Area in feet) feet =_____(Total feet) = Sta_____

Notes:

1) See page 10-43 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 “Hot-Mix Asphalt – Density Testing of Longitudinal Joints” (BDE) document that was effective January 1, 2010.

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.

This Page Is Reserved

Illinois Department of Transportation

Memorandum

To:	Regional Engineers
From:	Omer M. Osman
Subject:	Special Provision for Hot-Mix Asphalt – Density Testing of Longitudinal Joints
Date:	January 8, 2016

This special provision was developed by the Bureau of Materials and Physical Research to improve the performance of longitudinal joints in Hot-Mix Asphalt (HMA) pavements. It has been revised to fit with the 2016 Standard Specifications.

It should be inserted in HMA contracts utilizing Quality Control/Quality Assurance as the Quality Management Program for the pavement/resurfacing.

The districts should include the BDE Check Sheet marked with the applicable special provisions for the April 22, 2016 letting and subsequent lettings. The Project Development and Implementation Section will include a copy in the contract.

This special provision will be available on the transfer directory January 8, 2016.

80246m

HOT-MIX ASPHALT - DENSITY TESTING OF LONGITUDINAL JOINTS (BDE)

Effective: January 1, 2010
Revised: April 1, 2016

Description. This work shall consist of testing the density of longitudinal joints as part of the quality control/quality assurance (QC/QA) of hot-mix asphalt (HMA). Work shall be according to Section 1030 of the Standard Specifications except as follows.

Quality Control/Quality Assurance (QC/QA). Delete the second and third sentence of the third paragraph of Article 1030.05(d)(3) of the Standard Specifications.

Add the following paragraphs to the end of Article 1030.05(d)(3) of the Standard Specifications:

"Longitudinal joint density testing shall be performed at each random density test location. Longitudinal joint testing shall be located at a distance equal to the lift thickness or a minimum of 4 in. (100 mm), from each pavement edge. (i.e. for a 5 in. (125 mm) lift the near edge of the density gauge or core barrel shall be within 5 in. (125 mm) from the edge of pavement.) Longitudinal joint density testing shall be performed using either a correlated nuclear gauge or cores.

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 represents the Individual Test.

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

Revise the Density Control Limits table in Article 1030.05(d)(4) of the Standard Specifications to read:

"Mixture Composition	Parameter	Individual Test (includes confined edges)	Unconfined Edge Joint Density Minimum
IL-4.75	Ndesign = 50	93.0 – 97.4% [1/]	91.0%
IL-9.5	Ndesign = 90	92.0 – 96.0%	90.0%
IL-9.5,IL-9.5L	Ndesign < 90	92.5 – 97.4%	90.0%
IL-19.0	Ndesign = 90	93.0 – 96.0%	90.0%
IL-19.0, IL-19.0L	Ndesign < 90	93.0 [2/]– 97.4%	90.0%
SMA	Ndesign = 50 & 80	93.5 – 97.4%	91.0%"

80246

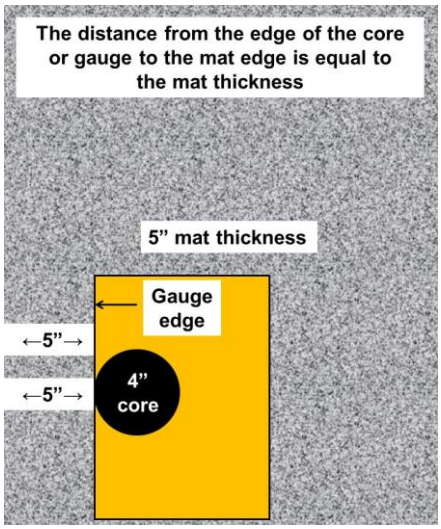
New Nuclear Density Test Site Locations Specification

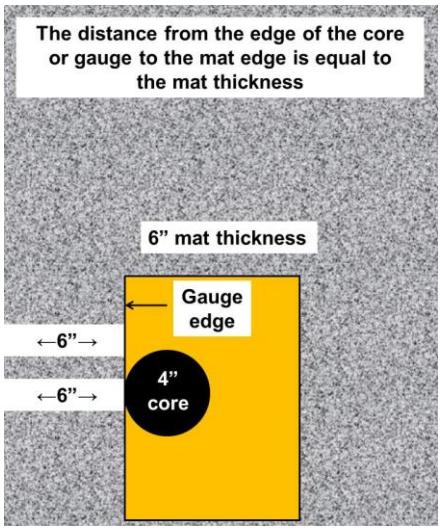
Effective of April 1, 2016

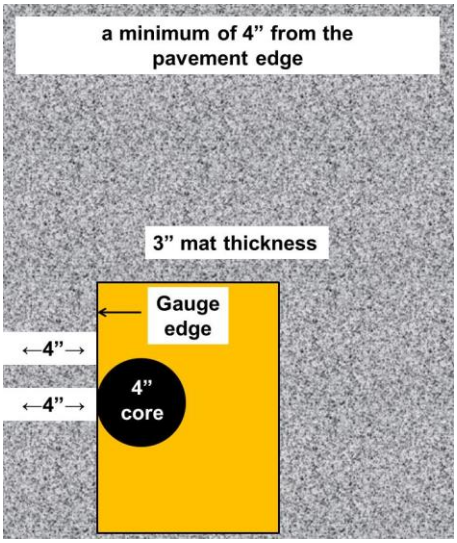
Random Test Determination Layout

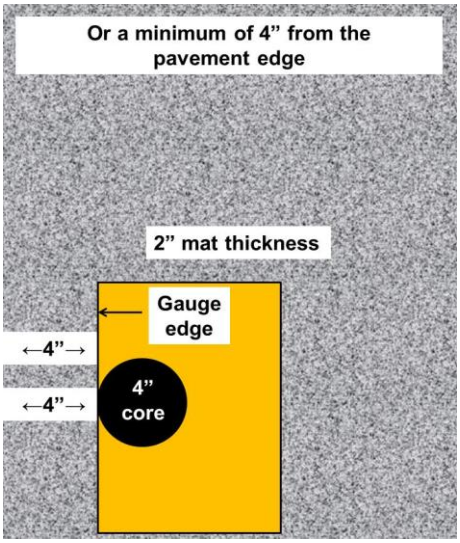
Nuclear density testing will be completed by cutting cores or using a correlated nuclear density gauge at random locations provided by the contractor or IDOT inspector. Density testing will include determinations diagonally across the center of the mat and longitudinally on the outside edges. The layout 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 a distance equal to the lift thickness, or a minimum of 4 in. (100 mm), from the edge of the nuclear density gauge or edge of the core from the pavement edge. See examples below:





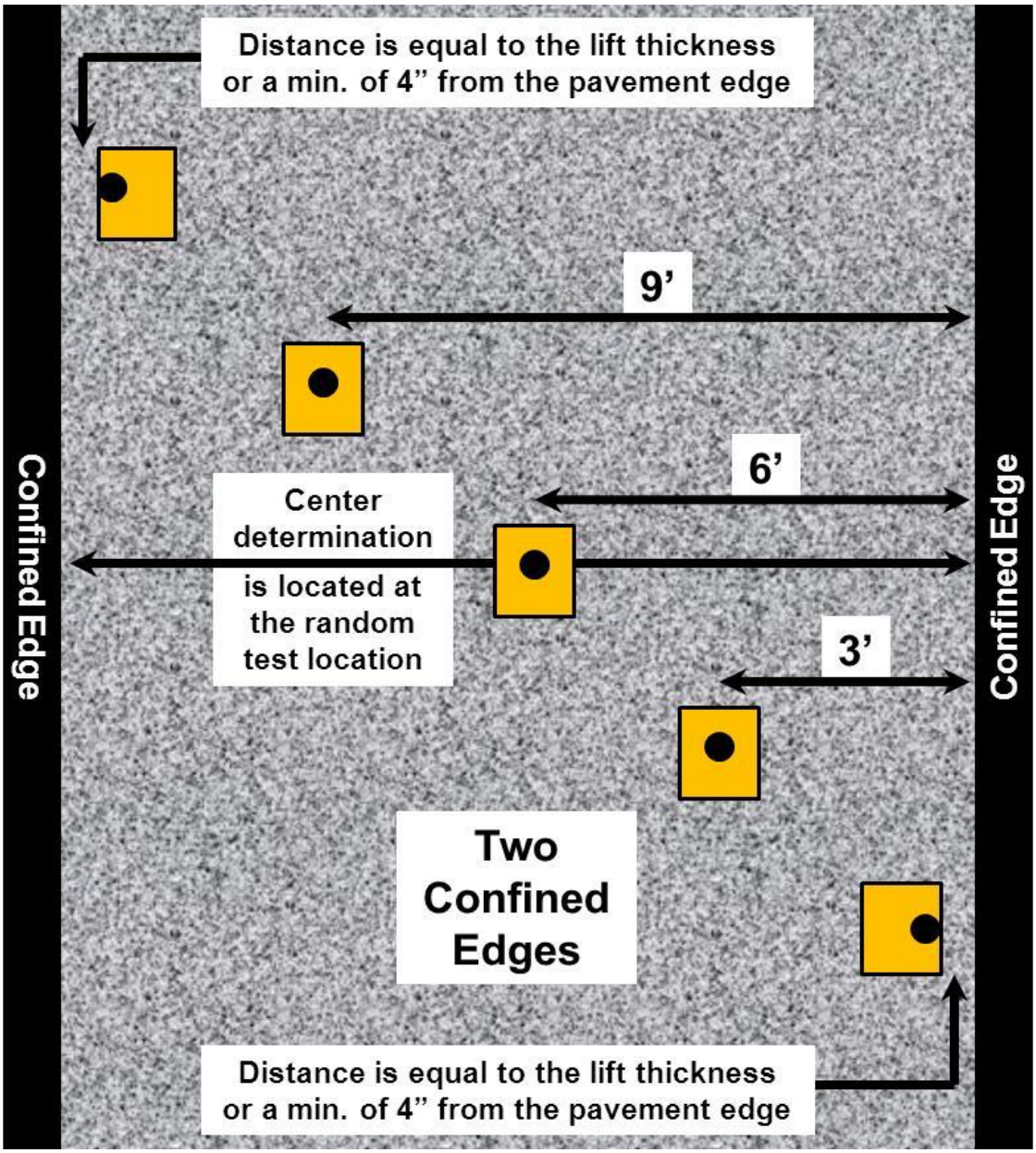




Random Test Determination Layout for Two Confined Edges (Inlay)

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.

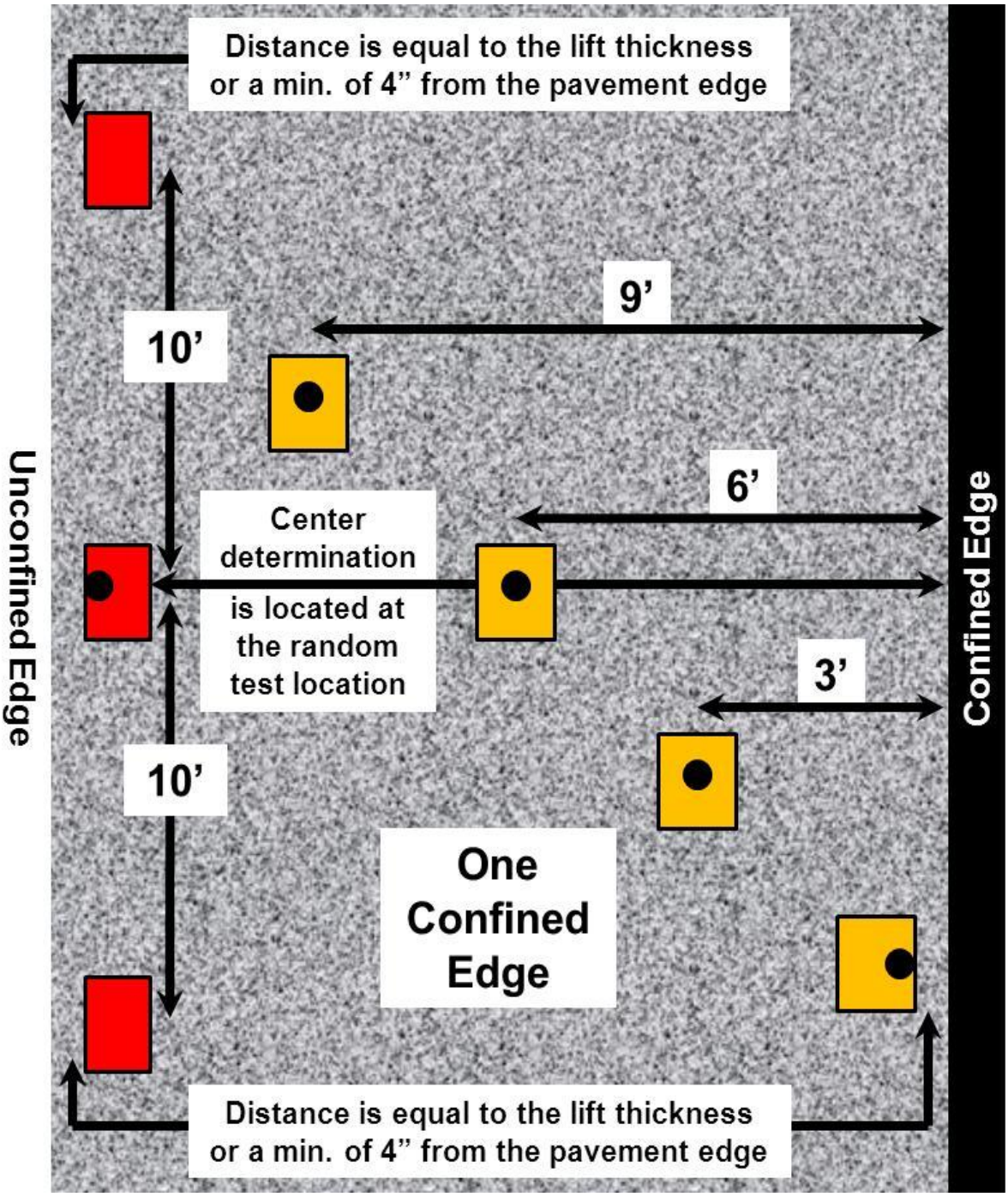
2. When testing with a nuclear density gauge, a total of three determinations will be taken longitudinally along the unconfined edge of the pavement at the required layout locations.

   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.


Distance is equal to the lift thickness or a min. of 4" from the pavement edge
9'
10'
6'
Center determination is located at the random test location
Unconfined Edge
Confined Edge
3'
10'
One Confined Edge
Distance is equal to the lift thickness or a min. of 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.

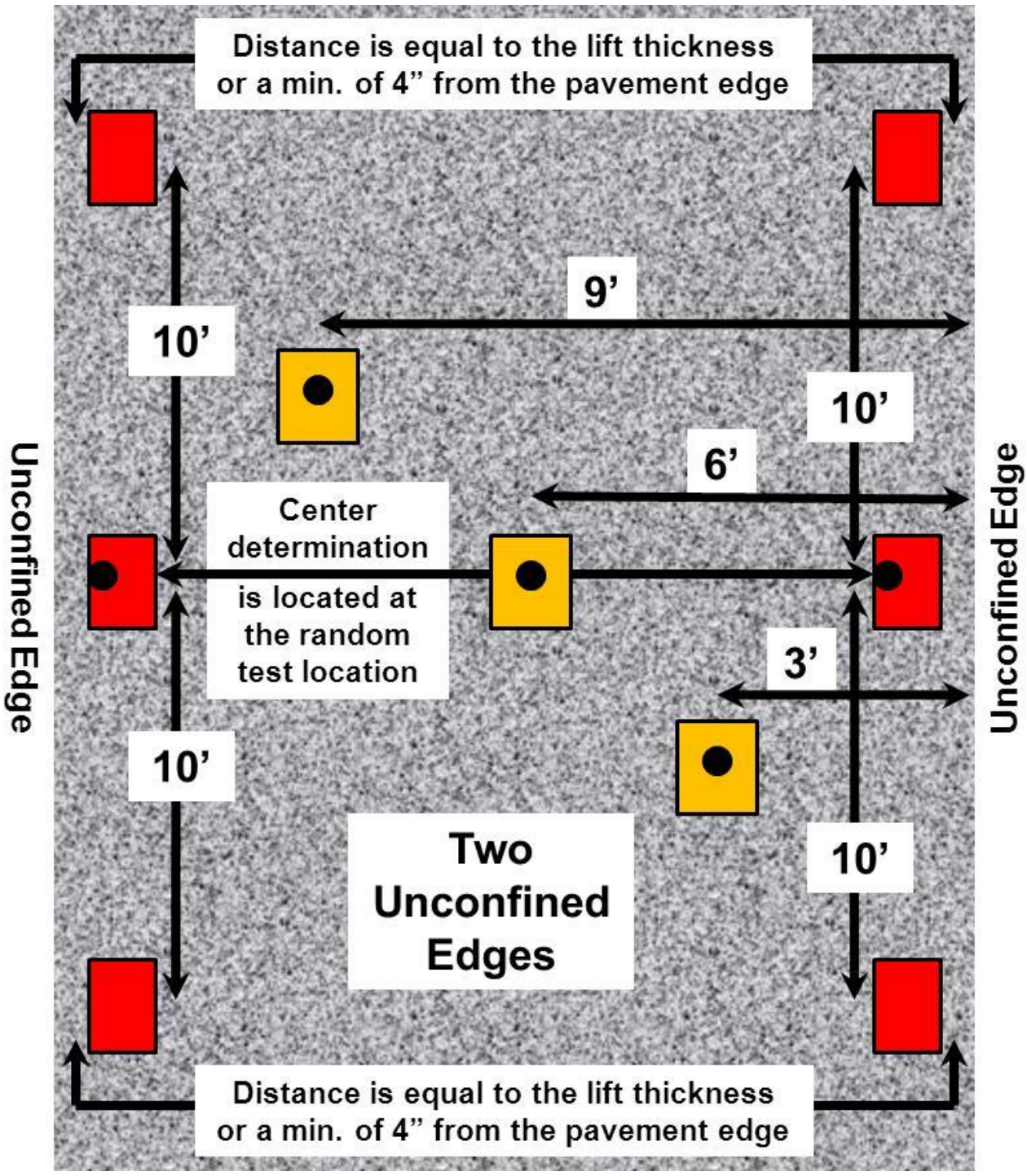
2. When testing with a nuclear density gauge, a total of three determinations will be taken longitudinally along each unconfined edge of the pavement at the required layout locations.

   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.


Distance is equal to the lift thickness or a min. of 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
Distance is equal to the lift thickness or a min. of 4" from the pavement edge

PFP and QCP Random Density Procedure
Appendix E.3

Effective: April 1, 2009
Revised: October 1, 2017

Density tests using cores shall be obtained at the frequency specified in the Hot Mix Asphalt Quality Control for Performance (QCP) and Pay for Performance (PFP) Using Percent within Limits special provisions. The random test locations shall be determined as follows:

A) The random core locations shall be taken at the randomly selected test location within each density testing interval. 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 approved software program. 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 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 and provide documentation to the Contractor upon completion of the project.

   Each core location shall be randomly located both longitudinally and transversely within each density testing interval. Each core location within the density testing interval shall be determined with two random numbers. The first random number is used to determine the longitudinal distance to the nearest 1 ft into the density testing interval. The second random number is used to determine the transverse offset to the nearest 0.1 ft from the left edge of the **paving lane**. In cases where paving is completed over multiple lanes in a single pass of one or more pavers to eliminate unconfined edges between lanes, the **paving lane** is defined as the total combined width of the lanes paved in that single pass. The density intervals shall 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 **paving lane** width is greater than 20 ft.

   To determine the longitudinal location of a core, multiply the length of the prescribed density interval by the random number selected from the Random Number table. Determine the random transverse offset as follows:

   1. PFP. The effective lane width of the pavement shall be used in calculating the transverse offset. The effective lane width is determined by subtracting 1.0 ft for each unconfined edge from the entire paved lane width (i.e. If a 12.0 ft wide paved lane has two unconfined edges, the effective lane width would be 10.0 ft.) Determine the transverse offset by multiplying the effective width by the random number selected from the Random Number table.

      The transverse offset is measured from the left physical edge of the paved lane to locate the core on the pavement. If the left edge was unconfined, it will be omitted by adding 1.0 ft to the calculated transverse offset measurement.

Random locations that fall within 4.0 inches of a confined edge shall be moved to 4.0 inches off the edge. Areas outside the mainline pavement that are paved concurrently with the mainline pavement (i.e. three-ft wide left shoulders, driveways, etc.) are not considered part of the paved mainline mat. See PFP example calculation herein.

The core density location for the outer 1.0 ft of an unconfined edge will be randomly selected within each 0.5 mile section for each unconfined edge. Longitudinal joint testing shall be located at a distance equal to the lift thickness or a minimum of 4.0 in. (100 mm), from each pavement edge. (i.e. for a 5 in. (125 mm) lift the near edge of the core barrel shall be within 5.0 in. (125 mm) from the edge of pavement.)

2. QCP. The entire width of the pavement shall be used in calculating the transverse offset. No offset movement is to be used for random locations that lie within 1.0 ft from an unconfined edge. Cores taken within 1.0 ft from an unconfined edge will have 2.0% density added for pay adjustment calculation purposes. Random locations that fall within 4.0 in. of an edge shall be moved to 4.0 in. off the edge. See QCP example calculation herein.

B) This process shall be repeated for all density intervals on a given project.

C) Moving Core Locations.

There are two scenarios in which random core 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 core location will not allow the necessary compactive effort to be applied, the Engineer will adjust the longitudinal location of the core in order to avoid the obstacle. Using the same random transverse offset, the core location will be moved longitudinally, ± 15 feet 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 represent longitudinal locations where a defect is present. These pavement defect locations will be approved by the Engineer. If a random core location lands at the same longitudinal location as the temporary mark, the core will be moved 5 feet 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 inches of asphalt pavement remaining after milling) the temporary markings shall show the extent or length of the defect. The core location will then be moved to a longitudinal distance 5 feet past the end of the defect toward the paver.

D) Example Calculations.

PFP Example.

This **PFP** example illustrates the determination of the core locations within the first mile of a lot.

Given 1.5 in. thickness would require a density testing interval of 0.2 miles. The pavement consists of a 13.0 ft-wide mat with the left edge confined and the right edge unconfined. 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 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 number by the effective width of the paved mat.

Determine the effective lane width by subtracting 1.0 ft, for each unconfined edge, from the entire paved lane width. In this case only the right edge is unconfined, so subtract 1.0 ft from the entire paved lane width of 13.0 ft.

Effective Width = 13.0 ft minus 1.0 ft = 12.0 ft

PFP and QCP Random Density Procedure
Appendix E.3

Effective: April 1, 2009
Revised: October 1, 2017

The random location for the first mile measured from the beginning of the lot and the left (confined) edge of the paved mat are as follows:

Core #	Longitudinal Location	Cumulative Distance	Transverse Location
1	1056 x 0.917 = 968 ft	1056 x (1-1) + 968 = 968 ft	12.0 x 0.890 = 10.7 ft
2	1056 x 0.289 = 305 ft	1056 x (2-1) + 305 = 1361 ft	12.0 x 0.317 = 3.8 ft
3	1056 x 0.654 = 691 ft	1056 x (3-1) + 691 = 2803 ft	12.0 x 0.428 = 5.1 ft
4	1056 x 0.347 = 366 ft	1056 x (4-1) + 366 = 3534 ft	12.0 x 0.998 = 11.7 ft
5	1056 x 0.777 = 821 ft	1056 x (5-1) + 821 = 5045 ft	12.0 x 0.003 = 0.0 ft = **0.3 ft**[1/]

1/ The 0.0 ft for Core #5 was moved in to 0.3 ft due to the 4 in. minimum from the edge requirement.

QCP Example.

This **QCP** example illustrates the determination of the core locations within the first mile of a project.

Given 1.5" thickness would require a density testing interval of 0.2 miles. The pavement consists of a 13.0 ft-wide mat with the left edge confined and the right edge unconfined. 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.

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 number by the width of the paved lane (13.0 ft).

PFP and QCP Random Density Procedure
Appendix E.3

Effective: April 1, 2009
Revised: October 1, 2017

The random location for the first mile measured from the beginning of the lot and the left (confined) edge of the paved mat are as follows:

Core #	Longitudinal Location	Cumulative Distance	Transverse Location
1	1056 x 0.904 = 955 ft	1056 x (1-1) + 955 = 955 ft	13.0 x 0.007 = 0.1 ft = **0.3 ft**[1/]
2	1056 x 0.231 = 244 ft	1056 x (2-1) + 244 = 1300 ft	13.0 x 0.059 = 0.8 ft
3	1056 x 0.517 = 546 ft	1056 x (3-1) + 546 = 2658 ft	13.0 x 0.996 = 13.0 ft = **12.7 ft**[2/]
4	1056 x 0.253 = 267 ft	1056 x (4-1) + 267 = 3435 ft	13.0 x 0.515 = 6.7 ft
5	1056 x 0.040 = 42 ft	1056 x (5-1) + 42 = 4266 ft	13.0 x 0.101 = 1.3 ft

1/ The 0.1 ft offset for Core #1 was moved in to 0.3 ft due to the 4 in. minimum from the edge requirement.

2/ The 13.0 ft offset for Core #3 was move in to 12.7 ft due the 4 in. minimum from the edge requirement. Since this core is within 1 ft from an unconfined edge 2% will be added to the measured core density.

Illinois Department of Transportation

PFP and QCP Random Density Procedure
Appendix E.3

Effective: April 1, 2009
Revised: October 1, 2017

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.

Special Provision Contents

PFP, QCP & WMA Specification Information

PFP = Payment for Performance
QCP = Quality Control for Payment

CBM = Central Bureau of Materials
MoTP = Manual of Test Procedures
BDE = BDE Special Provisions

THIS PAGE IS RESERVED.

Illinois Department of Transportation

PFP Quality Level Analysis
Appendix E.1

Effective: December 12, 2003
Revised: June 28, 2017

This stand-alone document explains the statistical analysis and procedure used to determine the pay factor for a hot-mix asphalt (HMA) mixture on Pay for Performance (PFP) project. HMA materials specified to be sampled and tested for percent within limits payment adjustment (voids, VMA, and in-place density) and dust/AC adjustments will be evaluated for acceptance in accordance with this document.

Pay parameters evaluated using percent within (PWL) limits will be analyzed collectively and statistically by the Quality Level Analysis method using the procedures listed 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. Two measures of quality are required to establish the contract unit price adjustment. The first measure is the Acceptable Quality Level (AQL) which is the PWL at which the lot will receive 100 percent pay. The second measure of quality is the Rejectable Quality Level (RQL) at which the Department has determined the material may not perform as desired and may be rejected.

The pay factor on full-depth projects shall be determined by weighting each mixture equally. Material placed at the same gyrations values but with and without polymer will be evaluated 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 mix will be evaluated as three equally (1/3) weighted mixtures even if the polymer binder is the only difference between binder lifts.

Pay adjustments for Dust/AC ratio will be applied using the Dust/AC Pay Adjustment Table found in the Hot Mix Asphalt Pay for Performance Using Percent within Limits special provision.

QUALITY LEVEL ANALYSIS

Note: Table 1: Pay Attributes and Price Adjustment Factors contain the UL, LL, and pay factor "f" weights.

Items 1 through 8 of the following procedure will be repeated for each lot of the various pay factor parameters.

(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

(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).

$PWL = (P_U + P_L) - 100$

(8) To determine the pay factor for each individual parameter lot:

Pay Factor (PF) = 55 + 0.5 (PWL)

Illinois Department of Transportation

PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
Revised: June 28, 2017

(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.

$$CPF = \left[f_{VMA}\left(TPF_{VMA}\right) + f_{voids}\left(TPF_{voids}\right) + f_{density}\left(TPF_{density}\right) \right] / 100$$

Substituting from Table 1:

$$CPF = \left[0.3\left(TPF_{VMA}\right) + 0.3\left(TPF_{voids}\right) + 0.4\left(TPF_{density}\right) \right] / 100$$

Where:

f_{VMA}, f_{voids}, *and* $f_{density}$ = Price Adjustment Factor listed in Table 1

TPF_{VMA}, TPF_{voids}, *and* $TPF_{density}$ = *Total Pay Factor for the designated measured attribute from (9)*

(11) Determine the final pay for a given mixture.

*Final Pay = Mixture Unit Price * Quantity * CPF*

Illinois Department of Transportation

PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
Revised: June 28, 2017

Table 1: Pay Attributes and Price Adjustment Factors			
Measured Attribute	Factor *"f"*	*UL*	*LL*
VMA	0.3	MDR[/1] + 3.0	MDR[/1] – 0.7
Plant Voids	0.3	Design Voids + 1.35	Design Voids – 1.35
In-Place Density	0.4	97.0[/2]	91.5[/2]
IL 9.5 FG Level Binder[3/]	0.4	97.0	90.5
IL 19.0	0.4	97.0	92.2
SMA	0.4	98.0	93.0

1. MDR = Minimum Design Requirement
2. Applies to all HMA mixes other than IL-4.75, IL-19.0, SMA and IL 9.5 FG Level Binder placed ≤ 1.25 in. (32 mm) thick
3. Placed at a thickness ≤ 1.25 in. (32 mm)

PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
Revised: June 28, 2017

Example:

Determine the Pay factor for the given lot of a N90 HMA surface being placed at 1.5 inches thick as an overlay. The project consists of 10,000 tons over 17 miles.

Note that mix sample and density lots are independent of each other.

In this example the mix sample lot represents 10,000 tons while the density lot represents 6 miles (N=30). The project would have two additional density lots following the same calculations as the first lot. All three lots are combined as per item (9).

Mix sample: Each sublot represents 1000 tons

Lot #	Sublot #	Voids TV = 4.0	VMA Design Min = 14.5
1	1	4.2	14.4
	2	4.5	14.7
	3	3.3	13.9
	4	5.0	15.0
	5	5.4	15.2
	6	2.5	13.5
	7	3.8	14.2
	8	4.1	14.3
	9	4.3	14.4
	10	4.5	14.6
Average:		4.16	14.42
Standard Deviation:		0.825	0.498

Density: Each density test interval represents 0.2 mile thus N=30 in which 5 cores are taken per mile would represent 6 miles of paving.

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.

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)

P_U = 94

P_L = 98

PWL = (94 + 98) - 100

PWL = 92

PF = 55 + 0.5 (92)

PF = 101.0

Determine the pay factor for Voids.

PF_{Voids} = 101.0

VMA:

Lot : Average = 14.42
Standard Deviation = 0.498

$$Q_U = \frac{(14.5 + 3.0) - 14.42}{0.498} = 6.18$$

$$Q_L = \frac{14.42 - (14.5 - 0.7)}{0.498} = 1.24$$

N = 10 sublots (from table)

P_U = 100

P_L = 90

PWL = (100 + 90) - 100

PWL = 90

PF = 55 + 0.5 (90)

PF = 100.0

Determine the pay factor for VMA.

PF_{VMA} = 100.0

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

Determine the total pay factors for each parameter. In this example 10,000 tons of mix represents the entire project so only one lot exists for VMA and voids. If more mix lots occurred on a project they would be combined just like density as shown.

Lot #	Mix Tons	Void PF	VMA PF	Density Distance	Density PF
1	10,000	9101.0	9100.0	31680 ft	9101.5
2				31680 ft	101.4
3				24640 ft	97.3
TPF		**9101.0**	**9100.0**	88000 ft	**9100.3**

$TPF_{Density} = W1PF_{lot1} + W2PF_{lot2} + W3PF_{lot3}$

$TPF_{Density}$= (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(100.0) + 0.4(100.3)] / 100

CPF = 1.004

Determine the price paid for the given mixture.

Given that the mixture bid price per ton = $65.00 and 10,000 tons were placed.

Plan Unit Pay = $65.00/ton * 10,000 tons = $650,000

Adjusted Pay = $65.00/ ton * 10,000 tons * 1.004 = $652,600

Determine the difference between the adjusted pay and the plan unit pay.

Adjusted pay – Plan Unit Pay = $652,600 – $650,000 = $2,600

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 paid. In this case a $2,600 incentive would be paid as per policy memorandum 9-4.

Full Depth Examples:

Given a full-depth project with two mixtures whose combined pay factors were determined to be 101.5% and 99.2%. The full-depth pay factor shall be calculated as follows:

101.5(1/2) + 99.2(1/2) = 100.4%

Determine the adjusted pay for the full-depth pay factor.

Given that the bid price per square yard = \$25.00 and 1400 yd^2 were placed.

Plan Unit Pay = \$25.00/ yd^2 * 1400 yd^2 = \$35,000

Adjusted Pay = \$25.00/ yd^2 * 1400 yd^2 * 1.004 = \$35,140

Difference = \$35,140 – \$35,000 = \$140 (Positive value = Incentive)

Given a full-depth project with three mixtures whose pay factors were determined to be 98.9%, 101.5% and 99.2%. The full depth pay factor shall be calculated as follows:

98.9(1/3) + 101.5(1/3) + 99.2(1/3) = 99.9%

Determine the adjusted pay for the full-depth pay factor.

Given that the bid price per square yard = \$25.00 and 1400 yd^2 were placed.

Plan Unit Pay = \$25.00/ yd^2 * 1400 yd^2 = \$35,000

Adjusted Pay = \$25.00/ yd^2 * 1400 yd^2 * 0.999 = \$34,965

Difference = \$34,965 – \$35,000 = -\$35 (Negative = Disincentive)

PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
Revised: June 28, 2017

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

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
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.

Illinois Department of Transportation

PFP and QCP Random Density Procedure
Appendix E.3

Effective: April 1, 2009
Revised: October 1, 2017

Density tests using cores shall be obtained at the frequency specified in the Hot Mix Asphalt Quality Control for Performance (QCP) and Pay for Performance (PFP) Using Percent within Limits special provisions. The random test locations shall be determined as follows:

A) The random core locations shall be taken at the randomly selected test location within each density testing interval. 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 approved software program. 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 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 and provide documentation to the Contractor upon completion of the project.

   Each core location shall be randomly located both longitudinally and transversely within each density testing interval. Each core location within the density testing interval shall be determined with two random numbers. The first random number is used to determine the longitudinal distance to the nearest 1 ft into the density testing interval. The second random number is used to determine the transverse offset to the nearest 0.1 ft from the left edge of the **paving lane**. In cases where paving is completed over multiple lanes in a single pass of one or more pavers to eliminate unconfined edges between lanes, the **paving lane** is defined as the total combined width of the lanes paved in that single pass. The density intervals shall 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 **paving lane** width is greater than 20 ft.

   To determine the longitudinal location of a core, multiply the length of the prescribed density interval by the random number selected from the Random Number table. Determine the random transverse offset as follows:

   1. PFP. The effective lane width of the pavement shall be used in calculating the transverse offset. The effective lane width is determined by subtracting 1.0 ft for each unconfined edge from the entire paved lane width (i.e. If a 12.0 ft wide paved lane has two unconfined edges, the effective lane width would be 10.0 ft.) Determine the transverse offset by multiplying the effective width by the random number selected from the Random Number table.

      The transverse offset is measured from the left physical edge of the paved lane to locate the core on the pavement. If the left edge was unconfined, it will be omitted by adding 1.0 ft to the calculated transverse offset measurement.

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PFP and QCP Random Density Procedure
Appendix E.3

Effective: April 1, 2009
Revised: October 1, 2017

Random locations that fall within 4.0 inches of a confined edge shall be moved to 4.0 inches off the edge. Areas outside the mainline pavement that are paved concurrently with the mainline pavement (i.e. three-ft wide left shoulders, driveways, etc.) are not considered part of the paved mainline mat. See PFP example calculation herein.

The core density location for the outer 1.0 ft of an unconfined edge will be randomly selected within each 0.5 mile section for each unconfined edge. Longitudinal joint testing shall be located at a distance equal to the lift thickness or a minimum of 4.0 in. (100 mm), from each pavement edge. (i.e. for a 5 in. (125 mm) lift the near edge of the core barrel shall be within 5.0 in. (125 mm) from the edge of pavement.)

2. QCP. The entire width of the pavement shall be used in calculating the transverse offset. No offset movement is to be used for random locations that lie within 1.0 ft from an unconfined edge. Cores taken within 1.0 ft from an unconfined edge will have 2.0% density added for pay adjustment calculation purposes. Random locations that fall within 4.0 in. of an edge shall be moved to 4.0 in. off the edge. See QCP example calculation herein.

B) This process shall be repeated for all density intervals on a given project.

C) Moving Core Locations.

There are two scenarios in which random core 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 core location will not allow the necessary compactive effort to be applied, the Engineer will adjust the longitudinal location of the core in order to avoid the obstacle. Using the same random transverse offset, the core location will be moved longitudinally, ± 15 feet to avoid the following obstacles only:

   a) Structures or Bridge Decks
   b) Detection loop or other pavement sensors
   c) Manholes or other utility appurtenances

Case 2. In the event there are pavement defects in the surface being overlaid, the Contractor may place temporary markings on the shoulder to represent longitudinal locations where a defect is present. These pavement defect locations will be approved by the Engineer. If a random core location lands at the same longitudinal location as the temporary mark, the core will be moved 5 feet 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 inches of asphalt pavement remaining after milling) the temporary markings shall show the extent or length of the defect. The core location will then be moved to a longitudinal distance 5 feet past the end of the defect toward the paver.

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PFP and QCP Random Density Procedure
Appendix E.3

Effective: April 1, 2009
Revised: October 1, 2017

D) Example Calculations.

PFP Example.

This **PFP** example illustrates the determination of the core locations within the first mile of a lot.

Given 1.5 in. thickness would require a density testing interval of 0.2 miles. The pavement consists of a 13.0 ft-wide mat with the left edge confined and the right edge unconfined. 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 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 number by the effective width of the paved mat.

Determine the effective lane width by subtracting 1.0 ft, for each unconfined edge, from the entire paved lane width. In this case only the right edge is unconfined, so subtract 1.0 ft from the entire paved lane width of 13.0 ft.

Effective Width = 13.0 ft minus 1.0 ft = 12.0 ft

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PFP and QCP Random Density Procedure
Appendix E.3

Effective: April 1, 2009
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The random location for the first mile measured from the beginning of the lot and the left (confined) edge of the paved mat are as follows:

Core #	Longitudinal Location	Cumulative Distance	Transverse Location
1	1056 x 0.917 = 968 ft	1056 x (1-1) + 968 = 968 ft	12.0 x 0.890 = 10.7 ft
2	1056 x 0.289 = 305 ft	1056 x (2-1) + 305 = 1361 ft	12.0 x 0.317 = 3.8 ft
3	1056 x 0.654 = 691 ft	1056 x (3-1) + 691 = 2803 ft	12.0 x 0.428 = 5.1 ft
4	1056 x 0.347 = 366 ft	1056 x (4-1) + 366 = 3534 ft	12.0 x 0.998 = 11.7 ft
5	1056 x 0.777 = 821 ft	1056 x (5-1) + 821 = 5045 ft	12.0 x 0.003 = 0.0 ft = **0.3 ft**[1/]

1/ The 0.0 ft for Core #5 was moved in to 0.3 ft due to the 4 in. minimum from the edge requirement.

QCP Example.

This **QCP** example illustrates the determination of the core locations within the first mile of a project.

Given 1.5" thickness would require a density testing interval of 0.2 miles. The pavement consists of a 13.0 ft-wide mat with the left edge confined and the right edge unconfined. 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.

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 number by the width of the paved lane (13.0 ft).

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PFP and QCP Random Density Procedure
Appendix E.3

Effective: April 1, 2009
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The random location for the first mile measured from the beginning of the lot and the left (confined) edge of the paved mat are as follows:

Core #	Longitudinal Location	Cumulative Distance	Transverse Location
1	1056 x 0.904 = 955 ft	1056 x (1-1) + 955 = 955 ft	13.0 x 0.007 = 0.1 ft = **0.3 ft**[1/]
2	1056 x 0.231 = 244 ft	1056 x (2-1) + 244 = 1300 ft	13.0 x 0.059 = 0.8 ft
3	1056 x 0.517 = 546 ft	1056 x (3-1) + 546 = 2658 ft	13.0 x 0.996 = 13.0 ft = **12.7 ft**[2/]
4	1056 x 0.253 = 267 ft	1056 x (4-1) + 267 = 3435 ft	13.0 x 0.515 = 6.7 ft
5	1056 x 0.040 = 42 ft	1056 x (5-1) + 42 = 4266 ft	13.0 x 0.101 = 1.3 ft

1/ The 0.1 ft offset for Core #1 was moved in to 0.3 ft due to the 4 in. minimum from the edge requirement.

2/ The 13.0 ft offset for Core #3 was move in to 12.7 ft due the 4 in. minimum from the edge requirement. Since this core is within 1 ft from an unconfined edge 2% will be added to the measured core density.

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PFP and QCP Random Density Procedure
Appendix E.3

Effective: April 1, 2009
Revised: October 1, 2017

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

Pay for Performance Dispute Resolution
Appendix E.5

Effective Date: April 1, 2010
Revised: October 1, 2017

A. Scope

This document describes the two methods for disputing 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.

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). If dispute resolution is necessary, the Contractor shall submit a request in writing within four working days of receipt of the results of the quality index analysis for the lot. The Engineer will document receipt of the request. The request shall specify Method 1 or Method 2. The Central Bureau of Materials (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 acceptable limits shown in the Special Provision for "Hot Mix Asphalt - Pay For Performance Using Percent Within Limits - Jobsite Sampling (BDE).

Table 1

Test Parameter	Limits of Precision
Voids	1.0 %
Field VMA	1.0 %
Ratio - Dust / Asphalt Binder	0.2
Core Density	1.0 %

2. Method 2:

Method 2 dispute resolution will be allowed when: 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 content) exceeding precision limits. The dispute resolution test result/s will replace the original Department result/s for the disputed parameters.

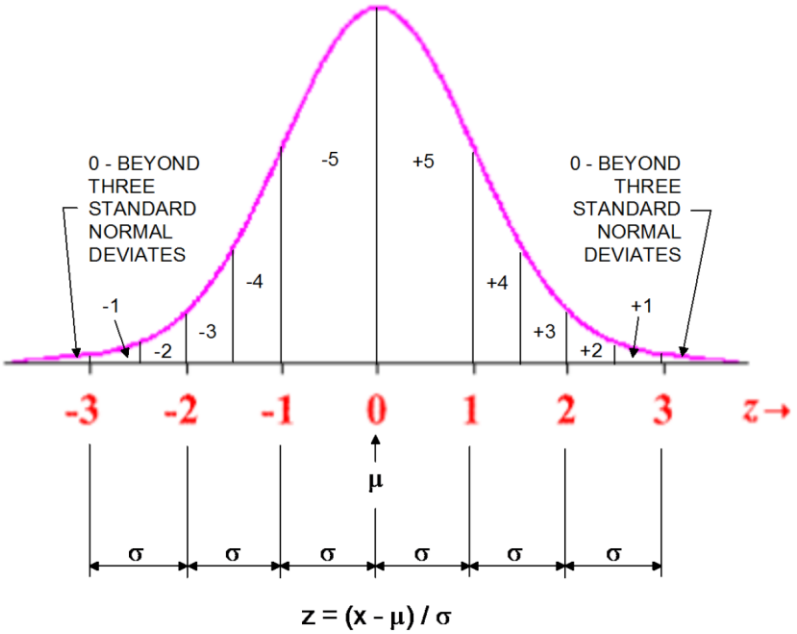
Table 2

Test Parameter	Limits of Precision
G_{mm}	0.008
G_{mb} 1/	0.012
Asphalt Binder	0.2

Note 1/ Both core G_{mb} and gyratory G_{mb}.

a. Proficiency Sample Testing

To qualify to dispute 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:



For the Contractor to dispute individual test results, G_{mm}, G_{mb}, and/or asphalt content, the following shall be met:

1) The Contractor's laboratory that conducts Quality Control testing shall participate in the appropriate AASHTO re:source PSP;

2) Within 60 calendar days of the date of issuance of a proficiency sample report, the Contractor shall submit each laboratory's proficiency sample report/s to the Department;

3) The Contractor's laboratory that conducts Quality Control testing received a proficiency score of 3 or better on the respective test; and

4) The adjusted split test results for the respective test, G_{mm}, G_{mb}, and asphalt 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;

c) For each sublot, subtract the average initial split for the lot from the initial split result to determine the adjusted split.

d) Compare the adjusted split precision limits listed in Table 2 to determine whether sample qualifies for dispute testing.

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	

If a Contractor laboratory receives a score of 2 or worse on a test, the Contractor shall in order to retain the ability to dispute individual test results, within 60 calendar days of the date of issuance of a proficiency sample report:

1) Conduct a root cause analysis to determine the possible reason(s) for the results;

2) Correct any issues that are uncovered in the investigation;

3) Document investigation and corrective actions; and

4) Submit AASHTO Accreditation Program (AAP) Proficiency Sample Corrective Action Report to the Department.

Consecutive occurrences of a laboratory receiving a score of 2 or worse on a test or nonparticipation in the most recent PSP shall result in the Contractor no longer being able to dispute individual test results until the Contractor receives a satisfactory score on the next regularly scheduled PSP or on an extra proficiency sample. 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 Department will report laboratory scores for all participants for informational purposes.

Density cores for dispute resolution testing shall be taken simultaneously 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 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}.

C. Dispute Testing Pay Schedule

The lot pay factor for the lot under dispute resolution will be recalculated. If the recalculated lot pay factor is less than or equal to the original lot pay factor, laboratory costs listed below 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 Content	$500

D. Dispute Submittal Instructions

When submitting HMA mix and/or core samples include the following:

1. All District and Contractor split sample test results on attached “PFP Dispute Resolution Form”,
2. Submit entire dispute resolution HMA mix split sample,
3. Cores must be split or sawed to lift testing thickness,
4. QC Package template and dailies 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: Joe Rechner *Joseph.Rechner@illinois.gov*

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/AC ☐

Method 2 ☐ Parameter Disputed: G_{mb} ☐ G_{mm} ☐ AC ☐

Contract # : ____________________

Dist. Lab ID # : ____________________

Mix Design # :

Mix Lot _____ Sublot _____

Mix Code #: ____________________

Producer #: ____________________

CBM Lab #: ____________________

Wt. for Gmb: ____________________

Sampled From: Truck ☐ MTD ☐ Road ☐

Sample Date: ____________________

Date Received:

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)			
#4 (4.75 mm)			
#8 (2.36 mm)			
#16 (1.18 mm)			
#30 (.60 mm)			
#50 (.30 mm)			
#100 (.15 mm)			
#200 (.075 mm)			
Asphalt Binder %			
Dust/Asphalt Binder Ratio			
G_{mm}			
G_{mb}			
% Voids			
G_{sb}			
Field VMA			

CORES

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QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
Revised: October 1, 2017

E) This document explains the procedure used to determine the pay adjustment for a hot-mix asphalt (HMA) mixture for Quality Control for Performance (QCP) projects.
F)
G) The following steps are used to determine the pay deduction for each QCP mixture:

1. Determine sublot deviation from target for each pay parameter.
2. Determine the sublot pay factor for each sublot using the Table 1 and the deviation from target.
3. Determine the average sublot Pay Factor for each pay parameter.
4. Calculate a Combined Pay Factor using the average sublot Pay Factors and Equation 1.
5. Determine the QCP pay deduction for the mixture using Equation 2.
6. The Combined Pay Factor shall not exceed 100%.
7. The 105% column only applies when the district conducts testing of all the sublots within a given lot and all of the tests are within the Acceptable Limits. The 105% column also applies to density sublots where no individual density test is less than 90.0% or greater than 98.0% density. The average sublot Pay Factor for each pay parameter shall be capped at 100.0% prior to calculating the Combined Pay Factor.

Table 1

Parameter	Pay Factor			
	1105%	100%	95%	90%
Voids[1/ 3/]	± 0.5%	± 1.2%	± 1.6%	± 2.0%
VMA [3/]	0% to +1.0% above minimum specified	-0.5% to +2.0%	-0.7% to +2.5%	-1.0% to +3.0%
Density[2/4/]	93.5% to 94.5%	92.5% to 96.5%	91.5% to 97.0%	90.0% to 98.0%
SMA	94.0% to 95.0%	93.5% to 96.5%	92.5% to 97.0%	92.0% to 98.0%
IL-9.5FG at < 1.25 in.	93.5% to 94.5%	91.0% to 96.5%	90.0% to 97.0%	89.0% to 98.0%

1/ Ranges based on deviation from the specified design percent Voids.
2/ If no density requirement applies the Contractor will receive 100% for the density pay factor in Equation 1.
3/ If mixture testing is waived for small tonnage, the Contractor will receive 100% for the Voids and VMA pay factors in Equation 1.
4/ A density test where the core thickness is less than 0.75 inch will not be used in the density pay factor calculation.

Illinois Department of Transportation

QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
Revised: October 1, 2017

Equation 1: $CPF = 0.30(PF_{Voids}) + 0.30(PF_{VMA}) + 0.40(PF_{Density})$

Where:

CPF = Combined Pay Factor

PF_{Voids}, PF_{VMA}, and $PF_{Density}$ = Average sublot pay factors for the pay parameters

The QCP deduction for a given mixture is calculated by multiplying the Mixture Unit Price by the Quantity and the CPF according to Equation 2 below.

Equation 2: QCP Deduction = (Mixture Unit Price x Mixture Quantity x CPF/100) – (Mixture Unit Price x Mixture Quantity)

Example:

Determine the QCP pay deduction for the given N70 HMA IL-9.5 surface mixture being placed at 1.5 inches thick as an overlay. The project consists of 6,900 tons placed over a distance of 12 lane miles.

Note that 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, representing 12 miles x 5 cores/mile = 60 cores).

Mix sample: Each sublot represents 1000 tons except for lot 2, sublot 3 which represents 900 ton.

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 mile which is 5 cores per mile. Each density sublot represents 1 mile. Therefore with cores taken every 0.2 mile, the density sublot will represent the average of 5 density cores.

QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
Revised: October 1, 2017

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
⋮	⋮	⋮	⋮	⋮	⋮
12	91.5	93.5	92.7	93.8	92.1

Determine the average sublot pay factor for each parameter:

Voids:

Since the District randomly selected and tested the split from sublot 2 in Lot 1, and the 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 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 void deviation from 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%

Using Table 1 and the deviation from Target, determine the corresponding Void 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%

Lot	Sublot	Contractor	District	Deviation	Sublot PF
1	1	4.1	***3.2***	***-0.8***	***100.0***
	2	3.9			
	3	2.8			
	4	3.0			
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 Voids. (Note: The 100% in Lot 1 represents four sublots and therefore is multiplied by four)

Ave Sublot Pay Factor (PF_{Voids}) = ((100% X 4) + 95% + 90% + 105%) / 7 sublots = **98.6%**

VMA:

Since the District randomly selected and tested the split from Sublot 2 in Lot 1, and the 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 Voids**, the District had to test all of the remaining sublot splits. (see completed table below):

Calculate the VMA deviation from 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%

QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
Revised: October 1, 2017

Using Table 1 and the deviation from Target, determine the corresponding 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 VMA = 15.0%					
Lot	Sublot	Contractor	District	Deviation	Sublot PF
1	1	14.9			
	2	14.5	***14.6***	***-0.4***	***100***
	3	14.4			
	4	14.8			
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 VMA. (Note: The 100% in Lot 1 represents four sublots and therefore is multiplied by four)

Ave 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: October 1, 2017

Density Sublot	Density Intervals (cores)					Sublot Ave	Sublot PF
	1	2	3	4	5		
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
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
12	91.5	93.5	92.7	93.8	92.1	92.7	100
						Average Density Sublot PF =	100.5

Combined Pay Factor:

Determine the Combined Pay Factor using Equation 1.

$$CPF = 0.30(PF_{Voids}) + 0.30(PF_{VMA}) + 0.40(PF_{Density})$$

$$= 0.30(98.6) + 0.30(98.6) + 0.4(100.5)$$

$$CPF = 99.4\%$$

QCP Deduction:

Determine the QCP deduction pay for the given mixture using Equation 2.

QCP Deduction = (Mixture Unit Price x Mixture Quantity x CPF/100) – (Mixture Unit Price x Mixture Quantity)

Where: Mixture Unit Price = $65.00

Mixture Quantity = 6,900 tons placed.

QCP Deduction = ($65.00/ton x 6,900 tons x 99.4 / 100) – ($65.00/ton x 6,900 tons)
= - $2691

In this case a $2691 disincentive would be paid as per Construction Memorandum 10-4.

QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
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Full Depth Examples:

Given a full-depth project with two mixtures whose combined pay factors were determined to be 100.0% and 98.2%. The full-depth pay factor shall be calculated as follows:

100.0(1/2) + 98.2(1/2) = 99.1%

Determine the adjusted pay for the full-depth pay factor.

Given that the bid price per square yard = $25.00 and 1400 yd^2 were placed.

Plan Unit Pay = $25.00/ yd^2 * 1400 yd^2 = $35,000

Adjusted Pay = $25.00/ yd^2 * 1400 yd^2 * 0.991 = $34,685

Difference = $34,685 – $35,000 = - $315

Given a full-depth project with three mixtures whose pay factors were determined to be 98.9%, 100.0% and 99.2%. The full depth pay factor shall be calculated as follows:

98.9(1/3) + 100.0(1/3) + 99.2(1/3) = 99.4%

Determine the adjusted pay for the full-depth pay factor.

Given that the bid price per square yard = $25.00 and 1400 yd^2 were placed.

Plan Unit Pay = $25.00/ yd^2 * 1400 yd^2 = $35,000

Adjusted Pay = $25.00/ yd^2 * 1400 yd^2 * 0.994 = $34,790

Difference = $34,790 – $35,000 = - $210

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Illinois Department of Transportation

Best Practices
For
Pay-For-Performance (PFP) and Quality Control for Performance (QCP)
Implementation

Appendix E.7

Effective Date: April 1, 2012
Revised Date: December 1, 2017

Purpose

This document is intended to aid district personnel in successfully preparing for and implementing the Pay-For-Performance (PFP) and Quality Control for Performance (QCP) specifications.

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 Bituminous Uniformity Studies" (aka Round Robins) and 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 21-08.0 "Minimum Requirements For Construction Materials Testing Laboratories - Department Operated Laboratories" at a minimum. Inspection and calibration immediately prior to PFP and QCP testing is highly recommended. Always use the same gyratory compactor for a given 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. Keep technician assignments as consistent as possible. It is highly recommended to conduct an in-house round robin 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 splitting. The samples should then be reheated and compacted as soon as the samples reach compaction temperature.

4) Efficiency – PFP and QCP are based on Department testing which results in a higher testing frequency for the district laboratory. 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 specification allows a 14 working day test turnaround time for PFP and a 10 day turnaround for QCP, 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 are 1) undisclosed random mix and density sample locations, 2) Sample either taken by the Engineer or witnessed by the Engineer, and 3) sample security. The CFR is intended to assure that the sample is 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) Discuss who will be responsible for sample identifying undisclosed sample location and sample layout
   b) Sample Security; discuss who will transport and / or store samples.
   c) Pay Calculations; discuss who will be responsible for entering data in software and how communication regarding pay factors will occur.
2) Procedures:
   a) Random sample locations
      i) Discuss when to disclose sampling location
      ii) Familiarize Construction personnel with random sample procedures detailed in the Manual of Test Procedures
   b) Sample Layout (utilization of random number table)
      i) Discuss how core densities will be:
         (1) transversely no closer than 1 foot to an unconfined longitudinal joint and 4 inches on a confined longitudinal joint for PFP.
         (2) transversely no closer than 4 inches from an edge for QCP.
      ii) Discuss how to handle coring locations that will 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.

Illinois Department of Transportation

Memorandum

To:	Regional Engineers
From:	Omer M. Osman 1/11/16
Subject:	Special Provision for Warm Mix Asphalt
Date:	January 8, 2016

This special provision was developed by the Bureau of Materials and Physical Research to implement Warm-Mix Asphalt technology as part of the Federal Highway Administration Every Day Counts Initiative. This special provision has been revised to fit with the 2016 Standard Specifications.

This special provision should be inserted in all Hot-Mix Asphalt contracts.

The districts should include the BDE Check Sheet marked with the applicable special provisions for the April 22, 2016 and subsequent lettings. The Project Development and Implementation Section will include a copy in the contract.

This special provision will be available on the transfer directory January 8, 2016.

80288m

WARM MIX ASPHALT (BDE)

Effective: January 1, 2012
Revised: April 1, 2016

Description. This work shall consist of designing, producing and constructing Warm Mix Asphalt (WMA) in lieu of Hot Mix Asphalt (HMA) at the Contractor's option. Work shall be according to Sections 406, 407, 408, 1030, and 1102 of the Standard Specifications, except as modified herein. In addition, any references to HMA in the Standard Specifications, or the special provisions shall be construed to include WMA.

WMA is an asphalt mixture which can be produced at temperatures lower than allowed for HMA utilizing approved WMA technologies. WMA technologies are defined as the use of additives or processes which allow a reduction in the temperatures at which HMA mixes are produced and placed. WMA is produced by the use of additives, a water foaming process, or combination of both. Additives include minerals, chemicals or organics incorporated into the asphalt binder stream in a dedicated delivery system. The process of foaming injects water into the asphalt binder stream, just prior to incorporation of the asphalt binder with the aggregate.

Approved WMA technologies may also be used in HMA provided all the requirements specified herein, with the exception of temperature, are met. However, asphalt mixtures produced at temperatures in excess of 275 °F (135 °C) will not be considered WMA when determining the grade reduction of the virgin asphalt binder grade.

Equipment.

Revise the first paragraph of Article 1102.01 of the Standard Specifications to read:

"**1102.01 Hot-Mix Asphalt Plant.** The hot-mix asphalt (HMA) plant shall be the batch-type, continuous-type, or dryer drum plant. The plants shall be evaluated for prequalification rating and approval to produce HMA according to the current Bureau of Materials and Physical Research Policy Memorandum, "Approval of Hot-Mix Asphalt Plants and Equipment". Once approved, the Contractor shall notify the Bureau of Materials and Physical Research to obtain approval of all plant modifications. The plants shall not be used to produce mixtures concurrently for more than one project or for private work unless permission is granted in writing by the Engineer. The plant units shall be so designed, coordinated and operated that they will function properly and produce HMA having uniform temperatures and compositions within the tolerances specified. The plant units shall meet the following requirements."

Add the following to Article 1102.01(a) of the Standard Specifications.

"(11) Equipment for Warm Mix Technologies.

a. Foaming. Metering equipment for foamed asphalt shall have an accuracy of ± 2 percent of the actual water metered. The foaming control system shall be electronically interfaced with the asphalt binder meter.

b. Additives. Additives shall be introduced into the plant according to the supplier's recommendations and shall be approved by the Engineer. The system for introducing the WMA additive shall be interlocked with the aggregate feed or weigh system to maintain correct proportions for all rates of production and batch sizes."

Mix Design Verification.

Add the following to Article 1030.04 of the Standard Specifications.

"(e) Warm Mix Technologies.

(1) Foaming. WMA mix design verification will not be required when foaming technology is used alone (without WMA additives). However, the foaming technology shall only be used on HMA designs previously approved by the Department.

(2) Additives. WMA mix designs utilizing additives shall be submitted to the Engineer for mix design verification."

Construction Requirements.

Revise the second paragraph of Article 406.06(b)(1) of the Standard Specifications to read:

"The HMA shall be delivered at a temperature of 250 to 350 °F (120 to 175 °C). WMA shall be delivered at a minimum temperature of 215 °F (102 °C)."

Basis of Payment.

This work will be paid at the contract unit price bid for the HMA pay items involved. Anti-strip will not be paid for separately, but shall be considered as included in the cost of the work.

80288

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Chapter 2 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
9-01-17	8:30 a	250	4.8	-	-	000-01	
"	11:30 a	450	4.5	-	-	000-02	
9-04-17	6:30 a	300	4.8	-	-	001-01	1
"	11:15 a	1800	4.8	-	-	001-01	2
9-05-17	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
9-06-17	7:30 a	200	3.7	-	-	003-01	1
"	12:30 p	1700	4.0	3.8	-	003-01	2
9-07-17	7:00 a	300	2.7	-	-		
"	1:00 p	1900	-	-	4.4		
"	3:30 p	2300	4.1	-	-		
9-08-17	6:30 a	450	4.0	-	-		
"	1:15 p	1900	3.7	6.0	-		
9-11-17	6:40 a	150	3.0	-	-		
"	11:05 a	1500	3.5	-	-		
9-12-17	7:10 a	250	3.1	-	-		
"	1:25 p	1400	3.1	-	-		
9-13-17	6:50 a	300	4.7	4.5	-		
"	1:10 p	1575	4.7	-	-		
9-14-17	7:20 a	275	4.6	-	-		
"	12:35 p	1675	3.1	2.9	-		
9-15-17	7:50a	150	4.2	-	-		

HMA I Homework

This Page Is Reserved

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 = _____%

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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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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 10-37 thru 10-39 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 HM-19)**

  Calculate average nuclear density field readings and copy results to field density form on page HM-21.

- **Part 2 (Page HM-21)**

  Use the given information below, along with the needed job data information and average nuclear readings from HM-19 to complete as much of the form on HM-21, as possible. (Directions for filling out the form are located in Chapter 10 on pages 10-17 thru 10-23.) Use the first determined station location from the Random Density Location problem found on page HM-15.

GIVEN: **George Brown works as a Nuclear Density Tester for the contractor Asphalt Service Industries (932-04). The standard count ran on the gauge was 2544, which was completed the same day as the field testing. The gauge was calibrated on January 25, 2017. Use the job stamp information found on the core correlation worksheet. Testing took place on the first lift of surface mixture on the northbound driving lane of IL 32. George took his first required density test for the ninth day of production. The QC Manager for this project is Dave Keller who also works for Asphalt Service Industries.**

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Job Data

DATE:	**08/25/2017**
CONTRACT:	**74226**
JOB #:	**C9701417**
ROUTE:	**IL 32**
COUNTY:	**Moultrie**
SECTION:	**(1,2) RS-3**
BASE MATERIAL:	**Milled Surface**
MIX #:	**87BIT1016**
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 _____ 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 2
Solutions

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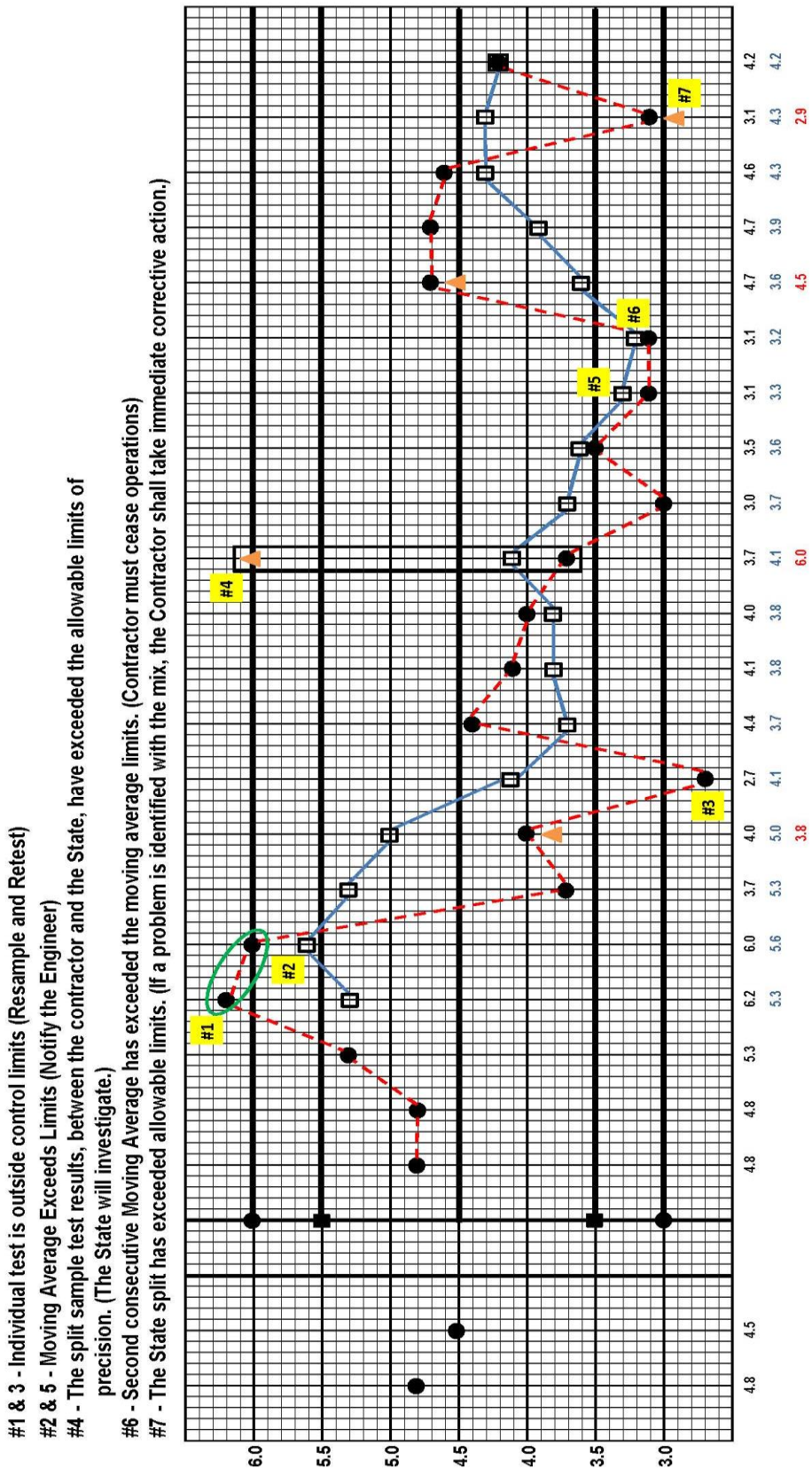
#1 & 3 - Individual test is outside control limits (Resample and Retest)
#2 & 5 - Moving Average Exceeds Limits (Notify the Engineer)
#4 - The split sample test results, between the contractor and the State, have exceeded the allowable limits of precision. (The State will investigate.)
#6 - Second consecutive Moving Average has exceeded the moving average limits. (Contractor must cease operations)
#7 - The State split has exceeded allowable limits. (If a problem is identified with the mix, the Contractor shall take immediate corrective action.)
#1
#2
#3
#4
#5
#6
#7
6.0
5.5
5.0
4.5
4.0
3.5
3.0

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Chapter 5 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 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 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	082517	Seq. No.	009			County	Moultrie
Bit Mix Plant	932-04	Bit Mix Code	19523	Equip.	A	QA	Y	Section	(1,2) RS-3
Contract No.	74226	Job No.	C9701417	Target Dens.	2261			Route	IL 32
Responsible Loc.	97	Lab	PC	Standard Count	2544			Project	0

Start Date	----------	Complete Date	----------	Correlation Data	
Gauge #	28769	Calib. Date	012517	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	082517	34+40	NBD	.1	2.306	2.444	94.4	APPR	PRO	2305.5	009-01
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: George Brown/*George Brown* — Agency: Asphalt Service Industries

RE — Inspector: Dave Keller/*Dave Keller* — Agency: Asphalt Service Industries

Contractor

MISTIC INPUT
Date Entered
Initials

/FOR DTY0303N
MI 303N QC/QA

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APPENDICES TABLE OF CONTENTS

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MTP = Manual of Test Procedures for Materials

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Illinois Department of Transportation

Hot-Mix Asphalt QC/QA Laboratory Equipment
Appendix D.4

Effective: April 1, 1997
Revised: December 1, 2017

This document summarizes the minimum requirements for Hot-Mix Asphalt (HMA) quality control, quality assurance, and design laboratories. It is the contractor's responsibility to ensure that all equipment complies with the applicable test specification in the *Manual of Test Procedures for Materials*.

The QC laboratory will be 600 ft^2 (55 m^2) or greater in size and be located at the mix production site. The laboratory will have running water and controlled heating and air conditioning capable of maintaining a temperature between 68 – 86 °F (20 - 30 °C). The laboratory will be properly maintained and contain the necessary equipment and supplies for performing the Quality Control testing. All testing will be performed at the QC laboratory.

A. Quality Control Equipment

1. Balance (1): As defined by Illinois Specification 101. 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 scale and water.

2. Water Baths (2):

    a. A water bath as defined by Illinois Modified AASHTO T 166 for immersing the specimen in water while suspended under the weighing device.

    b. A water bath as defined by Illinois Modified AASHTO T 209 for maintaining a constant water temperature, with the following additional requirements:

        - Commercial grade, built specifically for lab
        - Capable of maintaining 77 ± 1.8 °F (25 ± 1
        - Sufficient depth to immerse the pycnometer pot and capillary lid.
        - Having perforated false bottom or equipped with a shelf at least 2 in. (50 mm) above bottom of bath.

3. Freezer (1):

    a. Capable of storing twenty-five 4 in. (100 mm) cores.

    b. If freezer is not available, a saw capable of producing an undamaged specimen is required.

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Hot-Mix Asphalt QC/QA Laboratory Equipment
Appendix D.4
(continued)
Effective: April 1, 1997
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4. Metal Pot Pycnometer (2):

    a. Capable of containing a minimum sample weight of 1200 g, which will be completely submerged.

    b. Vacuum gauge or manometer capable of measuring residual pressure down to 30mm 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.)

    c. Capillary lid.

    d. Small piece of fine wire mesh over the vacuum hose opening.

5. Ovens:

    a. Aggregates (1): Capable of maintaining 230 ± 9 °F (110 ± 5 °C). (May be omitted if approved by the Engineer; in this event, hot plates shall be provided for drying.)

    b. Hot-mix asphalt (1): Capable of maintaining 325 ± 5 °F (163 ± 3 °C).

    Note: 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.

6. Personal Computer with Appropriate Software and Printer
(Contact Lyndsay Casad of the Central Bureau of Materials)

    Note: A minimum 8 MB memory is required for Windows version.

7. Sample Splitters:

    a. Aggregate (1 each): As defined by Illinois Modified AASHTO T 248.

    b. Hot-mix asphalt (1): As defined by Illinois Modified AASHTO T 248 with the following additional requirements:

        i. Length of discharge (catch) pan equals or exceeds total chute width.

        ii. Each chute separated by a vertical metal divider.

8. Sieve Shaker (Mary Ann type or equivalent) (1): Capable of holding 12 in. (305 mm) sieves.

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Hot-Mix Asphalt QC/QA Laboratory Equipment
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Effective: April 1, 1997
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9. Twelve-inch Sieves (2 sets), 2 in. in height*:

a. 1-1/2 in. (37.5mm)	3/8 in. (9.5mm)	No. 30 (600 μm)
1 in. (25mm)	1/4 in. (6.3mm)	No. 50 (300 μm)
3/4 in. (19mm)	No. 4 (4.75mm)	No. 100 (150 μm)
5/8 in. (16 mm)	No. 8 (2.36mm)	No. 200 (75 μm)
1/2 in. (12.5mm)	No. 16 (1.18mm)	bottom pan and lid

   b. Sieves No. 4 (4.75mm) and larger will be checked with “go/no-go” gauges for compliance with minimum and maximum size openings.

   c. Sieves below the 3/8 in. (9.5mm) may be 1 5/8 in. nominal height*.

   d. Extra No. 16 and No. 200 required as wash sieves.

   * Distance from the top of the frame to the sieve cloth surface

10. Thermometers:

   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).

11. Timer (1): Minimum 20-minute capability.

12. Vacuum Pump (1): Capable of removing entrapped air to a residual pressure of 30 mm Hg.

13. Gyratory Compactor (1) meeting the requirements of Illinois Modified AASHTO T 312.

14. Gyratory Mold-Loading Chute (1):

   a. Capable of holding a minimum of 130 $in.^3$ (2120 cm^3).

   b. Minimum length of 22 in. (560 mm).

   c. Capable of loading entire gyratory sample in one motion without spillage or segregation.

15. Gyratory Specimen Molds (2): As defined by Illinois Modified AASHTO T 312.

16. Printer (1): As defined by Illinois Modified AASHTO T 312.

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Hot-Mix Asphalt QC/QA Laboratory Equipment
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Effective: April 1, 1997
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17. Specimen Extruder (1):

    a. Does not allow free-fall of specimen.

    b. Diameter of extruding disk must not be less than 5.4 in. (138mm).

18. Ignition Oven (1): Gilson Binder Ignition Furnace, Model HM-378; Barnstead/Thermolyne Furnace, Models F 85930 or F 85938; CEM Max Furnace; Carbolite Furnace, Model ABA 7/35; or Troxler Furnace, Models 4730 or 4731 as defined by Illinois AASHTO T 308.

    Note: Other available furnace types may be used if acceptably evaluated by an IDOT-approved research laboratory.

19. 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.

20. Sampling Shovel with sides and back built up 1 – 1 1/2 in. (25 – 40 mm).

21. Nuclear Asphalt Density Gauge (1): As defined by Illinois Modified ASTM D 2950.

22, Nuclear Asphalt Content Gauge (1) and Related Apparatus: As defined by the Department's "Procedure for Asphalt Content of HMA Mixtures by the Nuclear Method."*

    ***Note:** Only required if lab utilizes Illinois Modified AASHTO T 287 (in place of Illinois Modified AASHTO T 308) to determine asphalt content of HMA mixtures.

B. <u>Additional Equipment Required for Mix Design and QA Testing Consultants</u>

1. Balance (1): As defined by Illinois Specification 101.

2. Extraction Apparatus (1), if utilizing recycled asphalt materials (RAP and/or RAS) : As defined by Illinois Modified AASHTO T 164, Test Methods A and B.

3. Hamburg Wheel Tracking Machine (1): As defined by IL Mod. AASHTO T 324. (HMA mix in both design and from production shall meet Hamburg requirements, but the Hamburg machine is not required equipment in every lab).

4. Loading Device (1): As defined by Illinois Modified AASHTO T 283.

5. Load-Measuring Device (1):

    a. Sensitivity 10 lbs (4.5 kg).

    b. Accuracy within 1%.

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Hot-Mix Asphalt QC/QA Laboratory Equipment
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(continued)
Effective: April 1, 1997
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6. Loading Strips (one set for 6 in. specimens): As defined by Illinois Modified AASHTO T 283.

7. Oven for short term aging (1): Capable of maintaining 325 ± 5 °F (163 ± 3 °C).

8. 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 perforated false bottom or equipped with a shelf at least 2 in. (51 mm) above bottom of bath.

    c. Thermostatically controlled.

    d. Capable of maintaining 140 ± 1.8 °F (60 ± 1 °C).

9. 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).

10. Baking Pans (2): Each providing a minimum surface area of 140 $in.^2$ (903 cm^2).

*11. Mixing Apparatus (1): As defined by Illinois Modified AASHTO T 245 with a minimum capacity of 12000 g.

*Optional

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Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
Appendix B.1

Effective: May 1, 1993
Revised: December 1, 2017

Producer Name: _____

Producer/Supplier No.: _____

Address: _____

City/State/ZIP Code: _____

Phone No.: _____

A. Contractor Responsibilities

This Annual Quality Control (QC) Plan explains how _____ proposes to control the equipment, ingredient materials, and production methods to ensure the specified product is obtained. All requirements of section 1030 of the Standard Specifications 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.

In joint ventures, 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. Materials

All materials proposed for use are from approved sources. Material sources are identified below for coarse aggregate, fine aggregate, mineral filler, asphalt binder, prime, anti-strip additive, and release agent. This includes the mix type, Producer/Supplier Number, firm name, and firm location.

	Material	Mix Type	Producer/ Supplier No.	Firm Name	Location
(1)					
(2)					
(3)					
(4)					
(5)					
(6)					
(7)					
(8)					
(9)					
(10)					

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Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
Appendix B.1
(continued)
Effective: May 1, 1993
Revised: December 1, 2017

1. Aggregates

The incoming aggregate gradation bands have been developed from the source gradation bands and are attached. Listed below are the contact persons for the aggregate sources furnishing mixture aggregates.

	Name	Firm	Phone Number
Coarse Aggregate			
CA/CM 07/11 (Binder)			
CA/CM 13/16 (Binder)			
CA/CM 13/16 (Surface)			
Fine Aggregate			
FA/FM 01/02			
FA/FM 20/21			

a. Aggregate Stockpile Procedures

All aggregate stockpiles will be built using procedures that will minimize segregation and degradation. All coarse and fine aggregate will be placed in single-layer truck-dumped stockpiles at the mix plant. QC personnel will pay special attention to the loadout, replenishing, and remixing of the aggregate stockpile.

If segregation/degradation becomes a problem, stockpiling procedures will be altered to correct the problem.

b. 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:

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Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
Appendix B.1
(continued)
Effective: May 1, 1993
Revised: December 1, 2017

(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 the QC/QA HMA mixture. The material will be removed from the certified aggregate stockpile.

Each contact person listed above has agreed to immediately provide information on aggregate production changes or any significant variations in aggregate characteristics. These include, but are not limited to, changes in production methods, ledge footage, gradation, quality, specific gravity, and absorption. As gradation information is accumulated during stockpile construction, the aggregate gradations will be compared with the mix design gradation. Significant variations from the design gradation but within the acceptable gradation bands will be discussed with the Engineer. A new mix design will be performed when required by the Engineer.

c. 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 according to the special provision. 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 District Engineer.

If a weekly required stockpile sample fails, the following resample procedure will be followed:

(1) Immediately resample and test the new stockpile sample.

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Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
Appendix B.1
(continued)
Effective: May 1, 1993
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(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, or any other action approved by the Engineer. The aggregate contact person 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 the QC/QA HMA mixture.

Aggregate not meeting the mix plant gradation bands shall not be used in the QC/QA HMA mixtures.

d. Reclaimed Asphalt Pavement (RAP)

RAP will meet the requirements of Sections 1030 of the Standard Specifications and any Special Provision in the contract.

C. Mix Design

Mix designs shall be completed according to the Department's Hot-Mix Asphalt Level III Technician Course. All design data and material samples shall be submitted to the Department for verification a minimum of 30 calendar days prior to production.

D. Quality Control Personnel

All requirements of the Standard Specifications Section 1030, and the items listed in the Department's current "QC Personnel Responsibilities and Duties Checklist" will be met by the QC personnel. All personnel being utilized to run the Quality Control sampling and testing shall have taken and passed the appropriate HMA QC/QA level of training. 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 run the QC Plan. Additional QC personnel will be added when necessary.

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Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
Appendix B.1
(continued)
Effective: May 1, 1993
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E. Quality Control Laboratory/Equipment

A QC laboratory will be provided and maintained in accordance with the Department's current "Hot-Mix Asphalt QC/QA Laboratory Equipment".

Laboratory equipment meeting the requirements of the Department's current "Hot-Mix Asphalt QC/QA Laboratory Equipment" will be provided and properly maintained at the QC laboratory. In the event of equipment failure, _____ will be the source for backup equipment.

All equipment has been calibrated, and the supporting documentation is on file at the QC laboratory. The QC Laboratory was approved by the Department's Central Bureau of Materials and by District _____ on _____. The laboratory/equipment will be available for inspection by the Engineer.

F. Mix Plant/Production

Manufacturer _____
Model Number _____
Serial Number _____
Batch Size _____
Tons Per Hour _____
Approved By _____
Approval Date _____

It is our intent to run the day following start-up. Production will not begin until the acceptable nuclear/core correlation is complete, all other required tests are acceptable, the targets are established, and the results are reviewed and agreed to by the Department.

The aggregate feeders will be calibrated prior to the start of production using the aggregates and approximate percentages approved in the Job Mix Formula (JMF). At this time aggregate samples will be taken and compared with the JMF.

At the start of mix production or when adjustments are made to the mix, the QC Manager will give the aggregate proportions to the plant operator, and then, periodically throughout the day, checks will be made of the actual proportions used. This will be especially noted and recorded when a nuclear asphalt and/or a mix sample is taken. The results will be immediately reported to the Resident Engineer and/or other designated Department personnel upon completion of the test.

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Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
Appendix B.1
(continued)
Effective: May 1, 1993
Revised: December 1, 2017

All scale and sensitivity checks will be performed in accordance with the Hot-Mix Asphalt Level II Technician Course manual. Surge bins may be utilized as part of the overall plant operation. The QC Manager shall contact the Department for approval when material will be stored overnight.

G. Sampling and Testing

All sampling and testing, including all required plant tests, resamples, and additional check tests (when necessary), will be performed in accordance with Department test methods in the time frame required in Section 1030 of the Standard Specifications. The "Radioactive Material License" required for nuclear density and asphalt binder content determinations are attached. District Materials or the Central Bureau of Materials personnel are welcome to observe all testing by the QC personnel. Time permitting, split samples will be shared with Department personnel prior to start-up. Coring will be performed using a truck-mounted drill rig or by suitable equipment as approved by the Engineer. An adjustment of 1-1/2% to 2% for minus No. 200 (0.075 mm) material of washed samples vs. dry gradations will be used until a gradation correction factor is established based on preliminary aggregate sampling and testing.

All Department split samples will be stored on site. These samples will be identified with the date and time the material was sampled, Sequence Number, Contract Number, mix plant Producer/Supplier Number, aggregate source Producer/Supplier Number, and the initials of the individual who sampled the material.

H. Placement and Compaction

Only approved equipment will be used in the placement and compaction of the mix in accordance with the Standard Specification requirements.

The QC Manager will verify that all laydown equipment conforms to Department requirements prior to start-up. At the start of laydown, Two Growth Curves will be run on a test strip to determine the suitability of the mix. Mix samples shall be taken and tested from trucks representing material between both Growth Curves. From Growth Curve information, a rolling pattern will be established. Nuclear tests and cores will be taken from the start-up area to verify density and correlation of the nuclear density gauge. Temperatures of the mix will be taken and duly recorded. After the start-up data is approved by the Department and actual production has begun, daily nuclear density tests will be taken at the start of each day's production, along with temperature readings, to verify continued conformance with density requirements. Nuclear density tests according to the Section 1030 will be performed to assure compliance with specified density requirements. Testing will be conducted within the project traffic control, or by use of flaggers, as needed.

Start-up and construction of the test strip is planned to be performed in the morning of the first day. If no problems are encountered, cores for nuclear/core correlation will be taken. The mat will be cooled with ice or dry ice. All tests will be completed for anticipated production the next day.

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Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
Appendix B.1
(continued)
Effective: May 1, 1993
Revised: December 1, 2017

Should any adverse mix characteristics be observed, the QC Manager shall make mix adjustments as needed to correct the situation.

If segregation should occur, appropriate adjustments will be made in the aggregate stockpiling/loadout, plant production, silo operation, truck loading, or paver operation to alleviate the condition. Only approved truck release agents will be used.

The QC Manager or his representative will check laydown equipment daily for specification compliance and immediately repair or replace nonconforming equipment.

I. Corrective Action

The QC Manager will initiate corrective action immediately according to Section 1030 of the Standard Specifications. Sufficient tests shall be taken to verify the corrective action has worked. Special care will be taken to assure that mix not complying with specifications is not placed on the road.

J. Reporting of Test Results

All test results will be reported daily to the Resident Engineer and other designated personnel as requested by the Department. The data will be reported on the following forms or on forms generated by the Department's current QC/QA software:

MI 504M	Field/Lab Gradations (stockpile gradations)
MI 305	Bituminous Daily Plant Output (front) Plant Settings and Scale Checks (back)
MI 303C	Bituminous Core Density Testing QC/QA
MI 303N	QC Nuclear Density Report
MI 308	Nuclear Asphalt Content and Volumetric Testing
LM-6	Sample Identification (for liquid asphalt)

The completed forms will be forwarded to the District Engineer within three days of test completion.

K. Control Charts

In addition, control charts will be posted at the laboratory and kept updated for the following test parameters in accordance with the Department's current "Hot-Mix Asphalt QC/QA Control Charts/Rounding Test Values".

1. Gradations

Hot-Bins/Combined Belt

Percent Passing 1/2-in. (12.5-mm) Sieve

Percent Passing No. 4 (4.75-mm) Sieve

Percent Passing No. 8 (2.36-mm) Sieve

Percent Passing No. 30 (600-µm) Sieve

Percent Passing No. 200 (75-µm) Sieve

Ignition Oven

Total Dust Content

2. Gravities

a. Bulk specific gravity

b. Maximum specific gravity

3. Marshall Air Voids

4. Density

5. Asphalt Binder Content

6. Stockpile Gradations

In the event the Total Dust Content is out of tolerance, measures will be taken to correct the problem, which may include adding Positive Dust Control Equipment.

Contractor's Signature _____ Date _____

(Please type or print name) _____ Title _____

Illinois Department of Transportation

Model Quality Control (QC) Addendum for Hot-Mix Asphalt (HMA) Production
Appendix B2

Effective: July 1, 1995
Revised: May 1, 2007

Contract No.: _____
Marked Route: _____
Route: _____
Section: _____
County: _____

Contractor: _____
Address: _____
City/State/ZIP Code: _____
Phone No.: _____

A. Contractor Responsibilities

This Quality Control Addendum to the Annual Quality Control Plan further explains how _____ proposes to control the equipment, ingredient materials, and production methods to ensure the specified product is obtained. All requirements in the Section 1030, the Annual QC Plan, and this QC Addendum will be adhered to.

In the case of joint ventures, _____ of _____ will be the QC Manager and will be ultimately responsible for the Quality Control on this Contract.

B. Reclaimed Asphalt Pavement (RAP)

RAP will meet the requirements of Sections 406, 1030 and 1102 of the Standard Specifications and any Special Provisions in the Contract. _____ percent of RAP is proposed for use in the _____ course.

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Model Quality Control (QC) Addendum for Hot-Mix Asphalt (HMA) Production
Appendix B2
(continued)
Effective: July 1, 1995
Revised: May 1, 2007

C. Mix Design

Mix designs are attached for Department verification.

D. Quality Control Personnel

The project QC Manager will have overall responsibility and authority for Quality Control at both the plant and on the road and will make the necessary adjustments in the mix production, placement, and compaction to assure conformance with the Standard Specifications and Contract Special Provisions.

The QC personnel and/or consulting firm that will be utilized, as well as the backup QC personnel and/or consulting firm, are as follows:

	Name	Level of Training	Firm	Phone Number
(1)				
(2)				
(3)				
(4)				
(5) (backup)				

E. Mix Plant/Production

The mix for this project will be produced by Producer/Supplier No. _____.

F. Control Charts

A copy of the Control Charts will be submitted to the Engineer upon completion of the Contract.

Contractor's Signature _____ Title _____

(Please type or print name) _____ Date _____

Illinois Department of Transportation

Hot-Mix Asphalt Mixture Design Verification Procedure
Appendix B9

Effective Date: January 1, 2002
Revised: January 1, 2013

1.0 GENERAL

Contractors shall provide all hot-mix asphalt (HMA) mix designs for use on Department contracts. All mix designs must provide mixture meeting Department mix criteria. The Department will provide current aggregate bulk specific gravity. The Engineer reserves the right to be present for the sampling of all aggregates for mix designs. Once verified, a mix design will be approved for use for a three year period. After three years, the mix design shall be redesigned if necessary, and re-verified.

2.0 PURPOSE

Establish a verification procedure to evaluate Contractor mix designs for use on Department contracts. This procedure also allows for comparison of the test accuracy and precision between laboratories.

3.0 REQUIRED DESIGN DATA/MATERIAL SAMPLES

3.1 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 Technicians or higher. The mix design shall be submitted with the following design data:

A. The material name, material code number, source name, source Producer/Supplier Number, and source location shall be provided for all materials used in the mix design.

B. The Contractor shall provide 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 5 (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 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.

Illinois Department of Transportation

Hot-Mix Asphalt Mixture Design Verification Procedure
Appendix B9
(continued)
Effective Date: January 1, 2002
Revised: January 1, 2013

C. The Contractor shall provide a summary of design test data and optimum design data utilizing a design package with the same output format as CARE-AC.

(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 CARE-AC format).

(3) Actual graph paper from the stability machine and actual G_{mm} lab worksheets (original copy unless otherwise specified).

(4) Batching worksheet.

(5) Dust correction worksheet (include an example packet, such as the one from the Level III manual).

(6) Batching sources sheet.

(7) Mix design graphs (full page).

(a) Gradation (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.

(e) Asphalt Binder Content vs. Voids Filled with Asphalt (VFA).

(8) Recalculations and/or retested points (e.g., recalculated G_{mm}'s using average G_{se}).

(9) TSR worksheet.

The forms used shall be the Department's computer spreadsheet from CARE-AC, or other forms having the same format as CARE-AC.

Illinois Department of Transportation

Hot-Mix Asphalt Mixture Design Verification Procedure
Appendix B9
(continued)
Effective Date: January 1, 2002
Revised: January 1, 2013

3.2 The Contractor shall provide samples of blended aggregate, asphalt binder, and additives which represent the materials in the mix design. The representative samples shall be identified and submitted as follows:

A. Aggregate (including mineral filler/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 (2) 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 4 qts (4,000 mL). Identified with source name, source location, source Producer/Supplier Number, material code, sample location, and sample date.

C. Additive(s) -- The same additive(s) as used in the Contractor's design, identified by the additive source name, source location, brand name or number, material code, sample location, sample date, additive MSDS, the manufacturer's recommended dosage rate, and the rate used in the design if different than the manufacturer's recommended dosage rate. NOTE: Prior to submitting the additive(s), the Contractor shall contact the District Materials Engineer for the required sample size.

3.3 All design data and material samples shall be submitted to the Department a minimum of 30 calendar days prior to production.

3.4 The Contractor shall certify in writing that all materials submitted for mix design verification meet Department requirements and represent the materials to be used during mix production.

3.5 Previously verified mix designs shall be resubmitted for verifications as per Section 4.1 herein.

4.0 DEPARTMENT VERIFICATION

4.1 At the option of the Department, mix designs may be verified using either Method A or Method B listed below:

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Hot-Mix Asphalt Mixture Design Verification Procedure
Appendix B9
(continued)
Effective Date: January 1, 2002
Revised: January 1, 2013

Method A. 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 testing of the asphalt mixture. Verification testing will include volumetric, TSR and Hamburg Wheel on a mixture made from the individual materials submitted by the Contractor. The mixture at the optimum design asphalt binder content shall meet the mix design criteria for the following: VMA, VFA, G_{mb}, G_{mm}, Pa (voids), Tensile Strengths, TSR values, and Hamburg Wheel.

Method B. 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 IL Modified AASHTO T 283 and IL Modified AASHTO T 324. IL Modified AASHTO T 324 will not be required for "All Other" HMA mixes.

4.2 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

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Hot-Mix Asphalt Mixture Design Verification Procedure
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Effective Date: January 1, 2002
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All aggregate field gradations submitted by the Contractor will be compared to previous mix plant and/or Aggregate Gradation Control System gradations for validity.

4.3 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 verification fails, the 30-calendar-day time for the Department to notify the Contractor starts over. Acceptable designs may be used in Department contracts, provided the design is reproducible in the mix plant.

This Page Is Reserved.

Illinois Department of Transportation
QC/QA PROCEDURE
Development of Gradation Bands on Incoming Aggregate at Mix Plants
Appendix A1

Effective: January 1, 1994
Revised: June 1, 2012

A. Scope

Quality Control Plans for QC/QA Contracts normally require incoming aggregate to be checked for gradation compliance before use in mix 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 the mix plant.

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 portland cement concrete plants, the Contractor may increase the specification limit for the minus 75-µm (No. 200) AASHTO T 11 sieve material upwards one half percent (0.5%) if the 75-µm (No. 200) 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 current *Standard Specifications for Road and Bridge Construction*.

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Appendix A1

Effective: January 1, 1994
Revised: June 1, 2012

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 B5

Effective: May 1, 1993
Revised: May 1, 2007

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 duties, as necessary, may be required to control the quality of production and placement of the Hot-Mix Asphalt (HMA) mixtures. A Level II Technician may be used to perform any Level I Technician duties.

Note: Testing frequency denoted as "P" = "Prior to Start-up" and as "D" = "Daily".

A. Level I Technician

1. Checklist

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. Split required sample and save the Department split; use proper identification. ___

g. Run required tests as soon as possible using proper QC/QA procedures. ___

h. Take resamples as required. ___

i. Plot all random and resample results on control charts as soon as test results are available. ___

j. Take check samples when necessary. (D) ___

k. Contact QC Manager immediately when tests fail or any time problems occur. (D) ___

l. Test cores for Nuclear/Core Correlation (after Start-up). ___

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2. Required Tests. The minimum test frequency shall be according to Section 1030 of the Standard Specification. However, additional tests may be required by the Engineer.

   a. Stockpiles
   (washed gradations minimum one per week for each material used) ___

   b. Moisture samples (drum only) ___

   c. Gradations - Belt, Cold-feed, Hot-bin, etc. ___

   d. Nuclear Asphalt Content ___

   e. G_{mb} ___

   f. G_{mm} ___

B. QC Manager and/or Level II Technician Checklist

1. Prior to Mix Production (Preliminary Inspection)

   a. Check for the approved sources of the materials:

      (1) Aggregates — ensure it is from Certified Source ___

      (2) Mineral filler/flyash ___

      (3) Asphalt binder (See d. below.) ___

      (4) Other additives ___

   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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QC Personnel Responsibilities and Duties Checklist
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(continued)
Effective: May 1, 1993
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(2) Compare aggregate source information to stockpile samples at the mix plant and with the design gradation. ___

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. Prior to Production/During Start-Up/During Production

a. Check the mix plant for the following:

(1) Approval and calibration (P) ___

(2) Asphalt binder storage (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) and pugmill dam gate (continuous plants) (PD) ___

(11) Surge and storage bins (PD) ___

(12) Platform scales or suspended weigh hopper (PD) ___

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(13) Anti-strip additive system (when required) (PD) ___

(14) Ticket printer (P) ___

(15) Computer and control systems (PD) ___

b. 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) ___

c. Coordinate any start-up per Department guidelines
(QC Manager only). ___

d. Monitor sampling and testing procedures, density test, and laydown operations; contact man from aggregate producer
(QC Manager only). ___

e. 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 (drum only) (PD) ___

(4) Temperature (D) ___

(5) Coating and segregation (D) ___

(6) Additives (D) ___

f. Laydown operation (QC Manager only) —
Monitor the following field checks:

(1) Check for obvious defects in truck
(segregation, uncoated, temperature, etc.) (D) ___

(2) Monitor paver operations
(equipment, laydown procedures, etc.) (PD) ___

(3) Rollers and operations
(equipment, pattern, procedure, etc.) (PD) ___

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(4) Mix characteristics on road (appearance, mat temperature, etc.) (D) ___

(5) Monitor densities as required (D) ___

g. Monitor all test results and make any adjustments necessary (QC Manager only) (D). ___

h. Perform scale checks (minimum one per week per scale). Follow procedure in Construction Manual Documentation Section. ___

i. Prepare and store samples for the District laboratory as required. (D) ___

j. Ensure following records are kept and reports are submitted in a timely manner as required (QC Manager only): (D)

(1) Daily plant output ___

(2) Field gradation ___

(3) Density ___

(4) Marshall (stability and flow when required) ___

(5) Control charts ___

(6) Additives ___

(7) Scale checks ___

(8) Plant diary ___

C. Level I Technician, Level II Technician, and Quality Control Manager Duties

1. Material Source

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. Aggregate Quality

The 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.

4. Gradations

The Level II Technician shall obtain the average gradations as well as the Master Bands from the aggregate source. He/She 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 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 his 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 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 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 Level I Technician. Equipment shall be furnished by the Contractor or Consultant, kept clean, and kept in good working condition. At the start of the project, the 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 field tests. Defective equipment could result in erroneous, as well as untimely, results.

7. 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. 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(a)(5) 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.

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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).

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)(8) of the Standard Specifications shall be applied.

e. Hot-Bins: The 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(a)(7) 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. On continuous plants, the pugmill dam gate shall be in the raised position. The required times are in the appropriate articles of the Standard Specifications.

h. Batching: The 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. On continuous plants, the gate openings shall be checked for the proper setting. It is recommended that batch counters and/or ton counters be set at "zero" or that 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)(6) of the Standard Specifications. Trucks shall be loaded in such a manner as to minimize segregation.

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Effective: May 1, 1993
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. 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 anti-strip additive system calibration shall be checked and the proper flow rate determined.

l. The weigh ticket printer shall be checked for information required by the specifications.

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 Level I Technician, under the direct supervision of the QC Manager or the 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. He/She 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 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 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 Level II Technician shall also verify and document the addition rates of the anti-strip additives.

In addition, the 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

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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.

It is the duty of both the Level I and 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 automatic printers, 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 frequency and procedure for the check tests are described in the "Documentation" section of the [Bureau of] *Construction Manual*. The tests will be performed by the Level II Technician and reported on the "Daily Plant Output Report" and/or form BC 2367.

11. Samples

The Level I Technician shall take check samples of the mixture in addition to the required samples. He/She must also store split samples in a dry storage area for the Engineer. 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 Output Report" (MI 305) 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
QC/QA PROCEDURE

Standard Test Method for Correlating
Nuclear Gauge Densities with Core Densities
Appendix B.3
Effective: May 1, 2001
Revised: December 1, 2017

A. Scope

1. This method covers the proper procedures for correlating nuclear gauge densities to core densities. Procedures are applicable to both direct transmission and backscatter techniques.

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. The direct transmission method shall be used for thick-lift layers. "Thick-lift" is defined as a layer 6 in. (152.4) mm or greater in compacted thickness.

B. Applicable Documents

1. Illinois Department of Transportation Standard Test Methods

   Illinois-Modified AASHTO T 166, "Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface Dry Specimens"

   Illinois-Modified AASHTO T 275, "Bulk Specific Gravity of Compacted Asphalt Mixtures Using Paraffin-Coated Specimens"

2. The density test procedure shall be in accordance with the Department's "Illinois-Modified ASTM D 2950, Standard Test Method for Determination of Density of Bituminous Concrete In-Place by Nuclear Method".

C. Definitions

Test location: The station location used for density testing.

Test site: Individual test site where a single density is determined. Five (5) test sites are located at each test location.

Nuclear Density: The average of 2 or possibly 3 density readings on a given test site.

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

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Revised: December 1, 2017

D. Significance and Use

1. Density results from a nuclear gauge are relative. If an approximation of core density results is required, 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 (direct transmission only), 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 material.

E. Site Selection

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

2. Three correlation locations shall be selected. Two sites will be located on the two growth curves from the first acceptable test strip. The third 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 start-up. The material from the third site shall correspond to the same material from which the second hot-mix sample was taken.

3. If a mixture start-up is not required, two of the three correlation locations shall be in an area containing a growth curve.

F. Procedures for Obtaining Nuclear Readings and Cores

1. Backscatter Mode

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

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

**Standard Test Method for Correlating
Nuclear Gauge Densities with Core Densities
Appendix B.3**

c. One core in good condition shall be obtained from each of 15 individual sites (Figure 1). Care should be exercised that no additional compaction occurs between the nuclear testing and the coring. 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 correlation form.

For quality assurance purposes, the Department may direct the Contractor to take additional cores adjacent to those above or to submit the quality control cores for Department testing.

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

2. Direct Transmission Mode

a. At each of the three correlation locations, five individual sites shall be chosen across the mat as shown on Figure 1.

b. A smooth hole in the pavement, slightly larger than the probe, shall be formed to a depth 2 in. (50 mm) greater than the test depth. The probe shall be inserted so that the side of the probe facing the center of the gauge is in intimate contact with the side of the hole. Two nuclear readings shall be taken at each of the 15 individual sites. (See Figures 1 and 2)

The gauge shall be rotated 180 degrees (see Figure 2) around the core area at each site. (The two uncorrected readings taken at a specific individual site shall be within 2.0 lbs/ft^3 [30 kg/m^3] (see Figure 2). If the two readings do not meet this criterion, one additional reading shall be taken in the desired direction. The nuclear densities are to be recorded on the correlation form (Figure 3).

c. One core in good condition shall be obtained from each of the 15 individual sites. (See Figures 1 and 2) The cores shall be obtained from beneath the center of the gauge no closer than 3-1/2 in (87.5 mm) from either access hole. The thickness of the core should represent the thickness of the layer being tested. The layer shall be carefully separated for testing in accordance with Illinois-Modified AASHTO T 166. Care should be exercised that no additional compaction occurs between the nuclear testing and the coring. The cores shall be tested for density in accordance with Illinois-Modified AASHTO T 166 or T 275.

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For quality assurance purposes, the Department may direct the Contractor to take additional cores adjacent to those above or to submit the quality control cores for Department testing.

The core densities are to be entered on the correlation form.

d. Extreme care shall be taken in identifying which location 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 individual site shall be entered on the correlation form and then averaged. The core density taken at each individual site shall be entered on the correlation form. After the averaging, there will be 15 paired data points, each pair containing the average nuclear density and core density for each of the 15 individual sites.

2. The paired density values shall be correlated using the Department's linear regression program. (Disks are available from the Central Bureau of Materials) 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 nuclear density 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. 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	=	nuclear gauge density
b	=	intercept
m	=	slope of linear regression ("best fit") line

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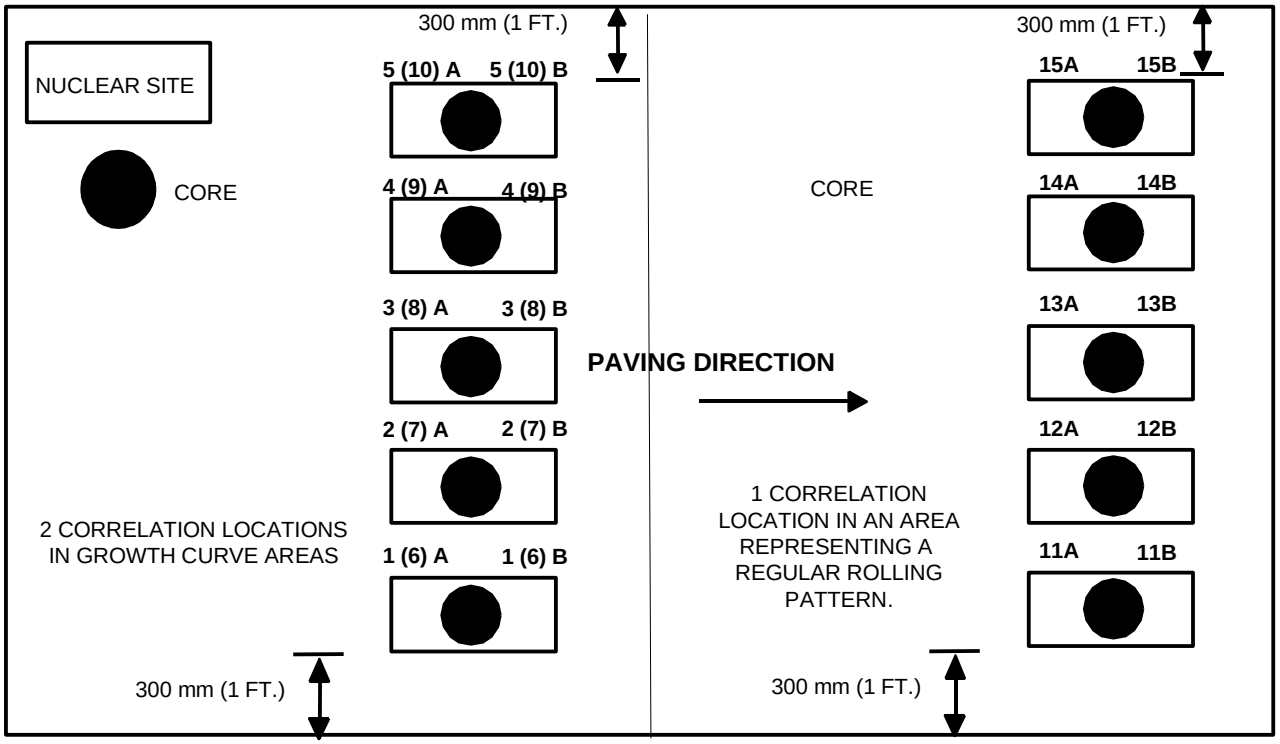
FIRST GROWTH CURVE IS BETWEEN 200 AND 225 METRIC TONS (225 AND 250 TONS), THE SECOND GROWTH CURVE IS BETWEEN 250 AND 275 METRIC TONS (275 AND 300 TONS).

(BACKSCATTER)



2 of 3 sites **1 of 3 sites**

FIGURE 1

NUCLEAR/CORE CORRELATION TEST LOCATIONS

Illinois Department of Transportation
QC/QA PROCEDURE

Standard Test Method for Correlating
Nuclear Gauge Densities with Core Densities
Appendix B.3
Effective: May 1, 2001
Revised: December 1, 2017

DIRECT TRANSMISSION MODE

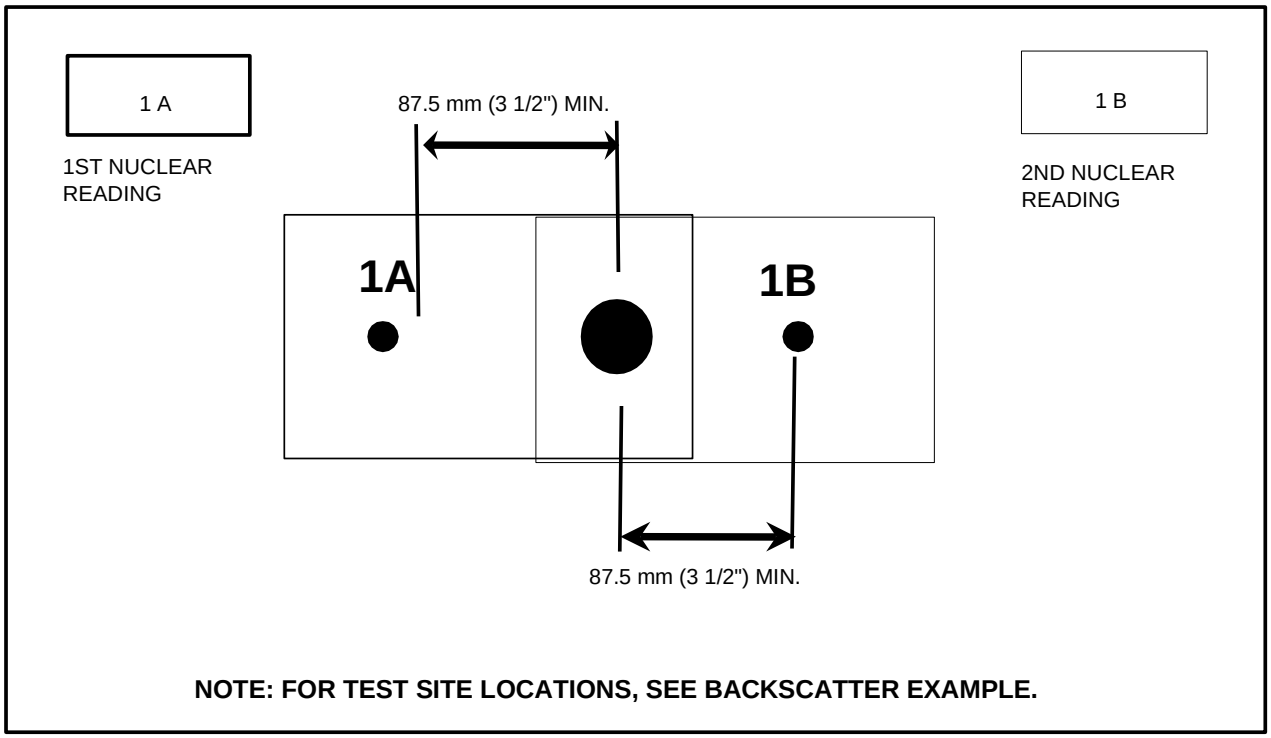


FIGURE 2

NUCLEAR/CORE CORRELATION

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	(23 kg/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: May 1, 1993
Revised: December 1, 2017

For mixtures where the quantity exceeds 3000 tons (2750 metric tons), the Contractor and the Department shall evaluate the mixture to be produced for each contract using a 300 ton test strip. The Contractor shall follow the following procedures for constructing a test strip.

A. Contractor/Department Test Strip Team

A team of both Contractor and Department personnel shall construct a test strip and evaluate mix produced at the plant.

The test strip team may consist of the following, as necessary:

1. Resident Engineer
2. District Construction Supervising Field Engineer, or representative
3. District Materials Mixtures Control Engineer, or representative
4. Contractor's QC Manager, required
5. Contractor's Density Tester
6. Central Bureau of Materials representative when requested
7. Bureau of Construction representative when requested

B. Communications

The Contractor shall advise the team members of the anticipated start time of production for the 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. Acceptance Criteria

1. Mix Design and Plant Proportioning - The mix design shall be 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.

2. Evaluation of Growth Curves - Mixtures which exhibit density potential less than or greater than the density ranges specified in Article 1030.05(d)(4) shall be considered to have a potential density problem which is normally sufficient cause for mix adjustment.

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

3. Evaluation of Required Plant Tests - If the results of the required plant tests exceed the JMF target value control limits, the Contractor shall make allowable

mix adjustments/plant changes, resample, and retest. If the Engineer determines additional adjustments to the mix will not produce acceptable results, a new mix design may be required.

D. Test Strip Method

The Contractor shall produce 300 tons (275 metric tons) of mix for the test strip. The test strip will be included in the cost of the mix and will not be paid for separately since the Contractor may continue production, at their own risk, after the test strip has been completed.

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

a. 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.

b. 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 solely with a vibratory roller as directed by the QC Manager.

c. Required Plant Tests - A set of mixture samples shall be taken at such a time as to represent the mixture in between the two growth curve trucks.

The mixture sampled to represent the test strip shall also include material sufficient for the Department to conduct a Hamburg Wheel test according to Illinois modified AASHTO T 324.

E. Compaction Requirements

1. Compaction Equipment - The Contractor shall provide a vibratory roller meeting the requirements of Article 1101.01(g) of the Standard Specifications. It shall be the responsibility of the test strip team to verify specification compliance before commencement of growth curve construction. An appropriate amplitude shall be selected on the basis of 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).

2. Compaction Temperature - In order to make an accurate analysis of the density potential of the mixture, the temperature of the mixture on the pavement at the beginning of the growth curve shall not be less than 280 °F (140 °C).

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.

F. Nuclear/Core Correlation

A correlation of core and nuclear gauge test results may be performed on-site as defined in the Department's "Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities". All correlation locations should be cooled with ice or dry ice so that cores can be taken as soon as possible. Three locations should be selected. Two sites should be located on the two growth curves from the first acceptable test strip. The third location should be in an area corresponding to the second set of mixture samples taken at the plant. This correlation should be completed at the same time 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 strips, required plant tests, and rolling pattern information (including growth curves) will be tabulated by the Contractor with a copy provided to each team member and the original retained in the project files.

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State of Illinois
Department of Transportation
Bureau of Materials and Physical Research

POLICY MEMORANDUM

Revised: July 1, 2015	6-08.2
This Policy Memorandum supersedes number 6-08.1 dated June 6, 2014	

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 DEFINITIONS

AASHTO R 18 - The American Association of State Highway and Transportation Officials (AASHTO) Standard for "Establishing and Implementing a Quality System for Construction Materials Laboratories." The principles of AASHTO R 18 are used by the Bureau of Materials and Physical Research (BMPR) to administer the qualified laboratory program for **District** and **Private Laboratories**.

ACCREDITED LAB – A laboratory that is currently accredited by the AASHTO Accreditation Program (AAP) or other accrediting body recognized by FHWA.

BMPR LABORATORY - The Department's central laboratory maintained and operated by the Bureau of Materials and Physical Research (BMPR). The BMPR Laboratory administers the qualified laboratory program for **District** and **Private Laboratories**.

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 LABORATORY - A **Department** laboratory that is operated by a District.

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.

HMA MIX DESIGN LABORATORY – Any **Private Laboratory** that has a **Department** approved HMA mix design lab. Consultants that are prequalified with the **Department** for HMA Mix Design must be capable of performing the tests listed in Table 1 under HMA Design.

PRIVATE LABORATORY - Any construction materials testing or design laboratory not operated by the **Department**. This includes **Contractor**, **Producer**, or **Consultant** laboratories performing Quality Control (QC), Quality Assurance (QA), acceptance, independent assurance, or any other required or contracted testing on a **Department** project.

PRODUCER - An individual or business entity providing materials for performance of prescribed work.

QUALIFIED LABORATORIES – **Laboratories** that are inspected and approved by the **Department**. FHWA's Construction 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 (HMA) or Portland cement concrete (PCC) testing is successful completion of the prescribed **Department** Quality Control/Quality Assurance (QC/QA) Trained Technician 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 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 Table 2.

QUALITY ASSURANCE LABORATORY - Any laboratory used for Quality Assurance (QA) testing (**Department** tests) required by the **Department**. Required tests for quality assurance laboratories are listed in Table 2.

QUALITY CONTROL LABORATORY - Any laboratory used for Quality Control (QC) testing (**Contractor** or **Producer** tests) required by the **Department**. Required tests for quality control laboratories are listed in Table 1.

QUALITY CONTROL (QC) MANAGER – An employee (or **Consultant**) of a **Contractor** or **Producer** who is responsible for compliance with the QC/QA requirements in a **Department** contract or policy.

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 (QC) testing requirements and the specified equipment.

2.0 SCOPE

This policy governs the minimum qualifications for materials **Quality Control** and **Quality Assurance Laboratories** operated by **Contractors**, **Producers** and **Consultants**. It applies to aggregate, hot-mix asphalt (HMA) and Portland cement concrete (PCC) testing laboratories.

3.0 PURPOSE

- To ensure that **Private Laboratories** are equipped and maintained at a uniform and high level of quality.
- To establish a uniform procedure for evaluating and approving **Private Laboratories**.
- To maintain a uniform standard for inspecting test equipment and test procedures.

4.0 AUTHORITY

Federal regulations (23 CFR Part 637) require the **Department** to establish a program for "qualifying" construction laboratories involved in tests which are used for acceptance. Under the **Department's** QC/QA specifications, **Contractor/Producer** test results are used in the acceptance process.

5.0 REFERENCE DOCUMENTS

- IDOT *Standard Specifications for Road and Bridge Construction.*
- IDOT *Manual of Test Procedures for Materials.*
- IDOT QC/QA Specifications for Hot-Mix Asphalt and Portland Cement Concrete.
- AASHTO, ASTM, and IDOT Test Procedures.
- Code of Federal Regulations (23 CFR Part 637).
- **Department** Policy MAT-15, "Quality Assurance Procedures for Construction."

6.0 PRIVATE LABORATORY REQUIREMENTS

6.1 Personnel Qualifications/Responsibilities

6.1.1 All testing for **Department** contracts shall be performed by **Qualified Personnel** as specified in the contract.

6.1.2 The **Department** will maintain a computer database of **Qualified Personnel** who have successfully passed the appropriate QC/QA classes.

6.2 Facilities and Equipment

6.2.1 The **Department** shall approve all **Private Laboratories** used on **Department** projects.

6.2.2 Each **Private Laboratory** shall maintain the equipment and facilities necessary to perform the tests as appropriate for the product to be tested. A list of required **Private Laboratory** tests is provided in Tables 1 and 2.

6.2.3 Each **Private Laboratory** shall have adequate floor space to efficiently conduct required tests. Suggested minimum floor space is provided under "Model Quality Control Plans" in the Manual of Test Procedures for Materials.

6.2.4 Each **Private Laboratory** shall have HVAC equipment capable of maintaining a room temperature of 20 to 30° C (68-86° F). A **Private Laboratory** that performs only aggregate gradation and/or aggregate moisture testing is exempt from this requirement.

6.2.5 All equipment shall be as specified in the current Manual of Test Procedures for Materials.

7.0 QUALITY SYSTEM CRITERIA

7.1 AASHTO R 18

Each **Quality Assurance Private Laboratory** shall establish and implement a quality system which meets the criteria from **AASHTO R 18**. Accredited Laboratories shall comply with all of **AASHTO R 18** for AMRL and ASTM C 1077 for CCRL, with the exception of Sections 6.1.7.4 and Section 6.1.7.5 of ASTM C 1077. The **Quality Assurance Private Laboratory** shall document staff technical proficiency in line with the requirements of AASHTO R 18 section 5.5.2.

7.2 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 and calibration, 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.

7.3 Equipment Calibration and Verification

The **Quality Control Private Laboratory** shall calibrate or verify all testing equipment associated with tests performed by the **Quality Control Private Laboratory** according to Table 3 which includes the maximum interval for calibrating most laboratory equipment. Heavy use or specific test requirements may justify more frequent checks. **Department** verification of **Quality Control Private Laboratory** equipment shall not be construed as part of, or substitute for, the equipment calibration requirement, except for **Department** verification of the gyratory compactor using the DAV-2 and **Department** verification of the gyratory molds using the bore gauge.

The **Quality Assurance Private Laboratory** shall calibrate, standardize, and check all significant equipment associated with tests the laboratory performs according to AASHTO R 18 for AMRL and ASTM C 1077 for CCRL in addition to Table 3 which may include equipment required for Illinois Modified Tests or Illinois Test Procedures.

7.4 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.

7.5 Records

7.5.1 Test Records – Each **Private Laboratory** shall maintain test records which contain sufficient information to permit verification of any test report.

7.5.2 Records Retention - Each **Private Laboratory** shall maintain documentation of the internal quality controls. At a minimum, the records shall include:

- Documentation of assignment of personnel responsible for internal quality controls.
- Documentation of equipment calibration.
- Logs of sample pick-up shall be maintained for a minimum period of three years.
- All documentation shall be maintained and available to **Department** inspection for a period of three years.

7.5.3 Equipment Calibration and Verification Records - Calibration records shall include the minimum information listed below. **AASHTO R 18** and ASTM Standard C 1077 provide additional guidance for calibration of most testing equipment.

1. Description
2. Model & Serial Number
3. Name of person calibrating
4. Calibration equipment used
   (e.g., standard weights, proving rings, thermometers)
5. Date calibrated & next due date
6. Reference procedure used
7. Results of calibration / verification

7.5.4 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.

7.6 Publications

Each **Approved Private Laboratory** shall maintain current copies or electronic access to all test procedures performed and the Manual of Test Procedures for Materials.

8.0 LABORATORY INSPECTIONS

8.1 General

The **Department** will approve **Private Laboratories** by inspection.

- AGGREGATE LABORATORIES - Initial inspections and re-inspections will be performed by the District.

- OTHER LABORATORIES - Initial inspections are performed by the **Bureau of Materials and Physical Research**. Re-inspections are performed by the District.

8.2 AASHTO Accredited Private Laboratories

8.2.1 Current AASHTO accreditation of the **private** laboratory is a prerequisite for **Consultant** prequalification as a **Quality Assurance Testing Consultant**. Conditions for prequalification may be found in the prequalification instructions and forms.

AASHTO accreditation does not waive the right of the **Department** to conduct inspections and/or re-inspections.

AASHTO accreditation is required for **Quality Assurance Testing Consultants** prior to initial **BMPR** inspection. AMRL (AASHTO Material Reference Laboratory) shall provide assessment for HMA and Aggregates. CCRL (Cement and Concrete Reference Laboratory) shall provide assessment for Portland Cement Concrete.

8.3 Initial Inspection

- Facilities - Physical and environmental conditions.
- Equipment - Test apparatus for specification compliance.
- Documentation - Calibration and verification records.
- Personnel - A review of qualified personnel credentials.
- 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.
- Report - The **Private Laboratory** will be provided with a report listing those tests for which it is approved. The report will note deficiencies.

8.4 Initial HMA and PCC Laboratory Inspections

8.4.1 The **Private Laboratory** shall submit a written request for an inspection to the District. The request shall indicate the following:

- The location of the **Private Laboratory**.
- The type of **Private Laboratory**, i.e., QC, QA or HMA Mix Design; aggregate, HMA, PCC.
- The name of the **Technical Manager**, who will be present for the inspection.
- The date the **Private Laboratory** will be ready for inspection.

8.4.2 The District will notify the **BMPR Laboratory** of the inspection request. **BMPR** personnel will establish a tentative date to perform the inspection.

8.4.3 The District will perform an inspection approximately seven calendar days before the **BMPR** inspection. The District will verify that the **Private Laboratory** is ready for inspection and notify **BMPR**.

8.4.4 **BMPR** personnel will perform the inspection and prepare a preliminary report. Standard inspection forms and a preliminary report, developed and maintained by the **BMPR Laboratory**, will be used.

8.4.5 **BMPR** personnel will assign identification numbers to all test equipment. Unless a District has an established numbering system, the following sequences will be used.

Sieves
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.

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

*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.

8.4.6 **BMPR** 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.

8.4.7 If a review of the preliminary report indicates there are no deficiencies, **BMPR** will provide written notification to the **Private Laboratory** indicating the **Private Laboratory** is now an approved **Quality Control** or **Quality Assurance Private Laboratory**. The notification will include an equipment list. A copy of the notification will be provided to the District.

8.4.8 If the preliminary report indicates there are deficiencies, **BMPR** 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.

8.4.9 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 **BMPR** in writing.

8.4.10 **BMPR** will provide written notification to the **Private Laboratory**, indicating the private laboratory is now an approved **Quality Control** or **Quality Assurance Private Laboratory**. The notification will include an equipment list. A copy of the written notification will be provided to the District.

8.4.11 Uncorrected deficiencies will not be waived. Equivalent equipment specifications may be approved only with the written approval of BMPR's Engineer of Tests.

8.5 Initial Aggregate Laboratory Inspection

For an aggregate **Private Laboratory**, the procedures outlined in 8.4 shall be followed, except District personnel will perform the inspection instead of personnel from **BMPR**.

8.6 Re-Approval of Approved Private Laboratories

8.6.1 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:

- Physical inspection of the laboratory facility and equipment.
- Review of the **Private Laboratory's** internal quality plan and documentation in accordance with this policy and those parts of **AASHTO R 18** incorporated by this policy.
- Observations of tests performed by qualified personnel.
- Results of split sample testing between the **Private Laboratory** and the District.
- Results of proficiency sample testing programs conducted by the **Department**.
- Overall past performance and experience.

8.6.2 The District may not waive any requirements for **Private Laboratories** or test equipment for **Required Tests**.

8.6.3 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.

8.6.4 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.

9.0 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** must 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.

10.0 LABORATORY DATABASE

The **Department** will maintain a computer database to monitor the approval status of **Private Laboratories**. The database will include the following information:

- Laboratory Codes (Department, Producer, etc.)
- Responsible District
- Type Laboratory (Aggregate, HMA, PCC, Other)
- Demographics (Address, etc.)
- Date Inspected
- Approval Status

Laura R. Mlacnik, P.E.
Acting, Engineer of Materials
and Physical Research

Attachments

TABLE1
QUALITY CONTROL PRIVATE LABORATORY TESTS

	PROCEDURE		PRIVATE LAB TYPE				
	Illinois Test Procedure	ASTM	AGG	HMA QC	HMA DESIGN	PCC QC	TITLE
AGGREGATE TESTS	ITP 2	____	√	√	√	√	Sampling of Aggregates
	ITP 11	____	√	√	√	√	Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
	ITP 19	____	√[1]			√	Bulk Density ("Unit Weight") and Voids in Aggregate
	ITP 27	____	√	√	√	√	Sieve Analysis of Fine and Coarse Aggregate
	ITP 84	____	√[2]				Specific Gravity and Absorption of Fine Aggregate
	ITP 85	____	√[2]				Specific Gravity and Absorption of Coarse Aggregate
	ITP 248	____	√	√	√	√	Reducing Samples of Aggregate to Testing Size
	ITP 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

TABLE1 (CONT'D)
QUALITY CONTROL PRIVATE LABORATORY TESTS

	PROCEDURE		PRIVATE LAB TYPE				
	AASHTO (Illinois Modified)	ASTM (Illinois Modified)	AGG	HMA QC	HMA DESIGN	PCC QC	TITLE
HOT-MIX ASPHALT TESTS	T 30 (IL)			√	√		Mechanical Analysis of Extracted Aggregate
	T 164 (IL)			√[3] Or T 287 or T 308[4]	√[3]		Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)
	T 166 (IL)			√	√		Bulk Specific Gravity (Gmb) of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens
	T 209 (IL)			√	√		Theoretical Maximum Specific Gravity (Gmm) and Density of Hot Mix Asphalt Paving Mixtures
	T 245 (IL)						Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus
	T 283 (IL)				√		Resistance of Compacted Hot Mix Asphalt (HMA) to Moisture-Induced Damage
	T 287 (IL)			√ Or T 164 or T 308[4]			Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method
	T 308 (IL)			√ Or T 164 or T 287[4]	√		Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
	T 312 (IL)			√	√		Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
	_____	D 2950 (IL)		√			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.

TABLE1 (CONT'D)
QUALITY CONTROL PRIVATE LABORATORY TESTS

	PROCEDURE		PRIVATE LAB TYPE				
	AASHTO (Illinois Modified)/Illinois Test Procedure	ASTM (Illinois Modified)	AGG	HMA QC	HMA DESIGN	PCC QC	TITLE
PORTLAND CEMENT CONCRETE TESTS	R 39 (IL)					Required if developing mix designs.	Making and Curing Concrete Test Specimens in the Laboratory
	R 60 (IL)					√	Sampling Freshly Mixed Concrete
	T 22 (IL)					√[5] Either T 22 or T 177	Compressive Strength of Cylindrical Concrete Specimens
	T 23 (IL)					√	Making and Curing Concrete Test Specimens in the Field
	T 119 (IL)					√	Slump of Hydraulic Cement Concrete
	T 121 (IL)					√	Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
	T 152 (IL)					√	Air Content of Freshly Mixed Concrete by the Pressure Method - Type A or B Air Meter
	T 177 (IL)					√[5] Either T 22 or T 177	Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading)
	T 196 (IL)						Air Content of Freshly Mixed Concrete by the Volumetric Method
	T 231 (IL)					Either T 231 or C 1231	Capping Cylindrical Concrete Specimens
		C 1064 (IL)				√	Temperature of Freshly Mixed Hydraulic Cement Concrete
		C 1231 (IL)				Either T 231 or C 1231	Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders
	ITP 301	____					Fine Aggregate Moisture Content by the Flask Method
	ITP 302	____					Aggregate Specific Gravity and Moisture Content by the Dunagan Method
	ITP 303	____					Fine or Coarse Aggregate Moisture Content by Pycnometer Jar Method
	ITP 306	____				Required if developing mix designs.	Voids Test of Coarse Aggregate for Concrete Mixtures

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
	Illinois Test Procedure/ AASHTO	ASTM	IDOT QA	AAP On-Site Assessment	AAP Proficiency Assessment	
AGGREGATE	ITP 2		√			Sampling of Aggregates
	ITP 11		√			Materials Finer Than 75-µm (No. 200)Sieve in Mineral Aggregates by Washing
		T 11		√	√	
	ITP 19		√			Bulk Density ("Unit Weight") and Voids in Aggregate
		T 19		√		
	ITP 27		√			Sieve Analysis of Fine and Coarse Aggregates
		T 27		√	√	
	ITP 84[3]		√			Specific Gravity and Absorption of Fine Aggregate
		T 84		√	√	
	ITP 85[3]		√			Specific Gravity and Absorption of Coarse Aggregate
		T 85		√	√	
	ITP 248		√			Reducing Samples of Aggregate to Testing Size
		T 248		√		
	ITP 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, AMRL 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 or PCC/AGG approved.

Note 3: Required for laboratories that run the Department's Slag Producers' Self-Testing Program.

TABLE 2 (CON'T)
REQUIRED TESTS – QUALITY ASSURANCE TESTING CONSULTANTS [1, 2]

	PROCEDURE		REQUIRED FOR PREQUALIFICATION			TITLE
	Illinois Modified/A AASHTO	ASTM Illinois Modified	IDOT QA	AAP On-Site Assessment	AAP Proficiency Assessment	
HOT-MIX ASPHALT	T 30 (IL)		√			Mechanical Analysis of Extracted Aggregate
	T 164 (IL) T 164		√	√		Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)
	T 166 (IL) T 166		√	√	√	Bulk Specific Gravity (Gmb) of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens
	T 209 (IL) T 209		√	√	√	Theoretical Maximum Specific Gravity (Gmm) and Density of Hot Mix Asphalt Paving Mixtures
	T 245 (IL)					Resistance of Plastic flow of Asphalt mixtures Using Marshall Apparatus
	T 283 (IL) T 283		√	√		Resistance of Compacted Hot Mix Asphalt (HMA) to Moisture-Induced Damage
	T 287 (IL)		√[4]			Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method
	T 308 (IL) T 308		√	√	√	Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
	T 312 (IL) T 312		√	√	√	Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
		D 2950 (IL)	√			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, AMRL 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 or PCC/AGG approved.

Note 4: Requirement determined on case to case basis by district in which lab is located.

TABLE 2 (CON'T)
REQUIRED TESTS – QUALITY ASSURANCE TESTING CONSULTANTS [1, 2]

	PROCEDURE		REQUIRED FOR PREQUALIFICATION			TITLE
	Illinois Modified/ AASHTO/Illinois Test Procedure	ASTM/Illinois Modified	IDOT QA	AAP On-Site Assessment	AAP Proficiency Assessment	
PORTLAND CEMENT CONCRETE		C 192			√	Making and Curing Concrete Test Specimens in the Laboratory
	R 60 (IL)	C 172	√	√		Sampling Freshly Mixed Concrete
	T 22 (IL)	C 39	√	√	√	Compressive Strength of-Cylindrical Concrete Specimens
	T 23 (IL)	C 31	√	√	√	Making and Curing Concrete Test Specimens in the Field
	T 119 (IL)	C 143	√	√	√	Slump of Hydraulic Cement Concrete
	T 121 (IL)	C 138	√	√	√	Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
	T 152 (IL)	C 231	√	√	√	Air Content of Freshly Mixed Concrete by the Pressure Method-Type A or B Air Meters
	T 177 (IL)	C 78	√	√[5]		Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading)
	T 196 (IL)	C 173	[6]	[6]	[8]	Air Content of Freshly Mixed Concrete by the Volumetric Method
	T 231 (IL)	C 617	[6]	[6]		Capping Cylindrical Concrete Specimens
		C 1064 (IL) C 1064	√	√		Temperature of Freshly Mixed Hydraulic Cement Concrete
		C 1231 (IL) C 1231	√	√		Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders
	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
	ITP 306		[7]			Voids Test of-Coarse Aggregate for Concrete Mixtures

Note 1: Compliance with IDOT test methods will be required for IDOT QA lab inspections. However, AMRL 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 or 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 must be presented during an inspection if the consultant lab has the ability to perform the test.

Note 7: Test equipment must be presented during an inspection if consultant lab has the ability to verify PCC mix designs.

Note 8: Test must be performed if consultant lab has the ability to perform the test.

TABLE 3[1]
EQUIPMENT CALIBRATION SCHEDULE

EQUIPMENT	REQUIREMENT	MAXIMUM INTERVAL (MONTHS)
AGGREGATE & GENERAL		
Unit Weight Measures	Standardize	12
General Purpose Balances, Scales	Commercial Service or Verification using standardized NIST traceable Masses	12
Standard Masses	Standardize	12
Mechanical Shakers	Check Sieving Thoroughness	12
Ovens	Standardize Thermometric Device	12
Coarse Sieves (Openings ≥ 4.75 mm)	Check Physical Condition and Dimensions of Openings	12
Fine Sieves (Openings <4.75 mm)	Check Physical Condition	12
Working Thermometers	Standardize with calibrated NIST traceable Reference Thermometer	12
Reference Thermometer	Calibrate	60
Timers	Check Accuracy	12
Calipers and Micrometers	Standardize	12
Caliper Checker (Gauge Blocks or Caliper Master)	Calibrate	60
HOT MIX ASPHALT		
Gyratory Compactor	Verify Angle, Pressure, Height	Once a month during use
	Verify Angle using a DAV-2	12
Plates, Ram Face, Molds	Check Critical Dimensions	12
Marshall Hammer	Check Physical Condition	12
	Standardize	36
Ignition Furnace	Standardize	Each Mix
Vacuum Pump	Check Pressure	12
Tensile Strength Machine	Standardize	12
Breaking Heads	Check Critical Dimensions	12
Pycnometers	Standardize Volume	12
Mixers	Check Physical Condition	12
Water Baths	Standardize	12
Extraction Equipment	Check Physical Condition	12
Residual Pressure Manometer	Standardize	12
Bore Gauge	Standardize	Each Use
Master Ring	Calibrate	60
Hamburg Wheel-Track		
Water Temperature	Verify	12
Speed	Verify	12
Wheel Weight	Verify	12
LVDT'S	Verify	12

Note 1: See AASHTO R18 for equipment calibration terminology definitions.

EQUIPMENT	REQUIREMENT	MAXIMUM INTERVAL (MONTHS)
PORTLAND CEMENT CONCRETE		
Air Meters (Pressure Type)	Standardize During Use	3 (Type B)
	Standardize	12 (Type A)
Air Meters (Volumetric Type)	Standardize	12
Compression & Flexural Testing Machine	Calibrate	12
Capping Material	Check Strength	3 or New Shipment
Slump Cones	Check Critical Dimensions	12
Reusable Molds	Check Critical Dimensions	12
Single Use Molds	Check Dimension	Each Shipment
Neoprene Pads	Check Physical Condition	Track Usage
Metal Retainers	Check Critical Dimensions	3
Metal Stem Thermometers	Standardize with calibrated NIST traceable Reference Thermometer	12
Moist Room/Storage Tanks Recording Thermometer or Max/Min Thermometer	Standardize with calibrated NIST traceable Reference Thermometer	12

Note 1: See AASHTO R 18 for equipment calibration terminology definitions.

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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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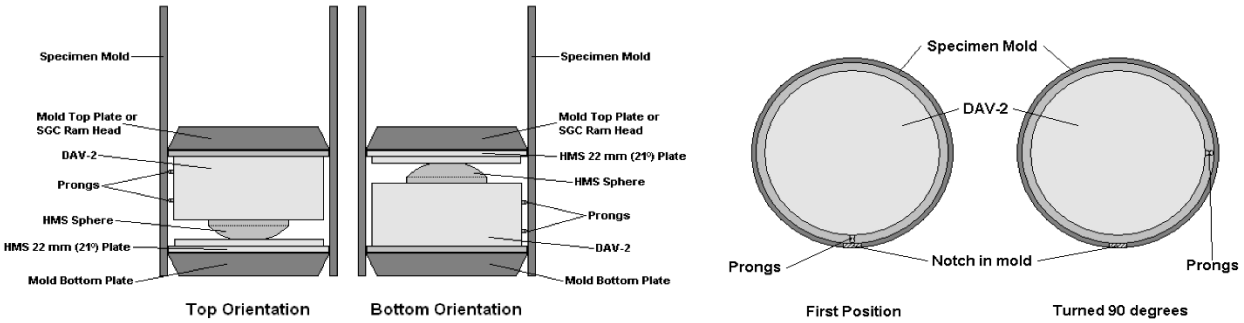
Procedure for Internal Angle Calibration of Superpave Gyratory Compactors (SGCs) using the Dynamic Angle Validator (DAV-2)

Internal Angle Testing with HMS

Nomenclature and DAV-2 orientation in the specimen mold

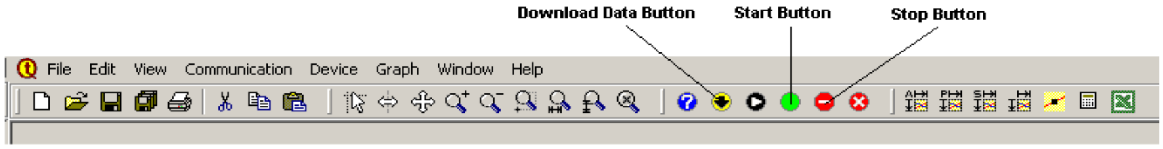
In the following sections, the terms "top" and "bottom" angles, "first position", and "turned 90 degrees" will be used. This refers to the position where the DAV-2 will be collecting angle data. The following diagrams will display how the DAV-2 will be oriented in the gyratory specimen mold and will help avoid confusion in the midst of testing:



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:

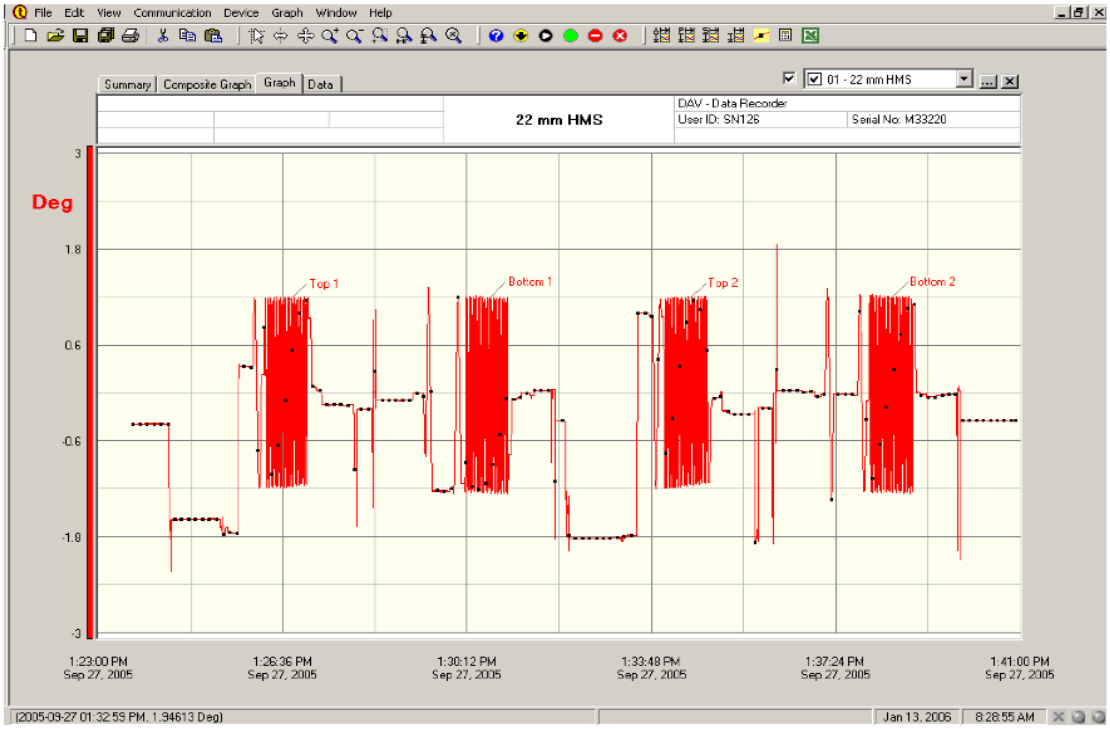


3. Open the Test Quip DAV-2 software and start data collection in the DAV-2 ("Start Button" in the illustration above). When data collection has been successfully initialized, disconnect the cable from the DAV-2. The DAV-2 has ~26 minutes of memory for data collection, so begin testing quickly so all 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.

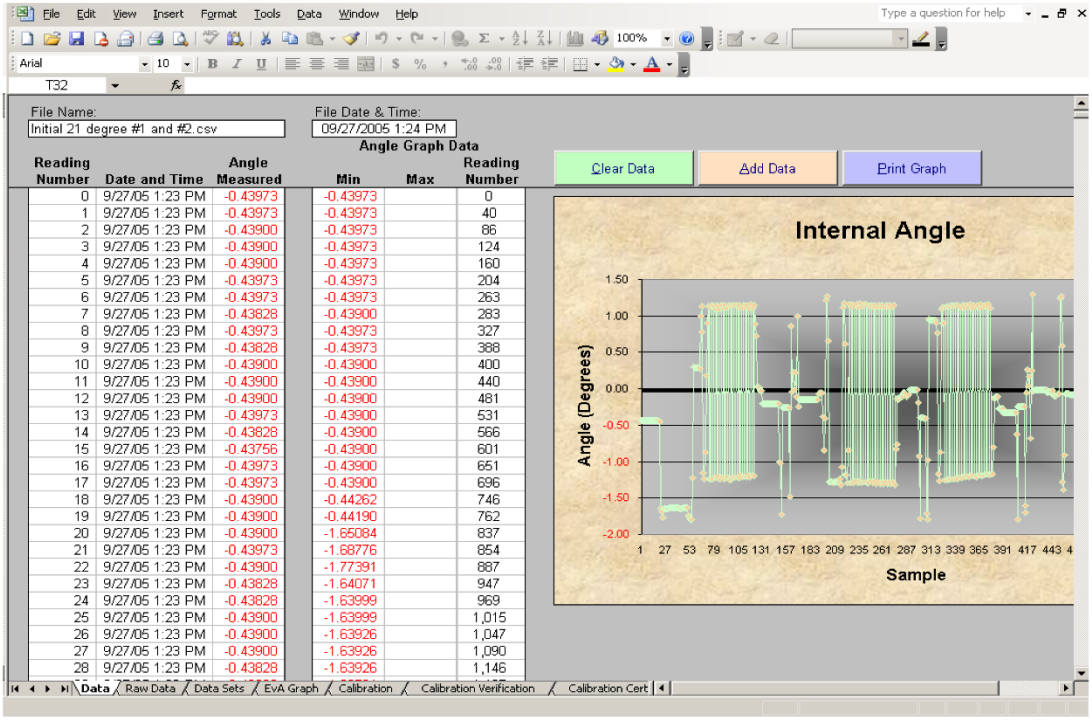
4. Take mold "A" out of the oven and begin testing. For the first bottom angle, place the DAV-2 and HMS plate into the mold, illustrated on the previous page as "bottom orientation". Choose a reference point on the mold (for example, the notch on the top of the Troxler 4140 molds makes a handy reference 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".

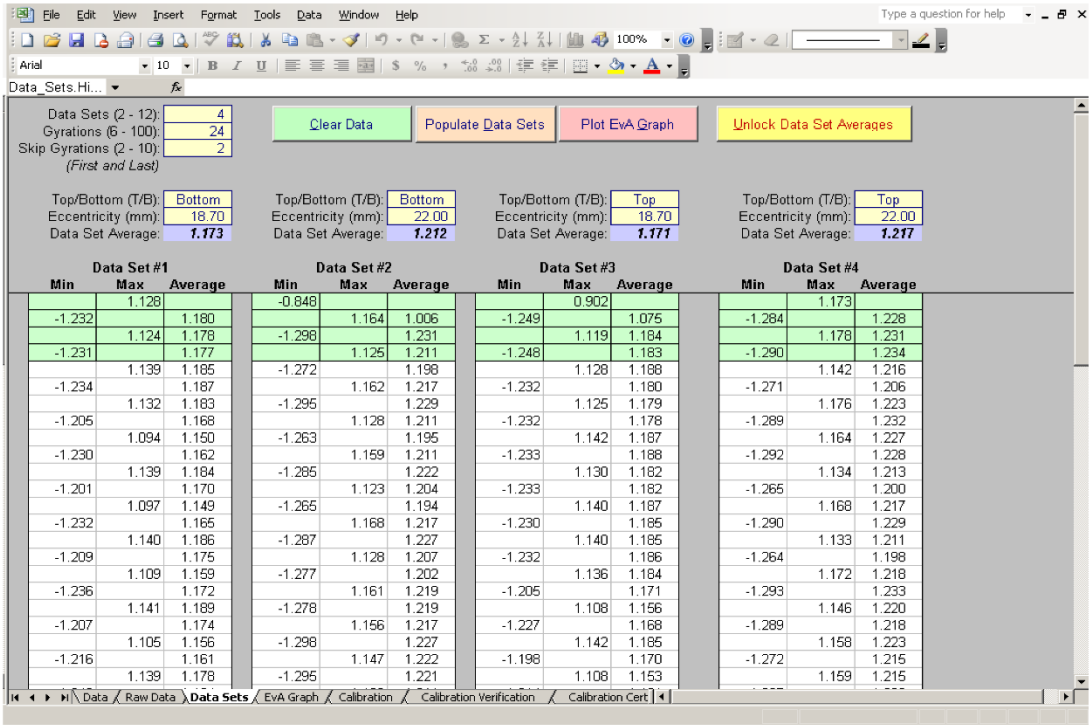
6. Connect the DAV-2 to the CPU with the interface cable and stop the data collection in the DAV-2 ("Stop Button" in the illustration on the previous page). Download the data to the CPU ("Download Data Button" in the illustration on the previous page). Label the data sheet as needed and save it to a 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:



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:



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 **will not** 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.

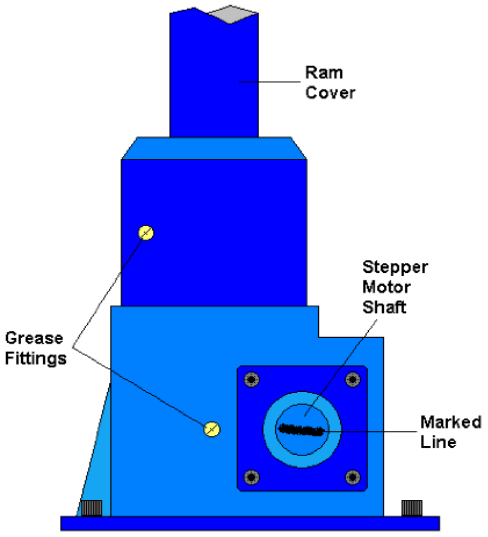
4. When the ram reaches ~130 mm, hit the "ESC" key to stop the ram. Make sure the ram head and collar are seated squarely in the top of the mold, with the pin on the collar fully down into the notch on the top of the mold.

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.



Troxler 4140 External Ram Assemby
(On top of the sample chamber)

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.

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.

QC/QA Document
Segregation Control of Hot-Mix Asphalt

Appendix B20

Effective: May 1, 2007

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 of 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 segregated areas 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 what 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.

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.

Off-Site Preliminary Test Strip and Modified Start-Up Procedures
Appendix B.23

Effective Date: April 1, 2010
Revised Date: December 1, 2017

When required, an off-site preliminary test strip and modified start-up shall be performed as follows:

(a) Team Members. The start-up team, if required, shall 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
(6) Central Bureau of Materials representative
(7) Bureau of Construction representative
(8) Contractor's Density Tester
(9) Asphalt Binder Supplier representative

(b) Communication. The Contractor shall advise the team members of the anticipated start time of production for both the off-site preliminary test strip and subsequent modified start-up for both the surface and binder courses. The QC Manager shall direct the activities of the start-up team. A Department-appointed representative from the start-up team will act as spokesperson for the Department.

(c) Off-site Preliminary Test Strip. The off-site preliminary test strip shall consist of 272 metric tons (300 tons). It shall contain two growth curves which shall be tested as outlined herein.

(1) Mix and Gradation Test Strip Samples. The first and second sets of mixture and gradation 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 ignition gradation and asphalt content test results. This information shall then be compared to the JMF and required design criteria.

(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) Constructing the Off-site Preliminary Test Strip. After the Contractor has produced the mix, transported the mix, and placed approximately 90 to 140 metric tons (100 to 150 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 45 to 90 metric tons (50 to 100 tons) of mix, placement shall 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.

(4) 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.

(5) Compaction Temperature. In order to make an accurate analysis of the density potential of the mixture, the temperature of the mixture on the pavement at the beginning of the growth curve shall be not less than the minimum mixture placement temperature specified herein. The mat temperature, at the location of the each growth curve, shall be monitored throughout the construction of each growth curve.

(6) Compaction and Testing. 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 pass is completed.

(7) Final 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.

(8) 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 AJMF and required design criteria.

If the density potential of the mixture not meet the minimum specified, the operation shall cease until all test data is analyzed 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.

Off-Site Preliminary Test Strip and Modified Start-Up Procedures
Appendix B.23
(continued)

(d) Documentation. All off-site preliminary test strip, modified start-up, 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. Any changes to the rolling pattern shall be by the Contractor and the Engineer and recorded.

(e) Modified Start-Up. At the start of placement on the jobsite, the Contractor shall construct a growth curve in between the first 90 to 140 metric tons (100 to 150 tons) for the purposes of evaluating the properties of the mixture and ensuring that the established rolling pattern was valid.

The placement shall stop until the growth curve has been evaluated. A hot-bin or a combined aggregate belt sample and a mix sample representative of the growth curve shall be obtained and tested expediently for determination of mix composition and air voids. This information shall then be compared to the preliminary test strip data.

If the growth curve and visual evaluation of the mix are satisfactory, the placement may be resumed. If the growth curve and visual evaluation of the mix are unsatisfactory, placement shall remain on hold until the plant samples are completed and reviewed by the QC Manager and the Engineer. If agreed by the Engineer, the Contractor shall make appropriate adjustments, resample and retest, construct another growth curve, and evaluate the mixture. This procedure will be followed until satisfactory test results are obtained.

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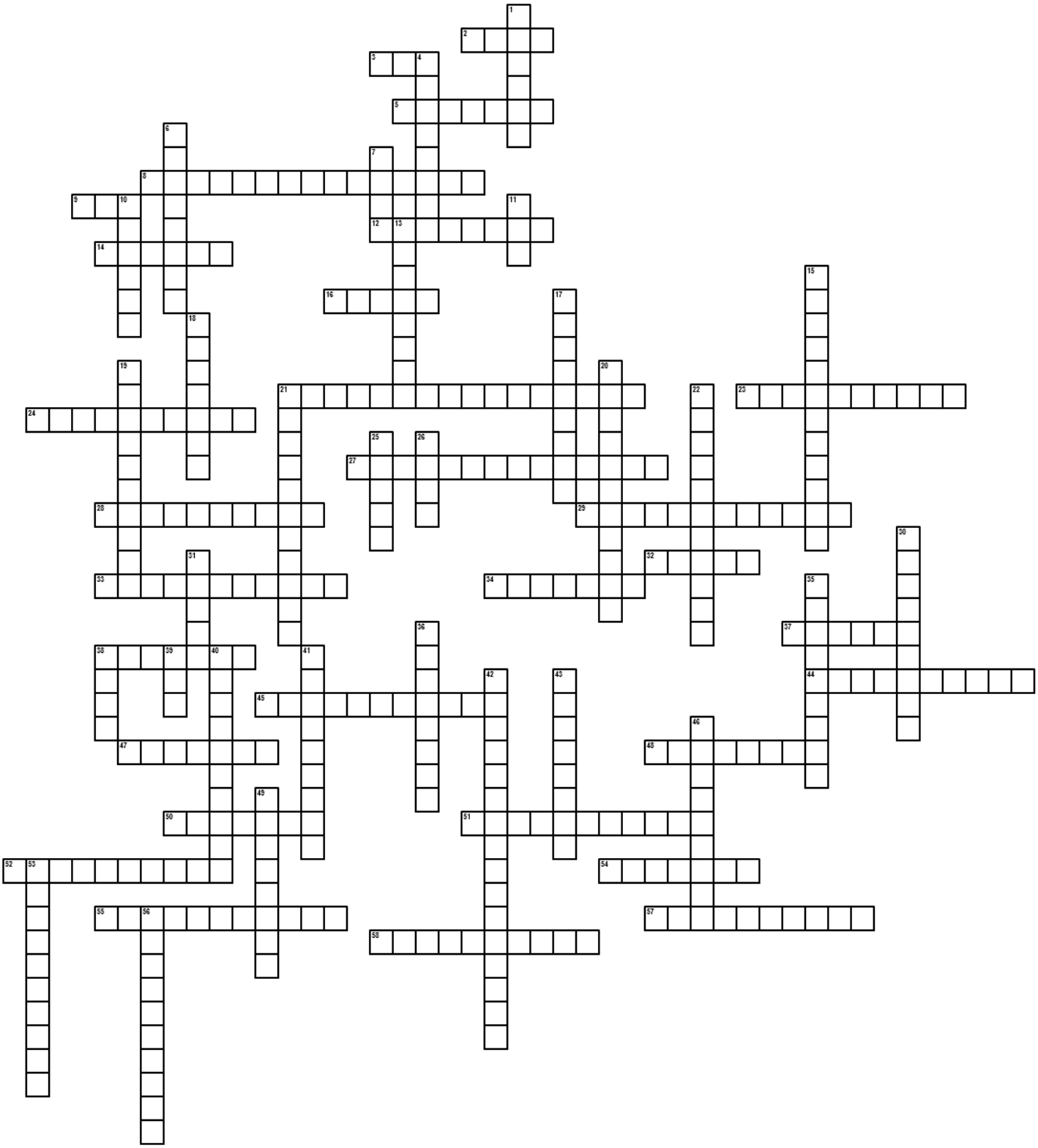
Hot Mix Asphalt Level I Crossword Review



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Hot Mix Asphalt Level I Crossword Review

Across:

2 _____ specific gravity is determined by obtaining the dry weight, submerged weight and saturated surface dry weight of a compacted specimen.

3 The submerged weight is subtracted from the _____ weight when determining the bulk specific gravity (Little "d") of a specimen.

5 After obtaining a hot mix asphalt sample from the job site, it must be _____ prior to reducing it.

8 The pycnometer pot and contents should be agitated manually by _____ _____ at intervals of about 2 minutes, during the vacuum period of the Big "D" test or mechanically agitated.

9 The 64 in a PG 64-22 means that is ____ resistant up to 64 degree C.

12 If the QA results do not meet the 100% sublot pay factor limits, their results must compare to QC results within 1% for ____ ____ for the limits of precision set forth by QCP Specifications.

14 A roadway that has 10 to 30 million design ESAL's would have a Ddesign of _____.

16 The most accurate means of determining density of a compacted mat is by taking _____ from its surface.

21 This device is used to convey hot mix asphalt from the discharge chute on the drier-drum mixer or from the pug mill of a batch plant to the surge silo.

23 When performing Maximum Specific Gravity or Big "D", the test procedure followed is Illinois Modified _____ .

Down:

1 When obtaining a sample of hot mix placed directly over a milled surface, rubblized concrete or an aggregate base the technician must use the sampling procedure using _____.

4 According to the Friction Aggregate (BDE) Special Provision, Mixture D allows a blend of 25% Limestone with what other aggregate.

6 When determining Big "D" we create a _____ mix by applying vacuum.

7 The core is considered dry at 230 degree +/- 9 degrees F if two successive weights in an hour differ by less than _____ of a gram.

10 The molds used for compaction in the gyratory compactor must be placed in an oven at 310 degrees +/- 5 degrees F for _____ minutes prior to use.

11 The target value for control charts is obtained from the _____.

13 The Density Testing _____ for PFP and QCP will be 0.2 mile (320 m) for lift thickness equal to or less then 3 inches (75 mm).

15 When constructing a test strip there are two _____ _____ completed, with cores take from each for the nuclear core correlation.

17 When determining Big "D" using the weighing in water method, the pycnometer pot is _____ in the water bath to determine the mass when submerged.

18 _____ tests are run on aggregates to classify an aggregate as Class A, B, C or D.

19 A moving average is represented on the control chart using an _____ _____.

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Hot Mix Asphalt Level I Crossword Review

Across:

24 A _____ factor must be determined when calibrating the ignition furnace.

27 All cores holes shall be filled with a _____ _____ mortar or concrete, which shall be mixed ina separate container prior to placement in the hole.

28 The correction factor determined during the calibration of the ignition oven is then _____ from the asphalt content result obtained from the ignition furnace during production.

29 The _____ _____, is the cross-sectional area of the specimen which the crack propagates through, calculated using the ligament length and the specimen thickness.

32 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.

33 _____ does occur in the hot bins at a batch plant.

34 A specimen used for little "d" testing should be _____ prior to obtaining a dry weight.

37 When selecting a saw and blade, for I-FIT testing, it is important to select dimensions that will allow for one _____ cut through the entire 150 mm diameter of the compacted cylinders.

38 When determining Big "D" of a sample, entrapped air is removed by applying a vacuum for _____ +/- 2 minutes.

44 Specimens are compacted according Illinois Modified _____ for the bulk specific gravity test or Little "d".

Down:

20 When completing TSR testing the _____ bricks are saturated.

21 When following QC/QA Specifications, the contractor shall be responsible for _____ 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 dairy which will become the property of the Department.

22 This is one method that can be used to separate a multi-lift core, to obtain a specimen for density determination.

25 A_____ plant has hot bins, a weigh hopper and pug mill.

26 Using the wrong _____ can give you erroneous density calculations.

30 _____ aggregates do not exist in nature and are the product of chemical or physical processing of materials.

31 If laboratory equipment becomes inoperable during production the contractor must _____ production.

35 Once the specimens have reached room temperature, determine the bulk specific gravity of the _____ specimens using Illinois Modified AASHTO T166.

36 _____ has low bulk specific gravity and a high, variable absorption, but is used because of its abrasion resistant qualities.

38 A moving average is calculated using the _____ most current test values.

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Hot Mix Asphalt Level I Crossword Review

Across:

45 If the freshly mixed ignition calibration sample is allowed to cool, it must be preheated in a 230 degree +/- 9 degree F oven for _____ minutes.

47 A _____ silo has a larger capacity and always insulated and usually heated.

48 The TSR test is used to identify mixtures which are susceptible to _____ damage.

50 exposing the asphalt binder to extreme temperatures and air can cause it to _____ or become hard and brittle, shortening the life of the pavement.

51 Determine the _____ of the water bath prior to calibration of the pycnometer pot during Big "D" testing.

52 During TSR testing the conditioned bricks are placed in vacuum chamber until 70%-80%._____ weight is achieved.

54 A PG 64-22 has a _____ temperature of 86 degrees C.

55 The depression left in the surface after filling a core hole can not be greater than a _____ _____.

57 When compacting gyratory samples, a large loading chute will be use to load the sample and it should be loaded in one smooth, _____ motion.

58 When soaking cores to determine density, they are placed on their _____ _____.

Down:

39 When following QC/QA Specifications, for High ESAL and Low ESAL mixtures, Illinois requires a minimum of _____ washed ignition oven gradation tests for a full days production.

40 When running the _____ test, one result obtained is asphalt binder content.

41 The ignition furnace must be _____ to 482 degrees C.

42 RAS and RAP are classified as what type of aggregate source? _____ _____

43 _____ material might be an indication of not enough mixing time.

46 When calculating the field VMA of a specimen, the Gsb value used is the average Gsb found in the _____ _____.

49 The purpose of completing the bulk specific gravity is to determine percent _____ _____ using a standard test procedure.

53 The Illinois Modified Test Procedure for Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface Dry Specimens is _____.

56 This is the "Standard Method of Test for Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method"

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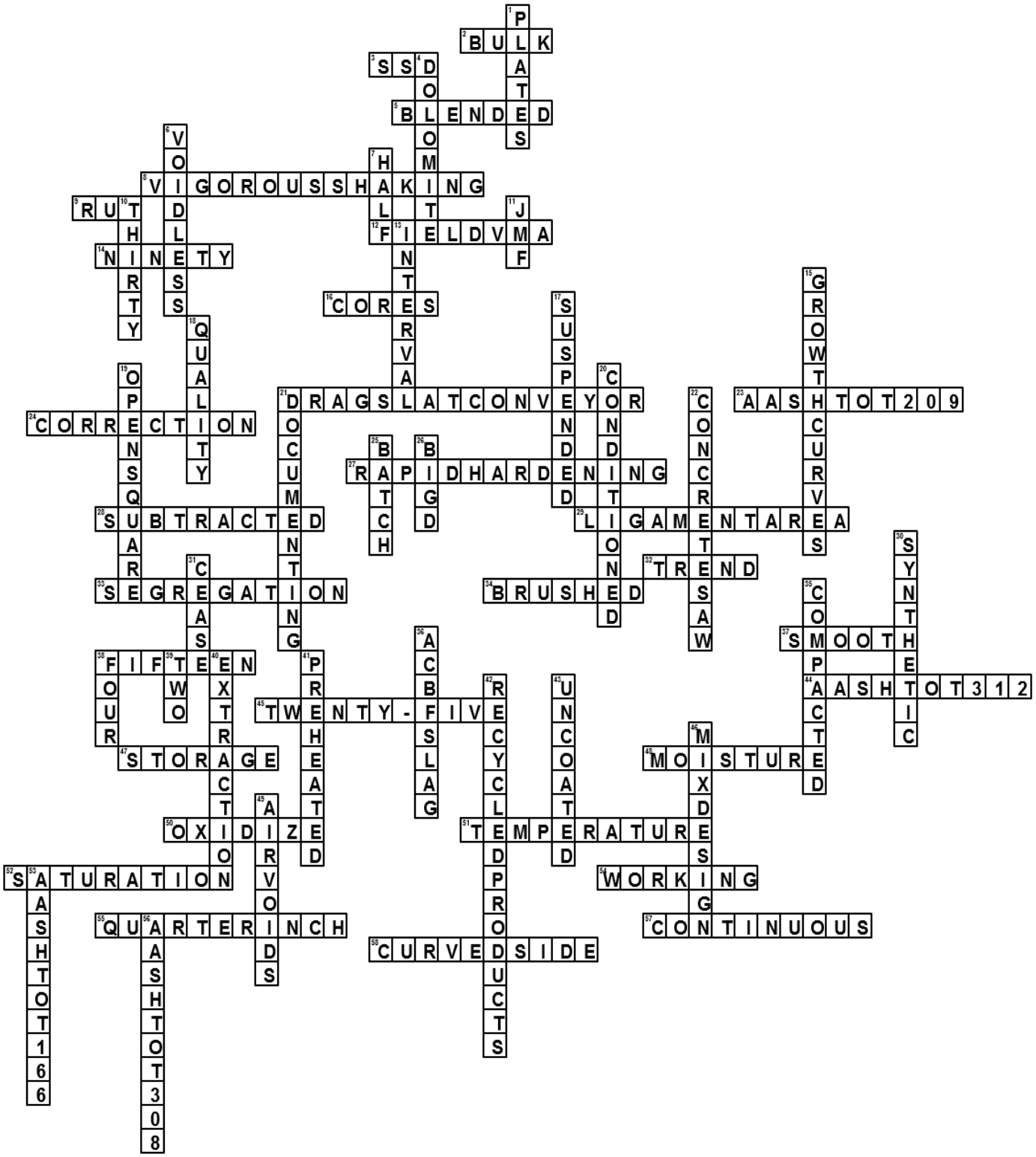
Hot Mix Asphalt Level I Crossword Review Solution



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