Nuclear Density Tester Course

LAKE LAND COLLEGE

2019-2020

Illinois Department of Transportation
Central Bureau of Materials

HOT MIX ASPHALT - 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 exam.**

Prerequisite Course:

None.

Written Test:

Time limit is 1 ½ hours. (Open book exam)
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 February 11, 2020, the last date to retest is August 31, 2020.)** Failure of the written *retest*, or failure to comply with the academic year retest time limit, 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 1 ½ hours. (Open book exam)
Minimum grade of 70 is required.

This Page Is Reserved

LAKE LAND COLLEGE - INSTRUCTORS AND COURSE EVALUATION

Course: **Hot Mix Asphalt Nuclear Density___** Section No.________ Date___________________

Lead Instructors Name:______________________ **Lab Instructor 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 ____

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.
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.	______	______
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.	______	______

OVER

LAKE LAND COLLEGE - INSTRUCTORS AND COURSE EVALUATION

(PAGE 2)

PERSONAL CHARACTERISTICS AND STUDENT RAPPORT:

			LEAD INSTR.	LAB INSTR.
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.)

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

(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).

Revise Article 1030.04(d) of the Standard Specifications to read:

"(d) Verification Testing. During mixture design, prepared samples shall be submitted to the District laboratory for verification testing. The required testing, and number and size of prepared samples submitted, shall be according to the following tables.

High ESAL – Required Samples for Verification Testing 1/		
Mixture	Hamburg Wheel Testing and I-FIT Testing	Tensile Strength Testing
Binder	total of 3 - 160 mm tall bricks 2/	6 - 95 mm tall bricks
Surface	total of 4 - 160 mm tall bricks 2/	6 - 95 mm tall bricks

Low ESAL – Required Samples for Verification Testing 1/		
Mixture	I-FIT Testing	Tensile Strength Testing
Binder	1 - 160 mm tall brick 2/	6 - 95 mm tall bricks
Surface	2 - 160 mm tall bricks 2/	6 - 95 mm tall bricks

1/ Prepared samples shall be compacted gyratory bricks yielding test specimens with 7.0 ± 1.0% air voids.

2/ If the Contractor does not possess the equipment to prepare the 160 mm tall brick(s), twice as many 115 mm tall compacted gyratory bricks will be acceptable.

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	Minimum Number of Wheel 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. Tensile strength testing shall be according to the Illinois Modified AASHTO T 283 procedure. The minimum allowable conditioned tensile strength shall be 60 psi (415 kPa) for non-polymer modified performance graded (PG) asphalt binder and 80 psi (550 kPa) for polymer modified PG asphalt binder. The maximum allowable unconditioned tensile strength shall be 200 psi (1380 kPa).

(3) I-FIT Flexibility Index (FI) Criteria. I-FIT testing will be according to Illinois Modified AASHTO TP 124 and the results will be for informational purposes only.

If a mix fails the Department's verification testing, 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."

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
(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

Start of HMA Production and Job Mix Formula (JMF) Adjustments. Revise Article 1030.06(a) of the Standard Specifications to read:

"(a) High ESAL Mixtures. A test strip will be required at the beginning of HMA production for each mixture according to the Manual of Test Procedures for Materials "Hot Mix Asphalt Test Strip Procedures". A test strip will not be required for shoulder applications or HMA mixtures with a quantity less than 3000 tons (2750 metric tons); however, such mixtures shall still be sampled on the first day of production for the Hamburg Wheel and I-FIT testing.

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.

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.

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

Mixture sampled to represent the test strip shall include approximately 60 lb (27 kg) of additional material for the Department to conduct Hamburg Wheel testing and approximately 80 lb (36 kg) of additional material for the Department to conduct I-FIT testing. Within one working day after sampling, the Contractor shall deliver prepared samples to the District laboratory for verification testing. The required number and size of prepared samples submitted for the Hamburg Wheel and I-FIT testing shall be according to the "High ESAL - Required Samples for Verification Testing" table in Article 1030.04(d) above.

Mixture sampled during production for Hamburg Wheel and I-FIT will be tested by the Department. The Hamburg Wheel results shall meet the requirements specified in Article 1030.04(d) above.

Upon notification by the Engineer of a failing Hamburg Wheel test and prior to restarting production, the Contractor shall make necessary adjustments approved by the Engineer to the mixture production and submit another mixture sample for the Department to conduct Hamburg testing. Prior produced material may be paved out provided all other mixture criteria is being met. Upon consecutive failing Hamburg Wheel tests, no additional mixture shall be produced until the Engineer receives passing Hamburg Wheel test results.

The Department may conduct additional Hamburg Wheel testing 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.

Add the following to the end of Article 1030.06(b) of the Standard Specifications:

"I-FIT testing will be performed for Low ESAL mixtures (excluding Class D patches, pavement patching and incidental HMA) during mixture production. Within one working day after sampling, the Contractor shall deliver prepared samples to the District laboratory for verification testing. The required number and size of prepared samples submitted for the I-FIT testing shall be according to the "Low ESAL - Required Samples for Verification Testing" table in Article 1030.04(d) above."

See the

"Hot Mix Asphalt Test Strip Procedures"

on following page.

Illinois Department of Transportation

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).

Illinois Department of Transportation

Hot Mix Asphalt Test Strip Procedures
Appendix B.4

Effective: May 1, 1993
Revised: December 1, 2017

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. <u>Nuclear/Core Correlation</u>

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. <u>Documentation</u>

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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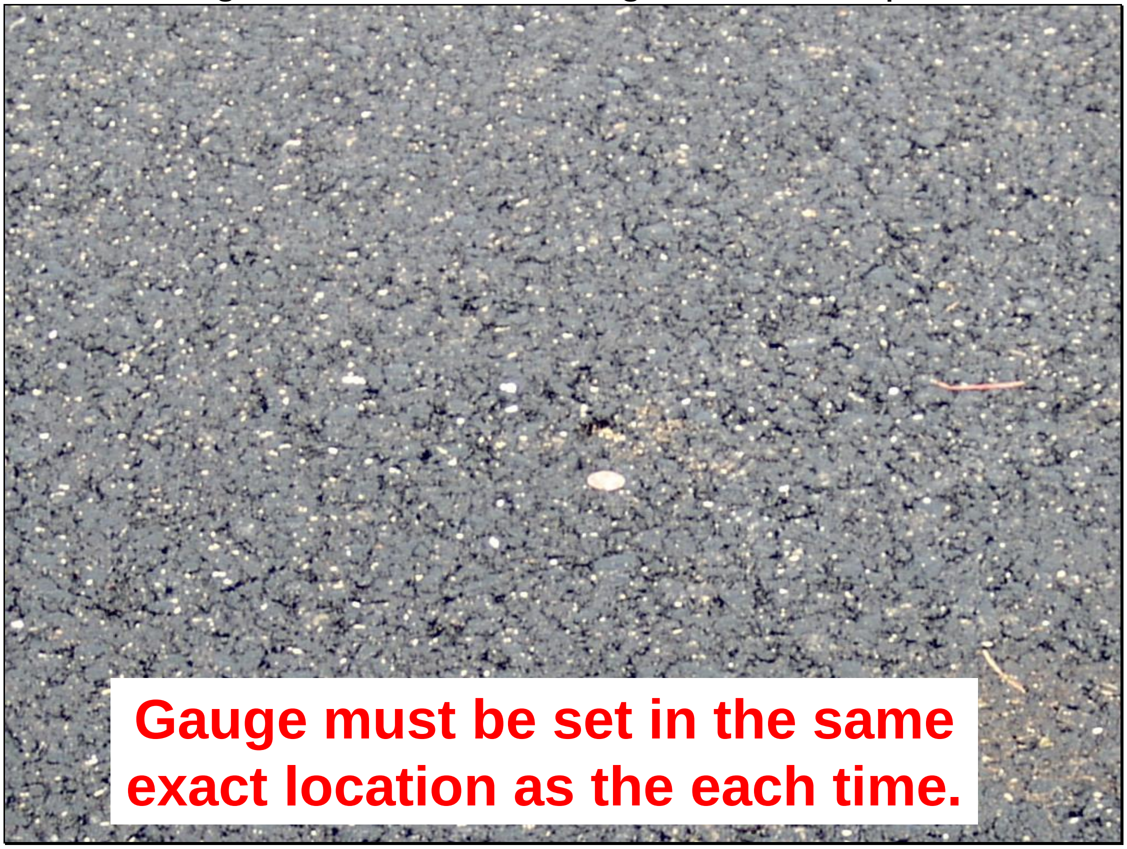
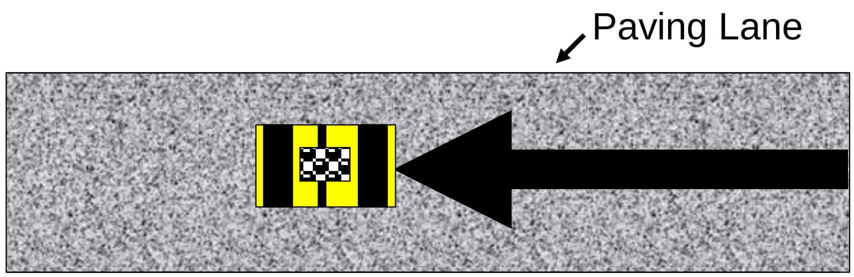
Determining Growth Curve during the Test Strip Procedure



Growth Curve

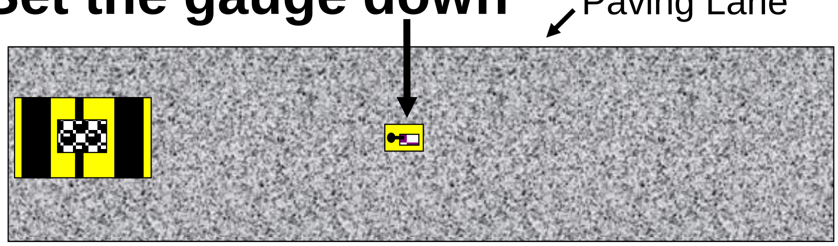


First Roller Pass

Growth Curve

Set the gauge down

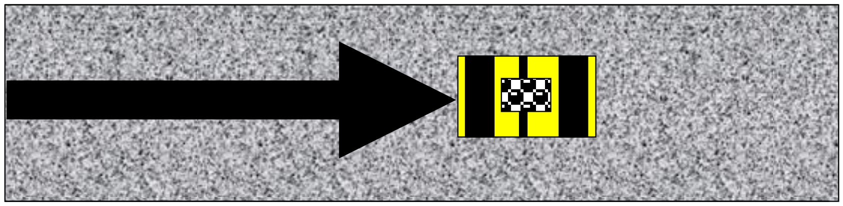
Paving Lane



Take first measurement

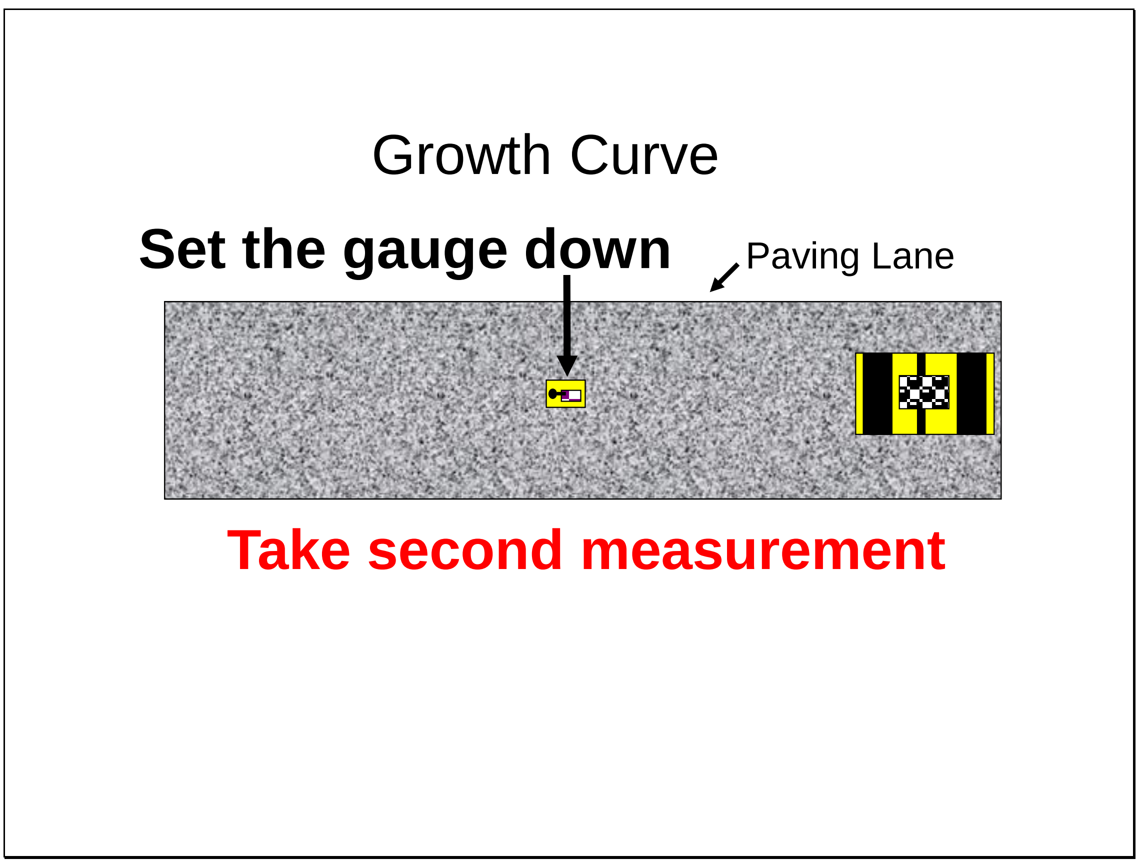
Growth Curve

Paving Lane

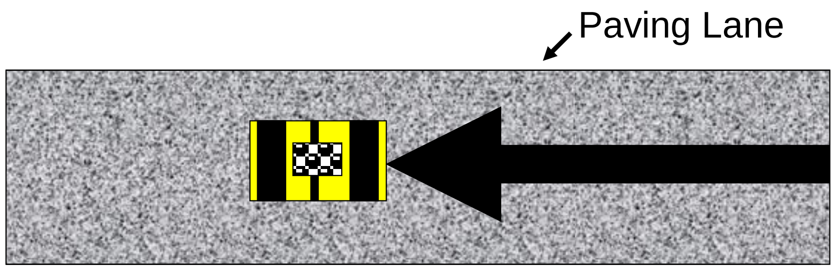


Second Roller Pass


Set the gauge down and
take the second measurement


Growth Curve
Set the gauge down
Paving Lane
Take second measurement

Growth Curve

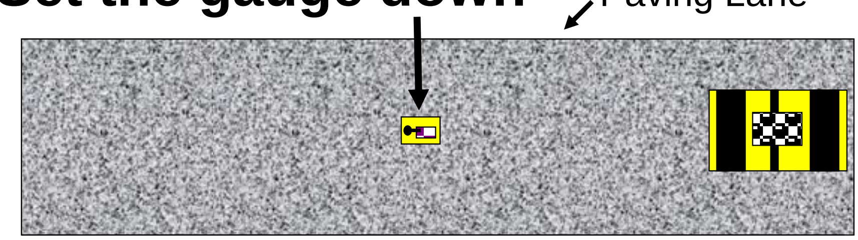


Third Roller Pass

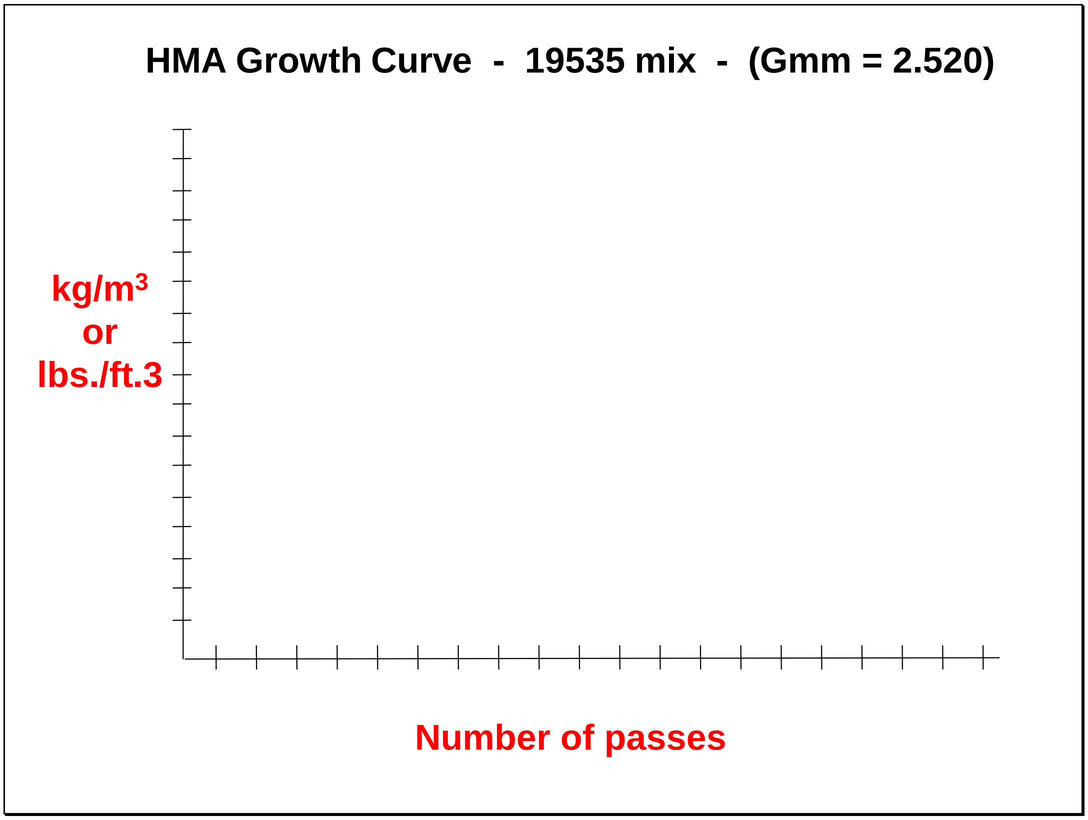
Growth Curve

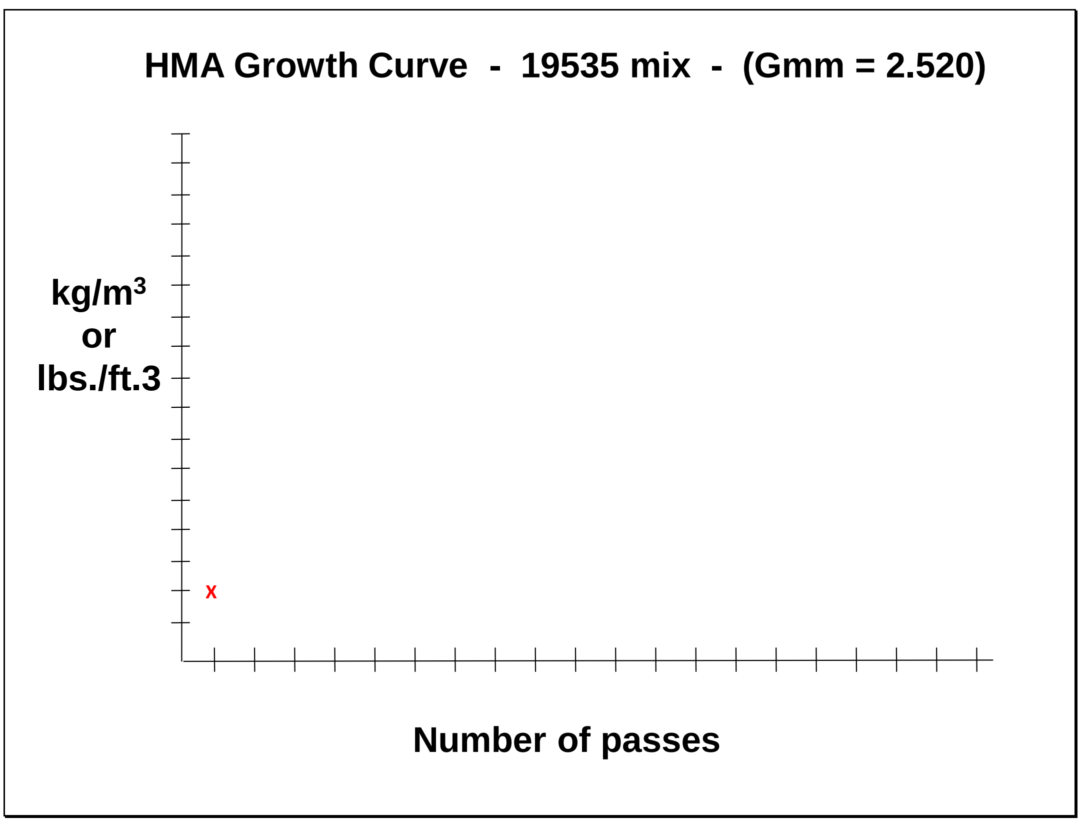
Set the gauge down

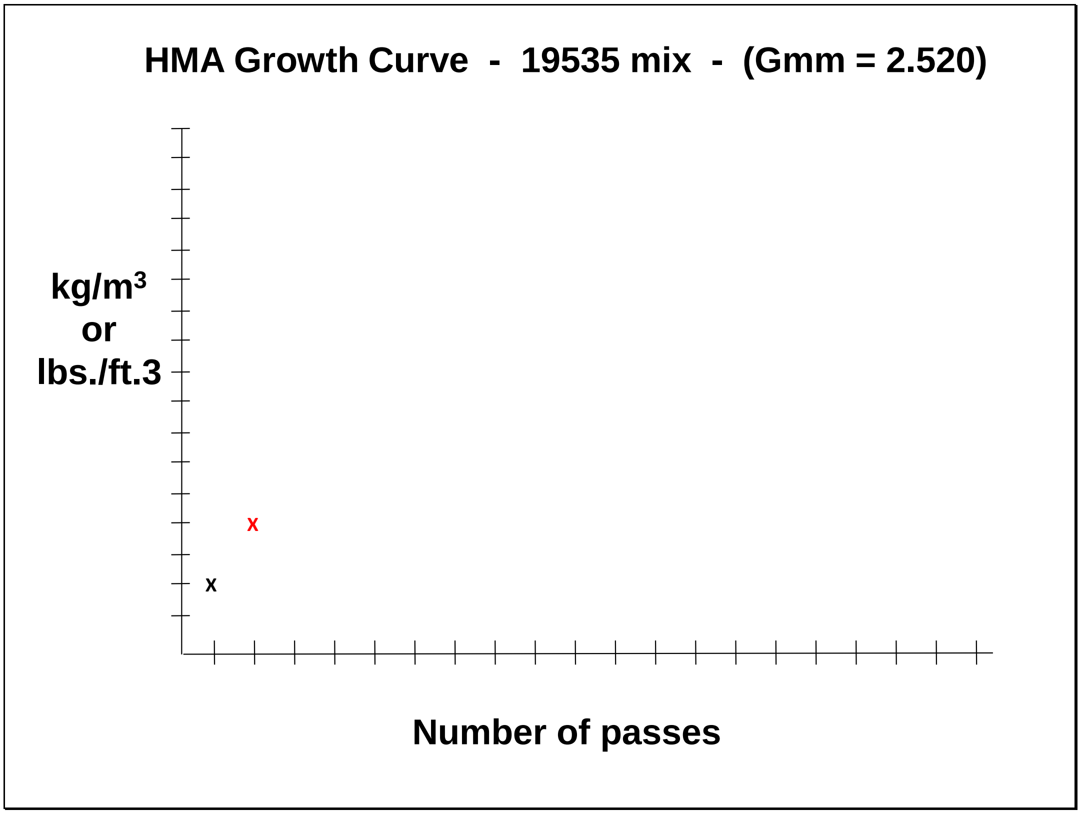
Paving Lane

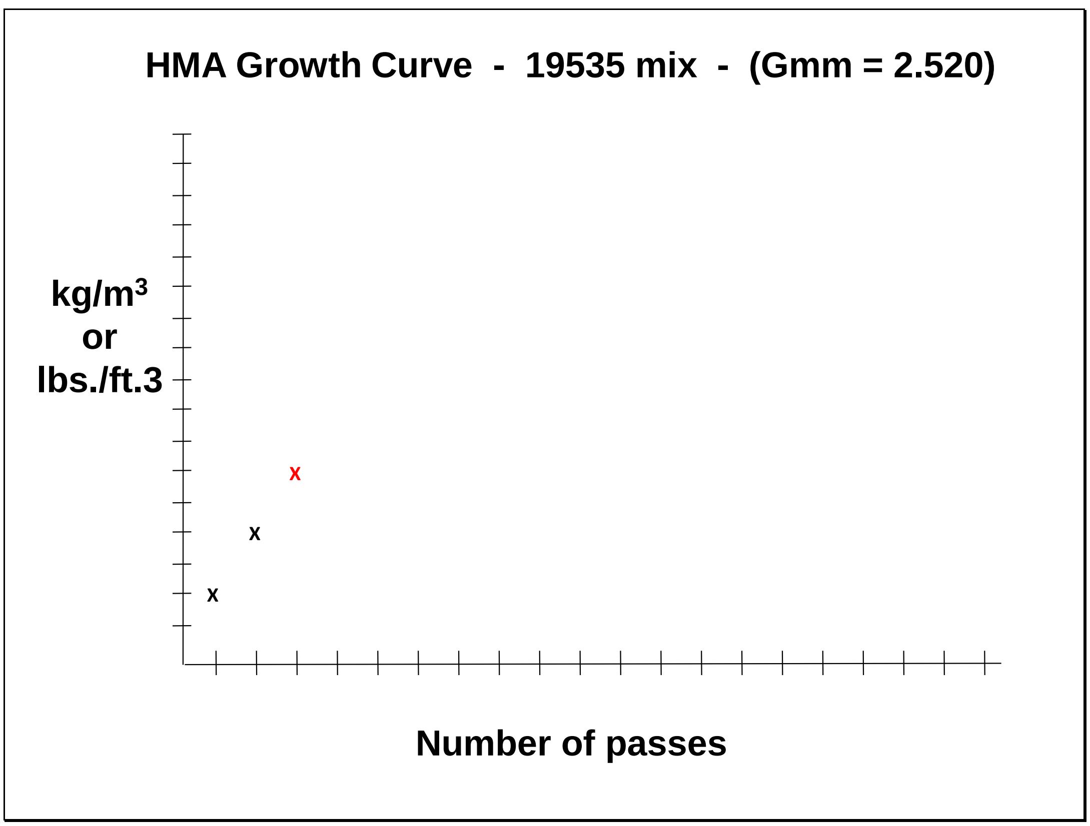


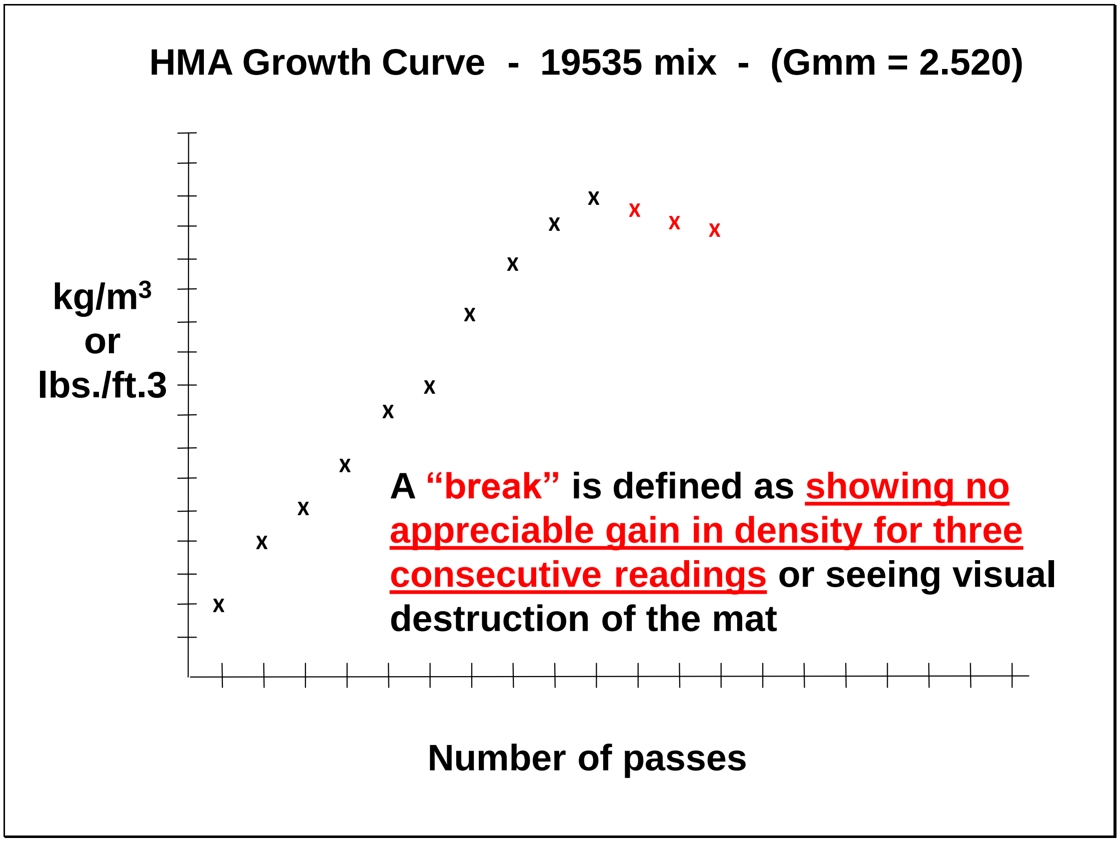
Take third measurement

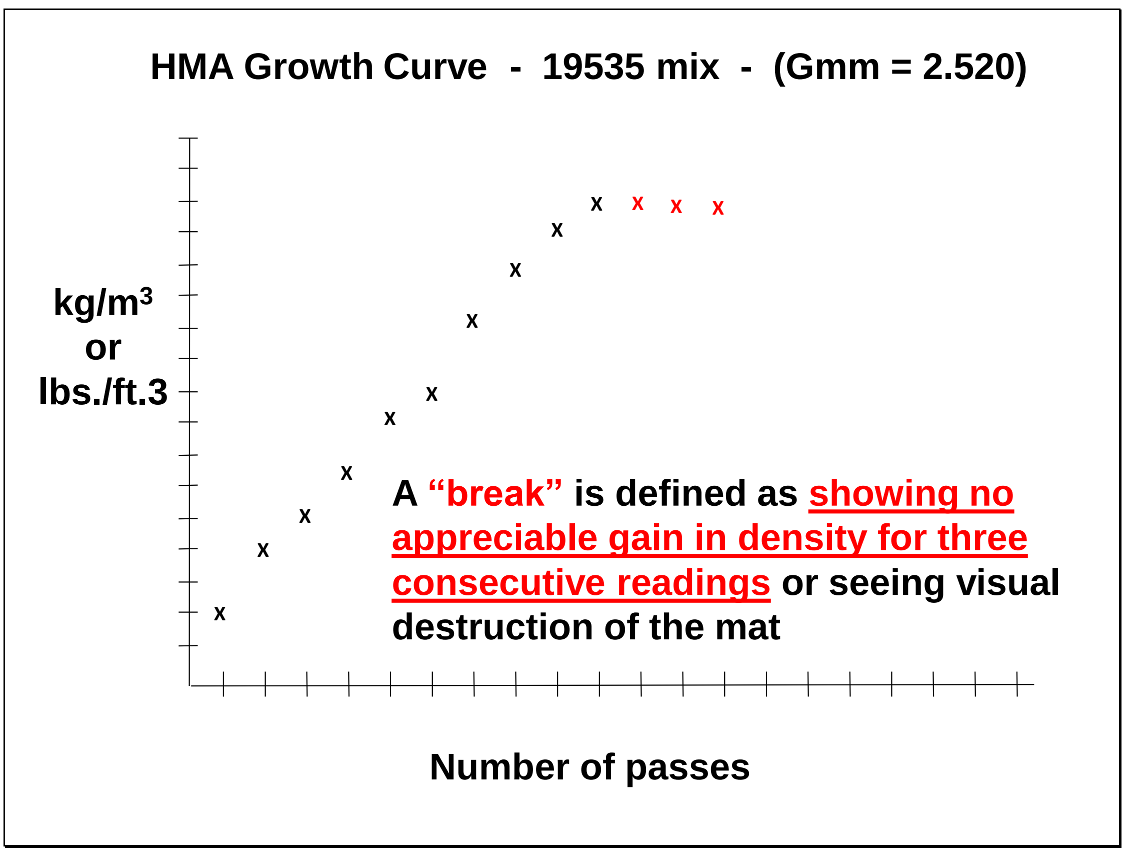

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m3
or
lbs./ft.3
Number of passes

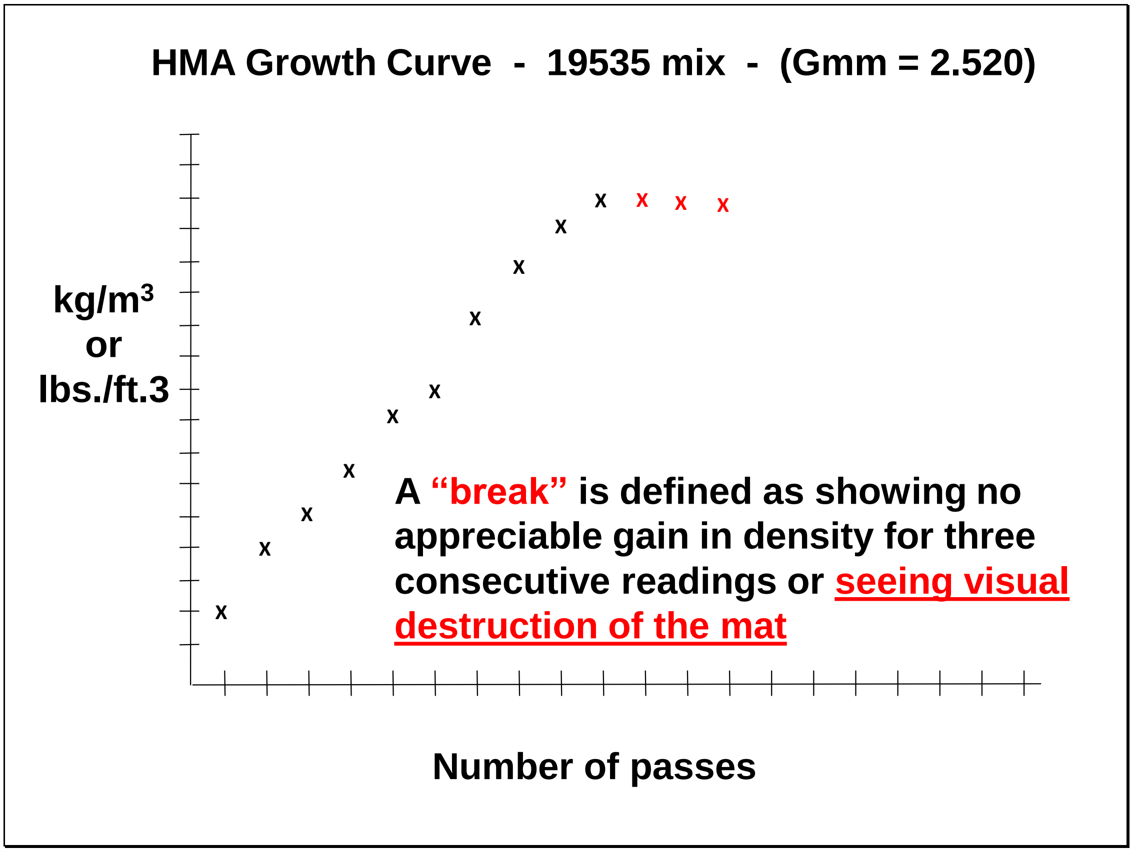

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m3
or
lbs./ft.3
x
Number of passes

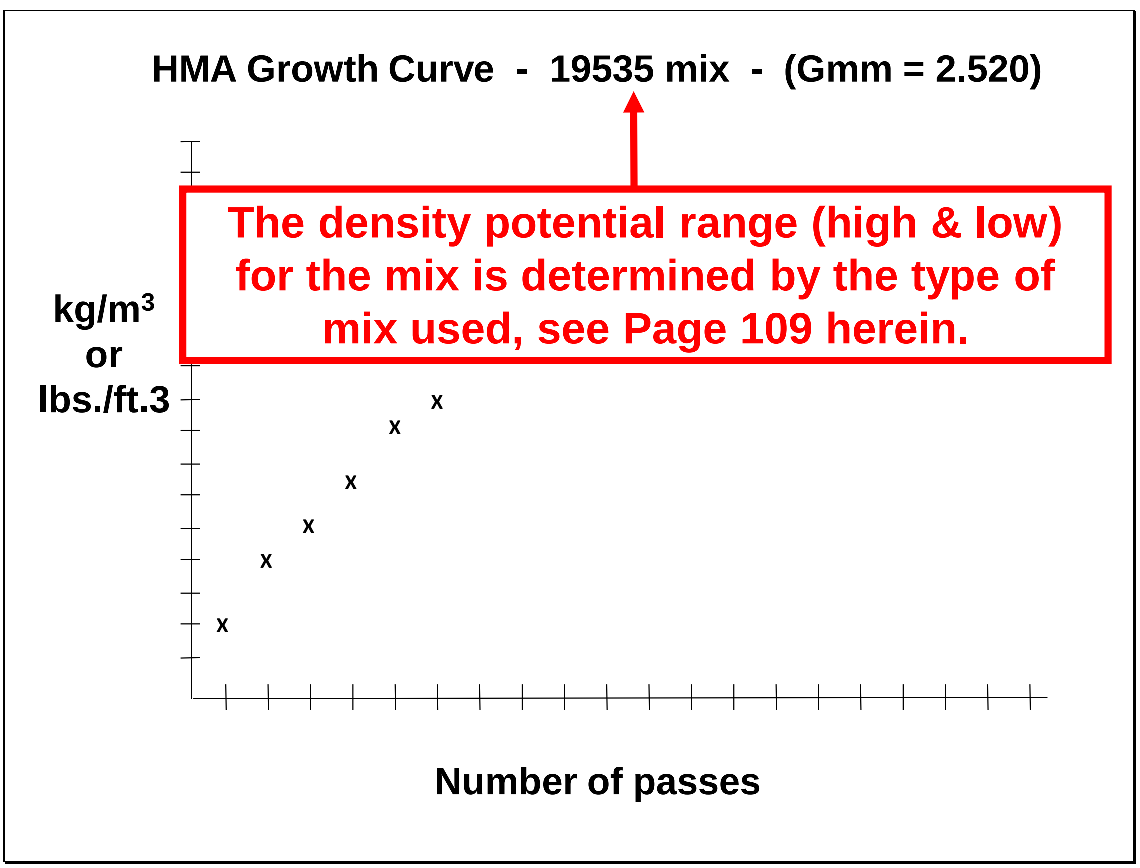

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m3
or
lbs./ft.3
x
x
Number of passes

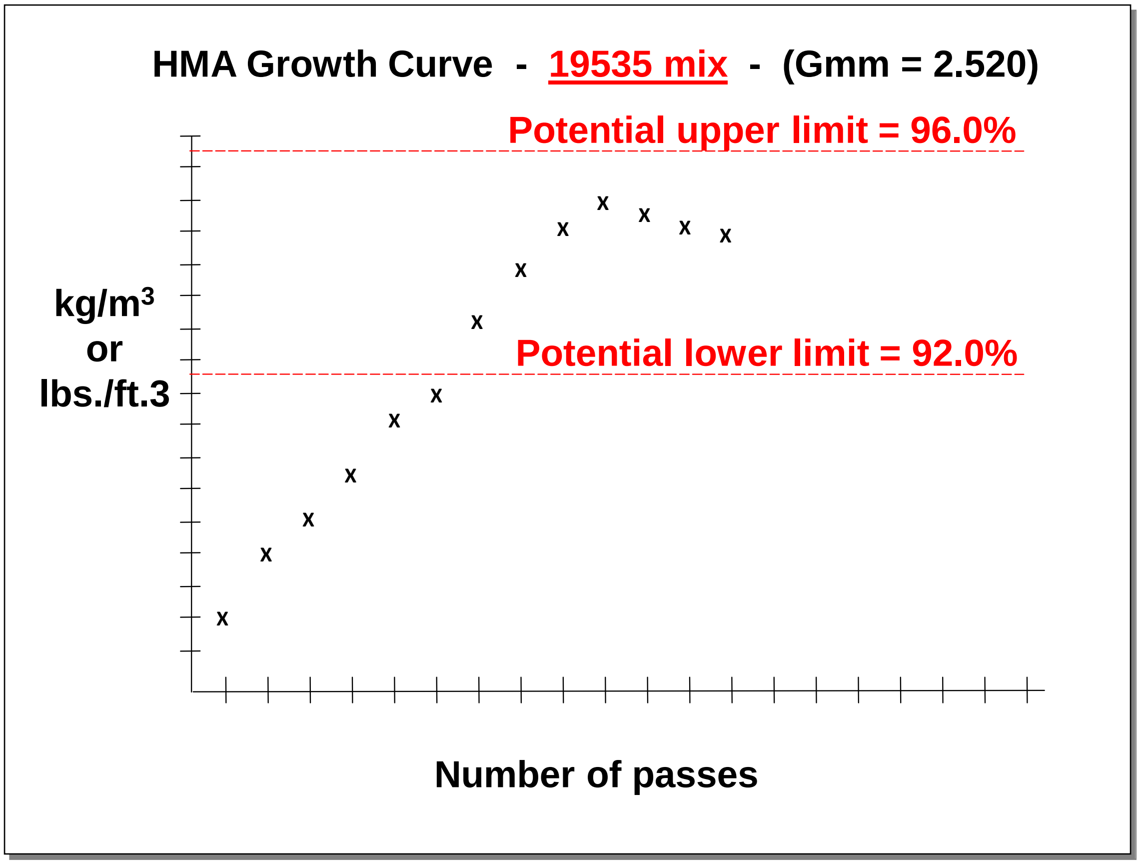

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m3
or
lbs./ft.3
x
x
x
Number of passes

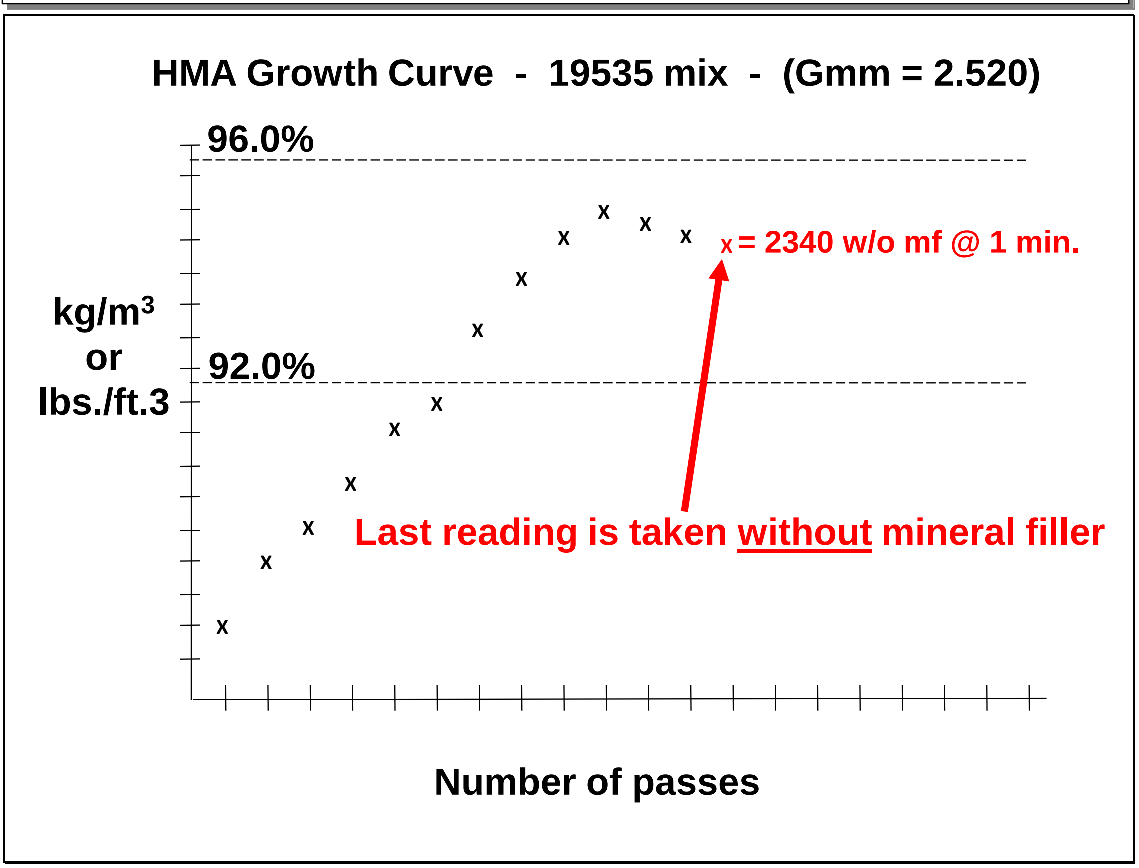

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m3 or lbs./ft.3
A "break" is defined as showing no appreciable gain in density for three consecutive readings or seeing visual destruction of the mat
Number of passes

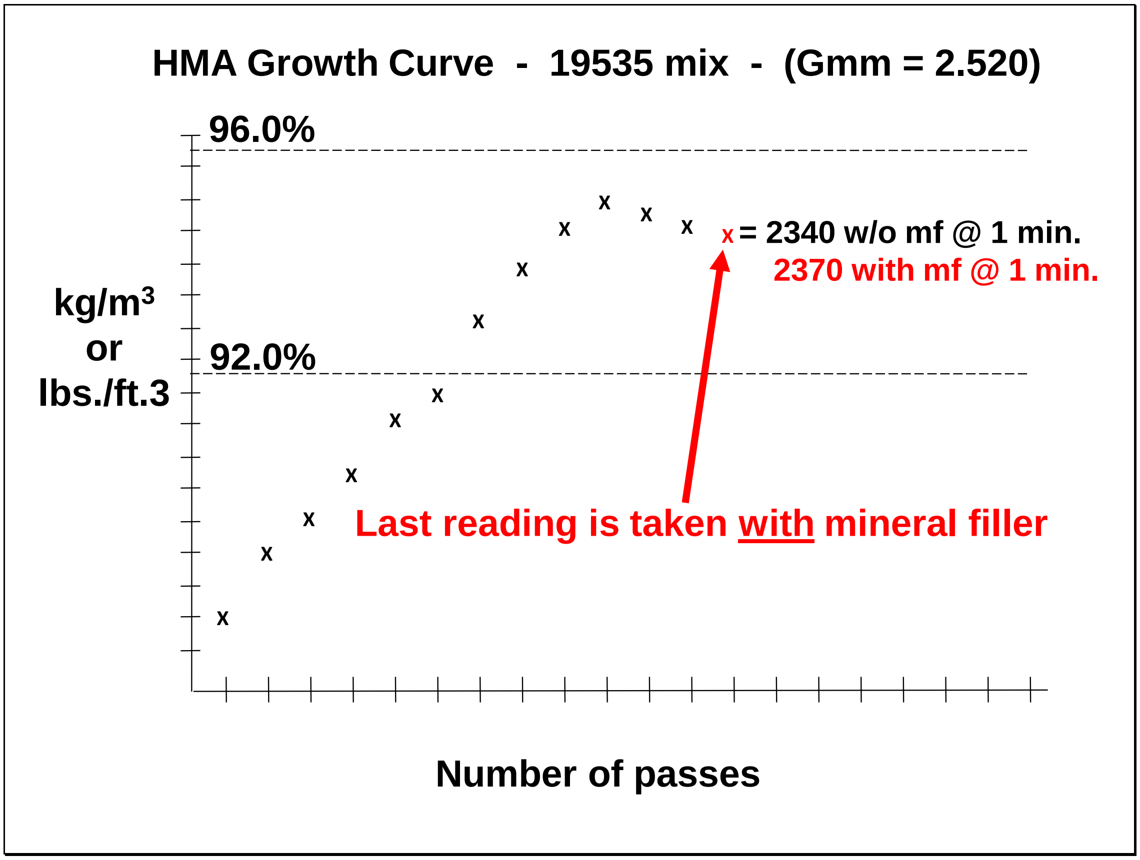

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m3 or lbs./ft.3
A "break" is defined as showing no appreciable gain in density for three consecutive readings or seeing visual destruction of the mat
Number of passes

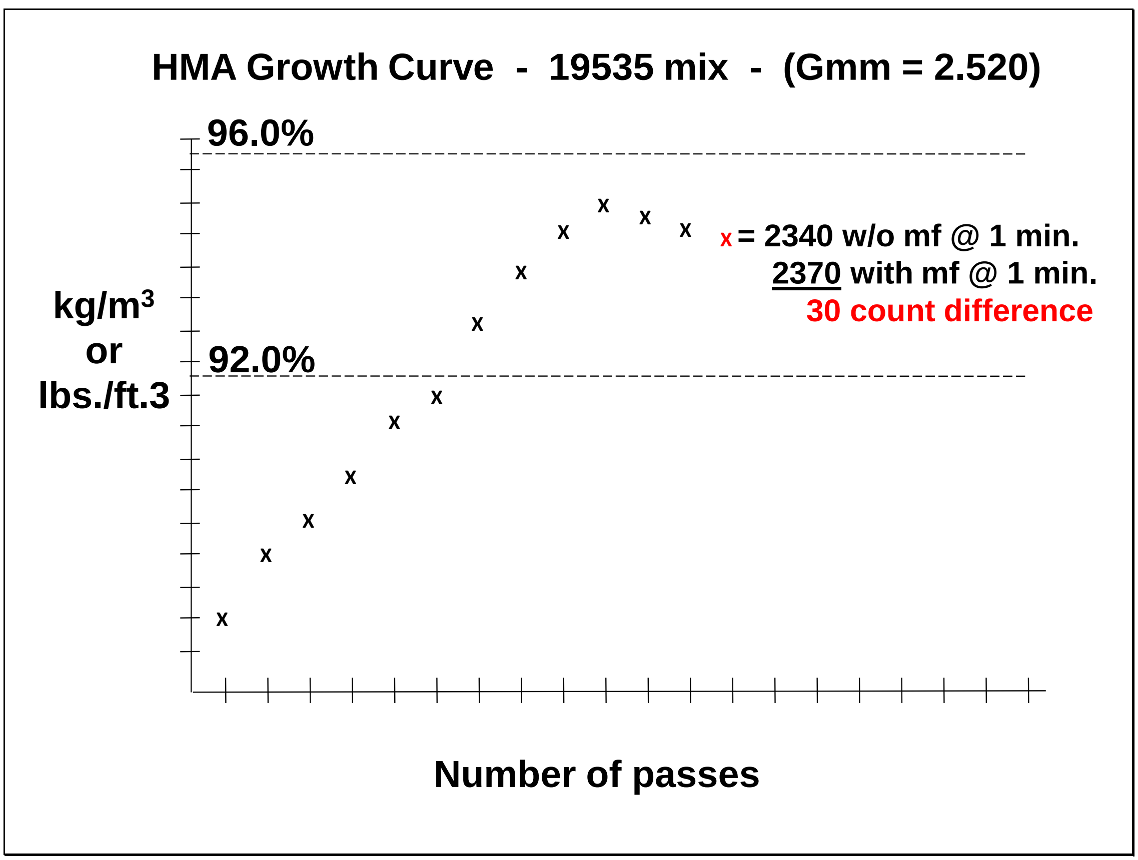

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m3 or lbs./ft.3
A "break" is defined as showing no appreciable gain in density for three consecutive readings or seeing visual destruction of the mat
Number of passes

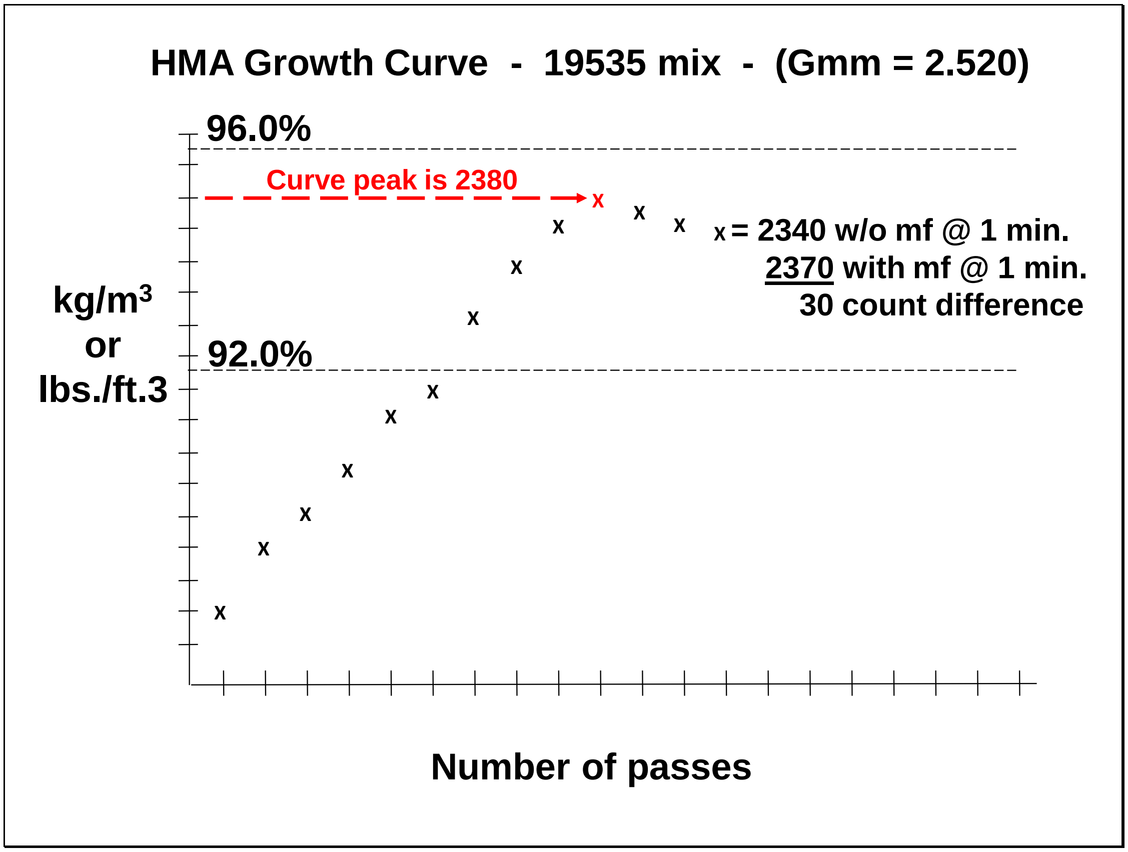

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m3 or lbs./ft.3
The density potential range (high & low) for the mix is determined by the type of mix used, see Page 109 herein.
Number of passes

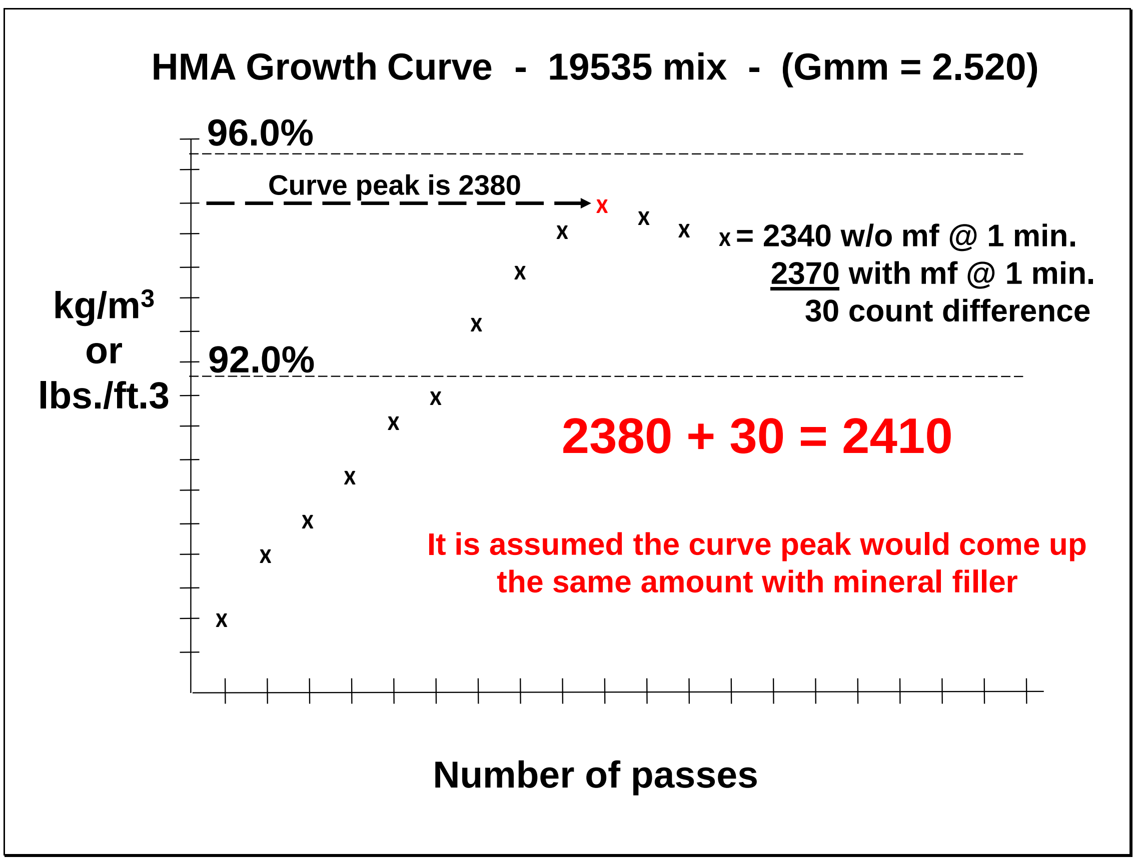

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
Potential upper limit = 96.0%
Potential lower limit = 92.0%
kg/m3
or
lbs./ft.3
Number of passes

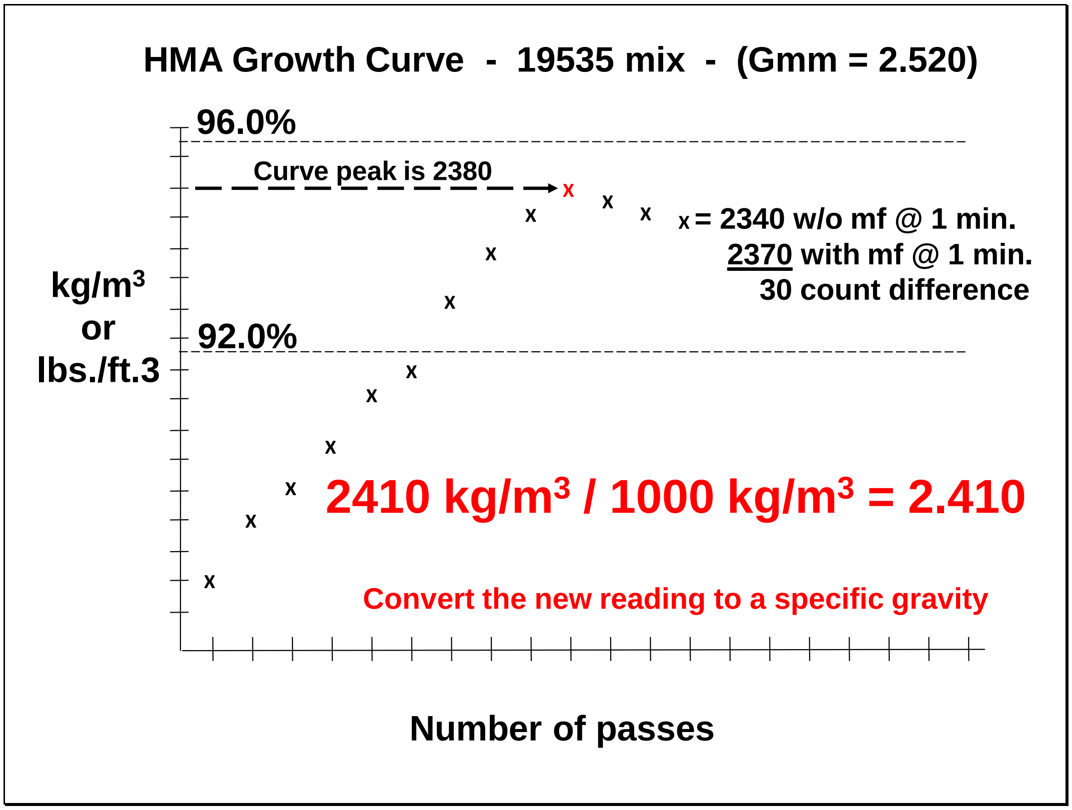

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
96.0%
92.0%
x = 2340 w/o mf @ 1 min.
Last reading is taken without mineral filler
kg/m3
or
lbs./ft.3
Number of passes

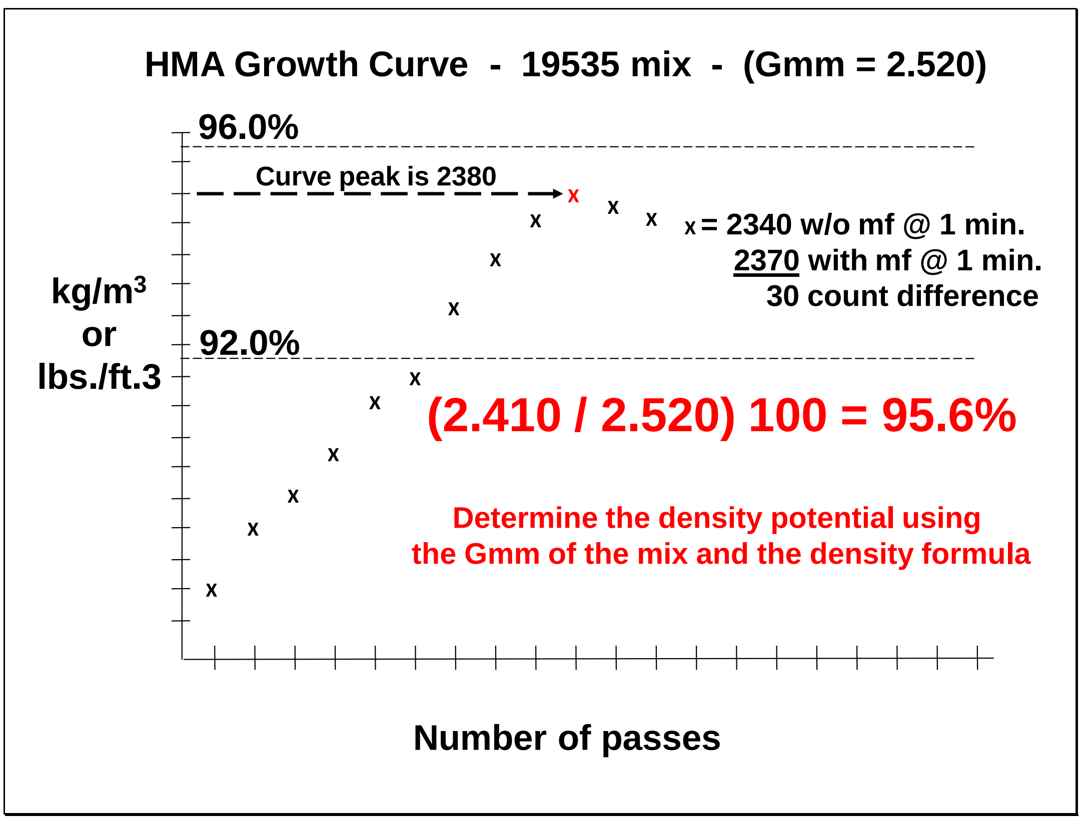

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
96.0%
92.0%
kg/m3
or
lbs./ft.3
x = 2340 w/o mf @ 1 min.
2370 with mf @ 1 min.
Last reading is taken with mineral filler
Number of passes

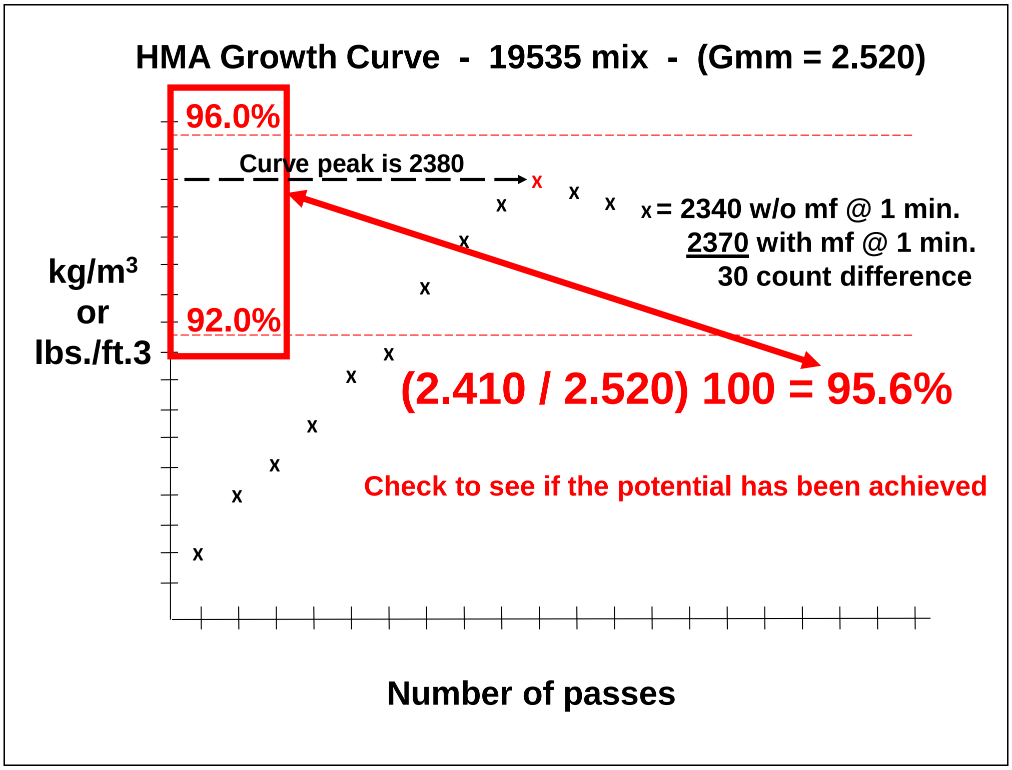

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
96.0%
92.0%
kg/m3
or
lbs./ft.3
x = 2340 w/o mf @ 1 min.
2370 with mf @ 1 min.
30 count difference
Number of passes


HMA Growth Curve - 19535 mix - (Gmm = 2.520)
96.0%
Curve peak is 2380
x = 2340 w/o mf @ 1 min.
2370 with mf @ 1 min.
30 count difference
kg/m³ or lbs./ft.3
92.0%
Number of passes


HMA Growth Curve - 19535 mix - (Gmm = 2.520)
96.0%
Curve peak is 2380
x = 2340 w/o mf @ 1 min.
2370 with mf @ 1 min.
30 count difference
kg/m³ or lbs./ft.3
92.0%
2380 + 30 = 2410
It is assumed the curve peak would come up the same amount with mineral filler
Number of passes


HMA Growth Curve - 19535 mix - (Gmm = 2.520)
96.0%
Curve peak is 2380
x = 2340 w/o mf @ 1 min.
2370 with mf @ 1 min.
30 count difference
kg/m3 or lbs./ft.3
92.0%
2410 kg/m3 / 1000 kg/m3 = 2.410
Convert the new reading to a specific gravity
Number of passes


HMA Growth Curve - 19535 mix - (Gmm = 2.520)
96.0%
Curve peak is 2380
x = 2340 w/o mf @ 1 min.
2370 with mf @ 1 min.
30 count difference
kg/m3 or lbs./ft.3
92.0%
(2.410 / 2.520) 100 = 95.6%
Determine the density potential using
the Gmm of the mix and the density formula
Number of passes


HMA Growth Curve - 19535 mix - (Gmm = 2.520)
96.0%
Curve peak is 2380
x = 2340 w/o mf @ 1 min.
2370 with mf @ 1 min.
30 count difference
kg/m3
or
lbs./ft.3
92.0%
(2.410 / 2.520) 100 = 95.6%
Check to see if the potential has been achieved
Number of passes

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.

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
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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).

Illinois Department of Transportation
QC/QA PROCEDURE

Standard Test Method for Correlating
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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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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

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:

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

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
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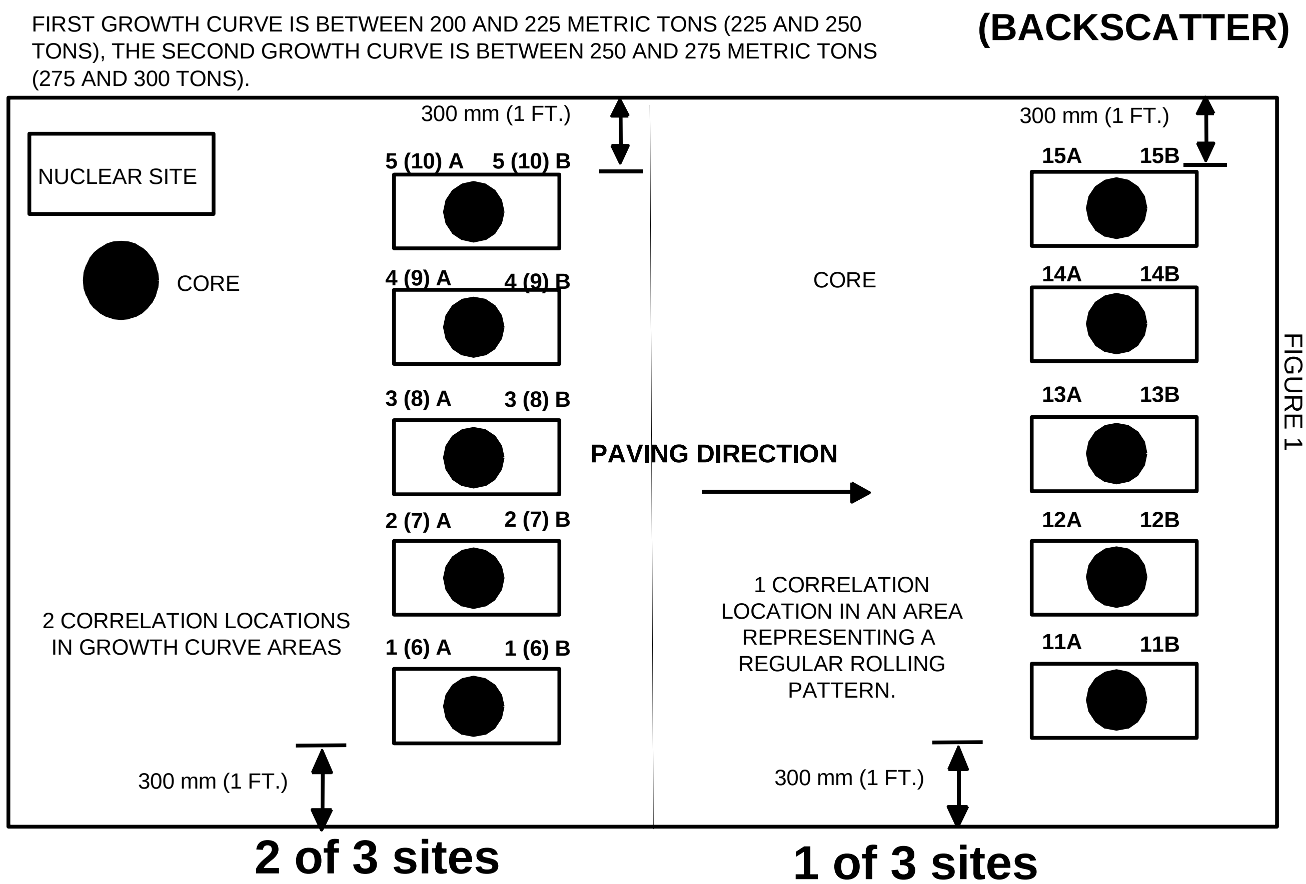

NUCLEAR/CORE CORRELATION TEST LOCATIONS

Illinois Department of Transportation
QC/QA PROCEDURE

Standard Test Method for Correlating
Nuclear Gauge Densities with Core Densities
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DIRECT TRANSMISSION MODE

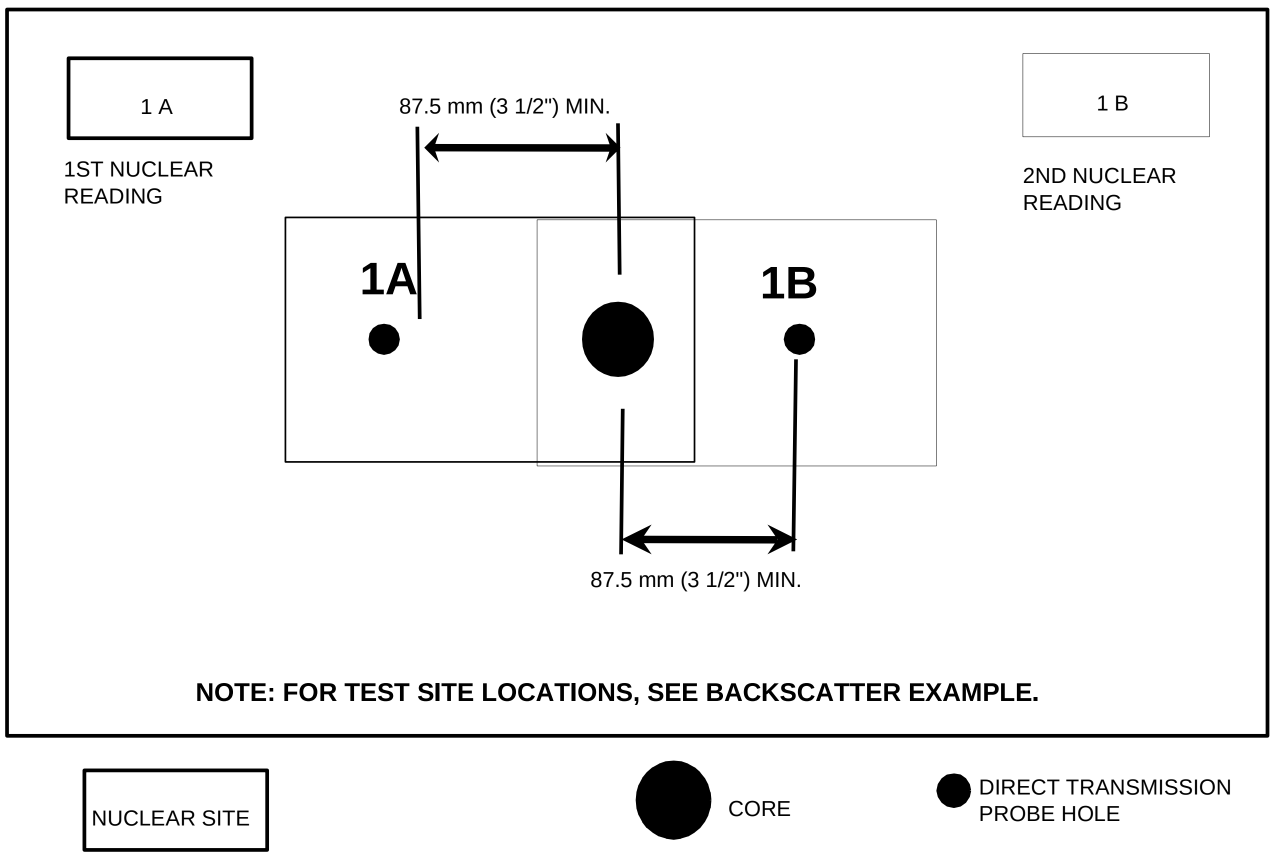

FIGURE 2

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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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)

Appendix B3
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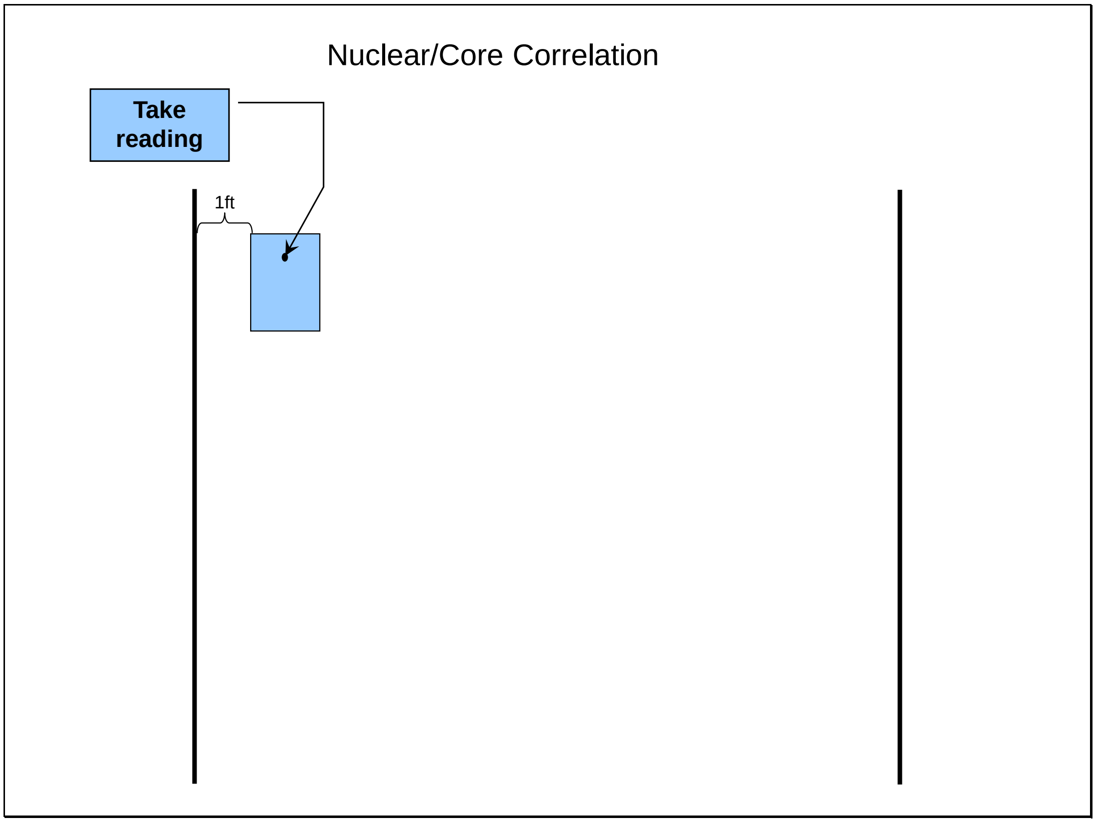
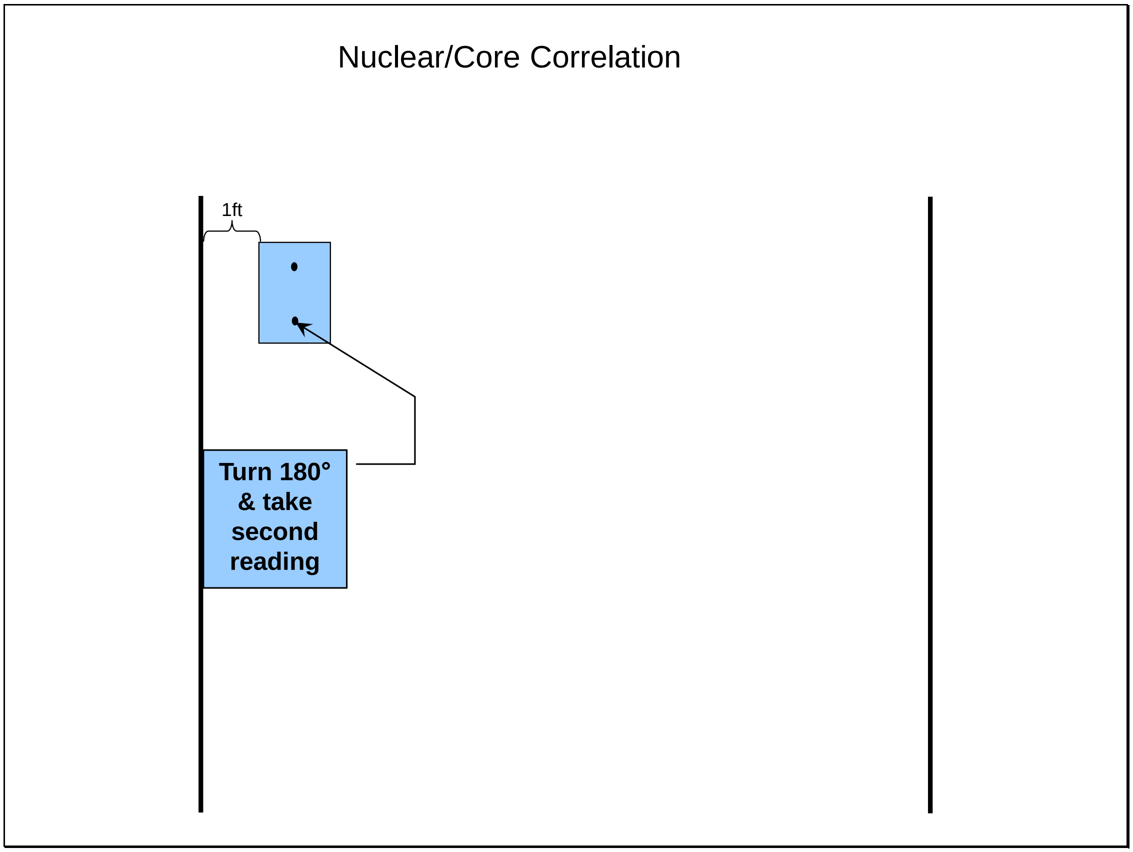
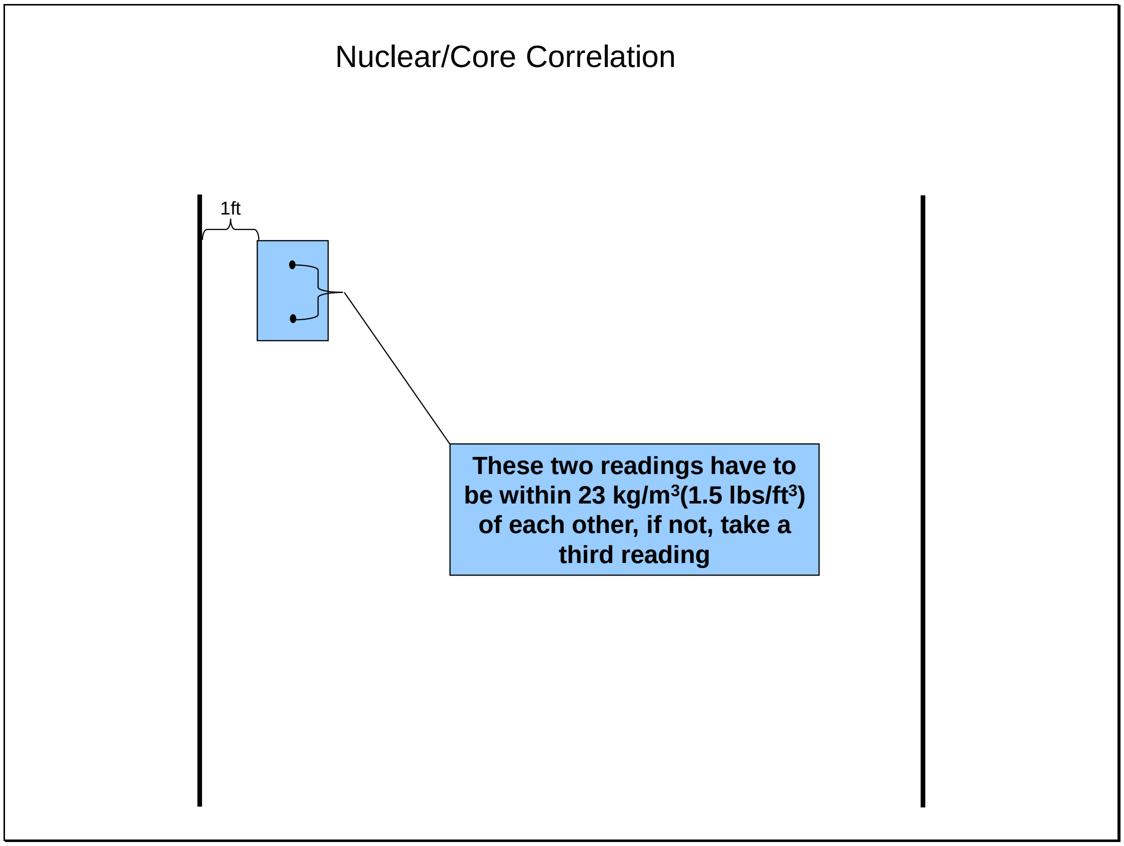
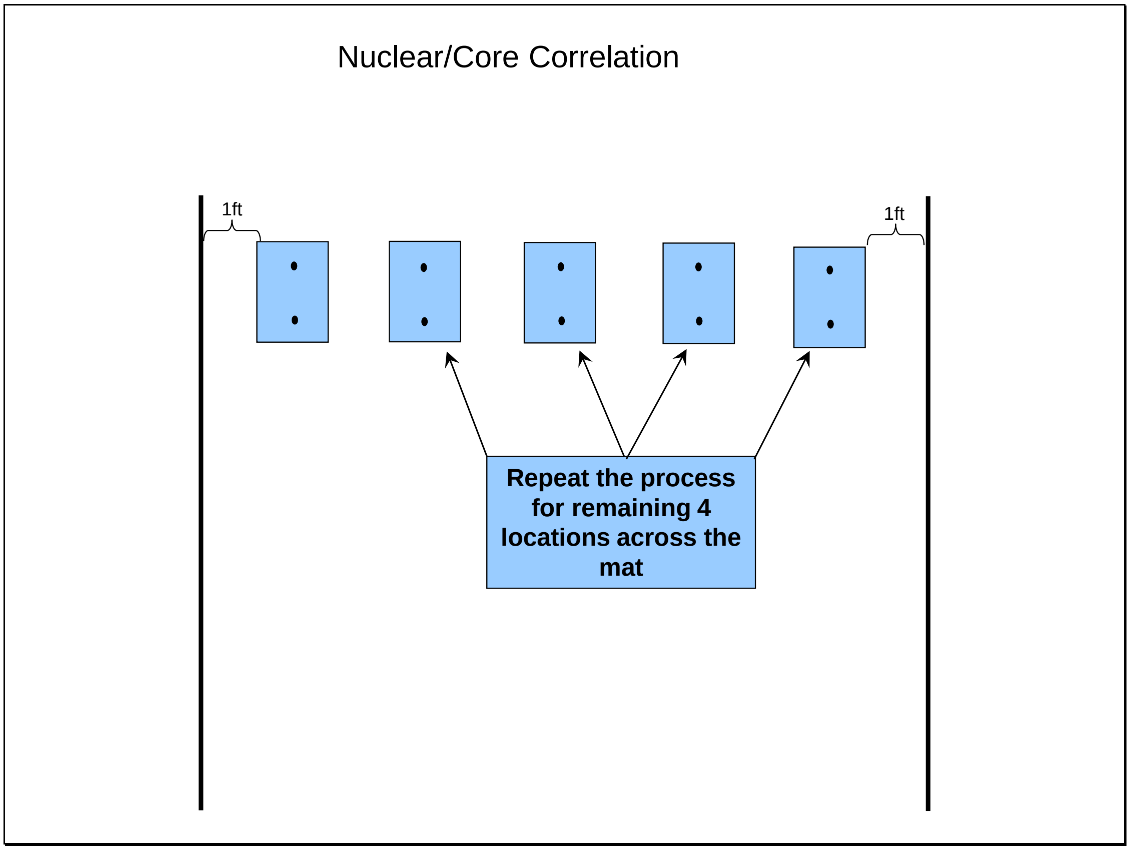
Completing a Nuclear Core Correlation During Test Strip

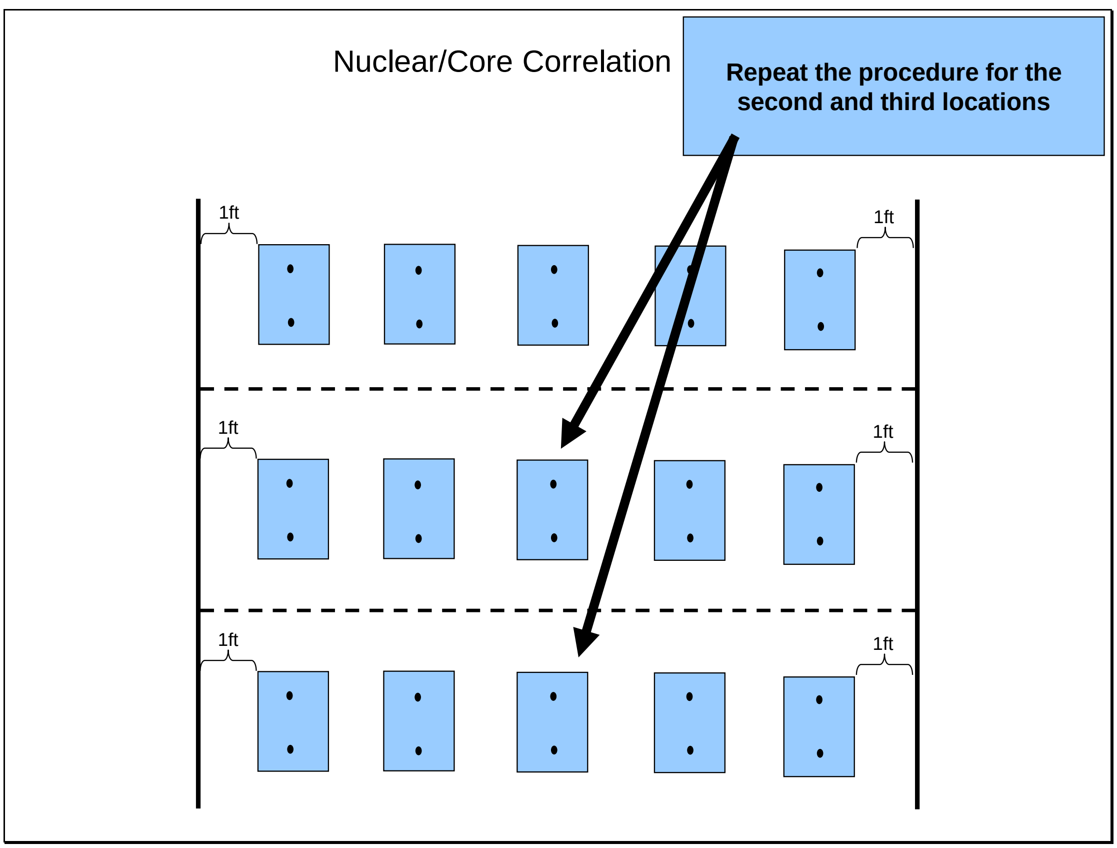


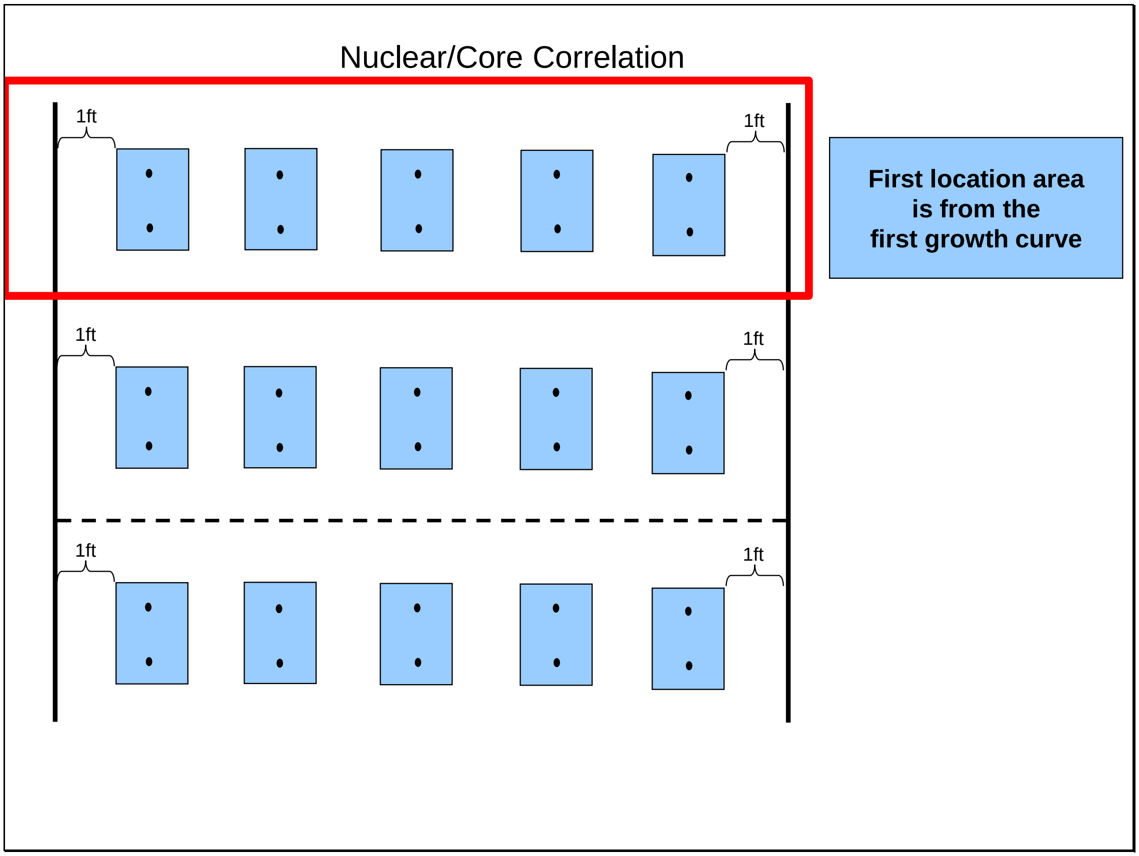

Nuclear/Core Correlation
1ft
Turn 180° & take second reading

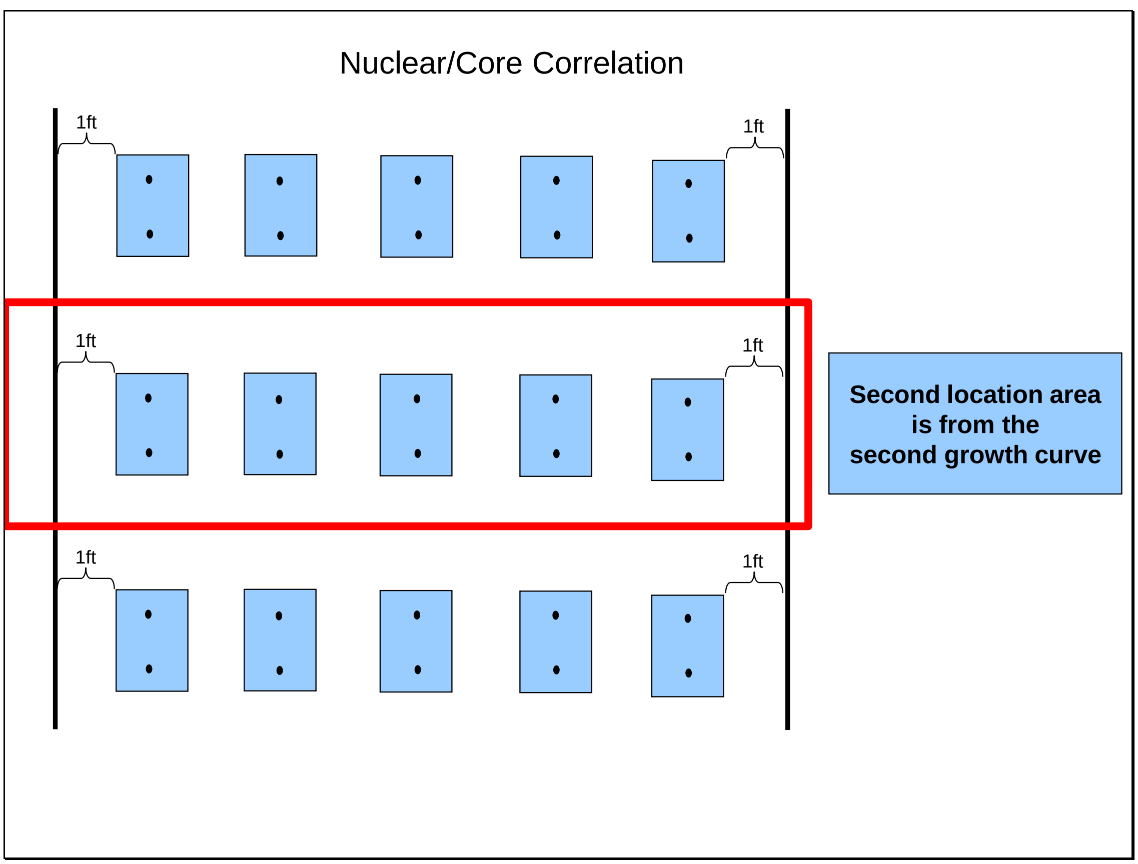

Nuclear/Core Correlation
1ft
These two readings have to be within 23 kg/m³(1.5 lbs/ft³) of each other, if not, take a third reading

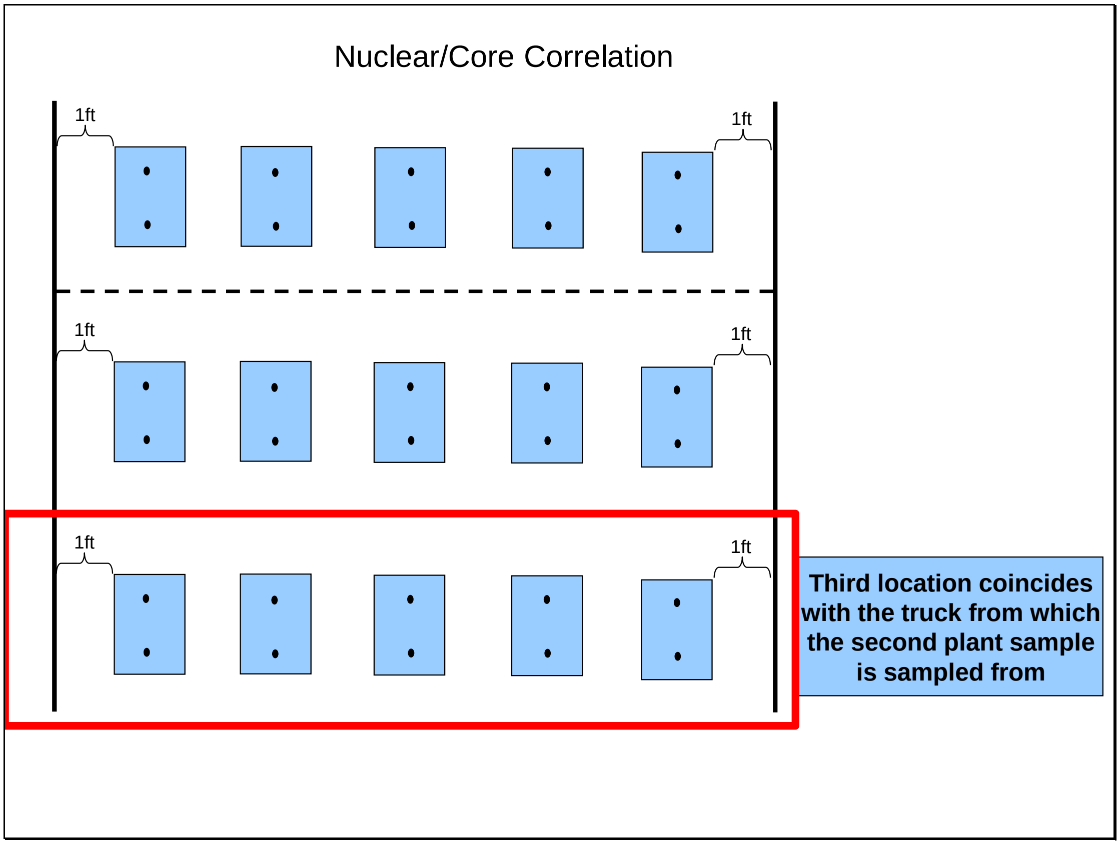

The direction of the gauge is up to the technician for the third measurement

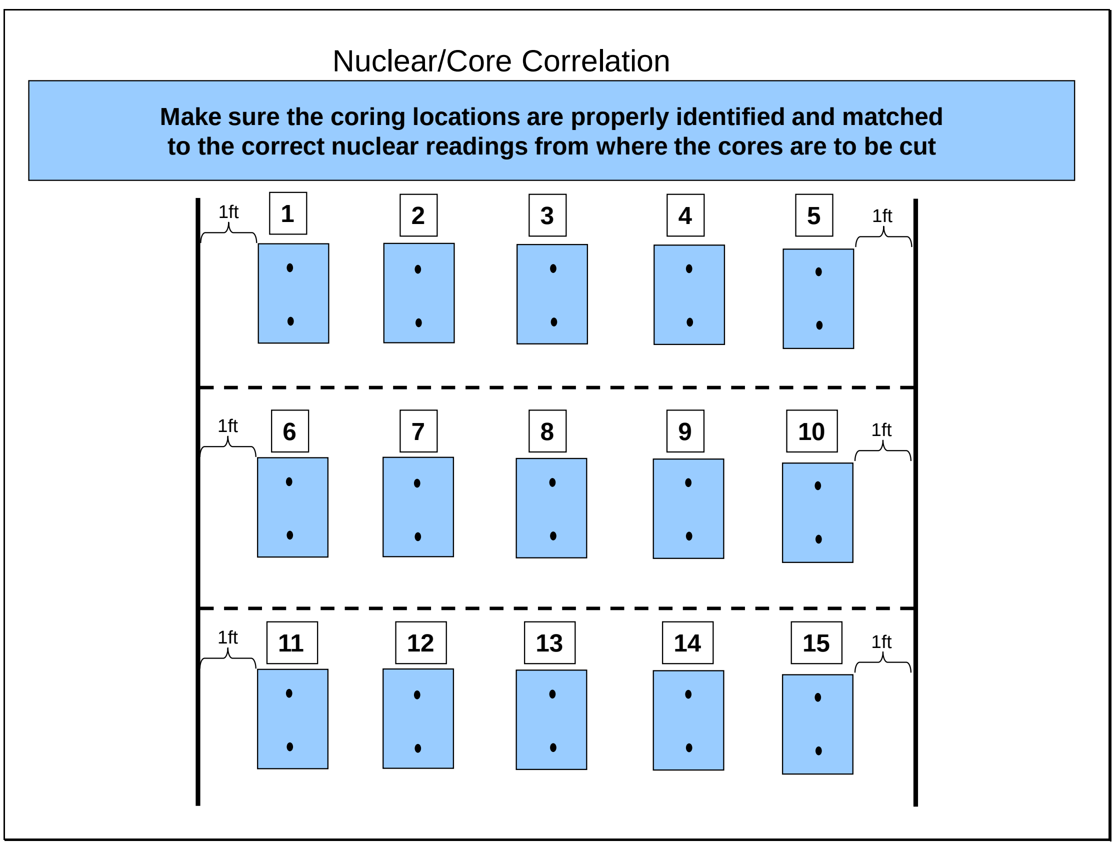

Nuclear/Core Correlation
1ft
1ft
Repeat the process for remaining 4 locations across the mat

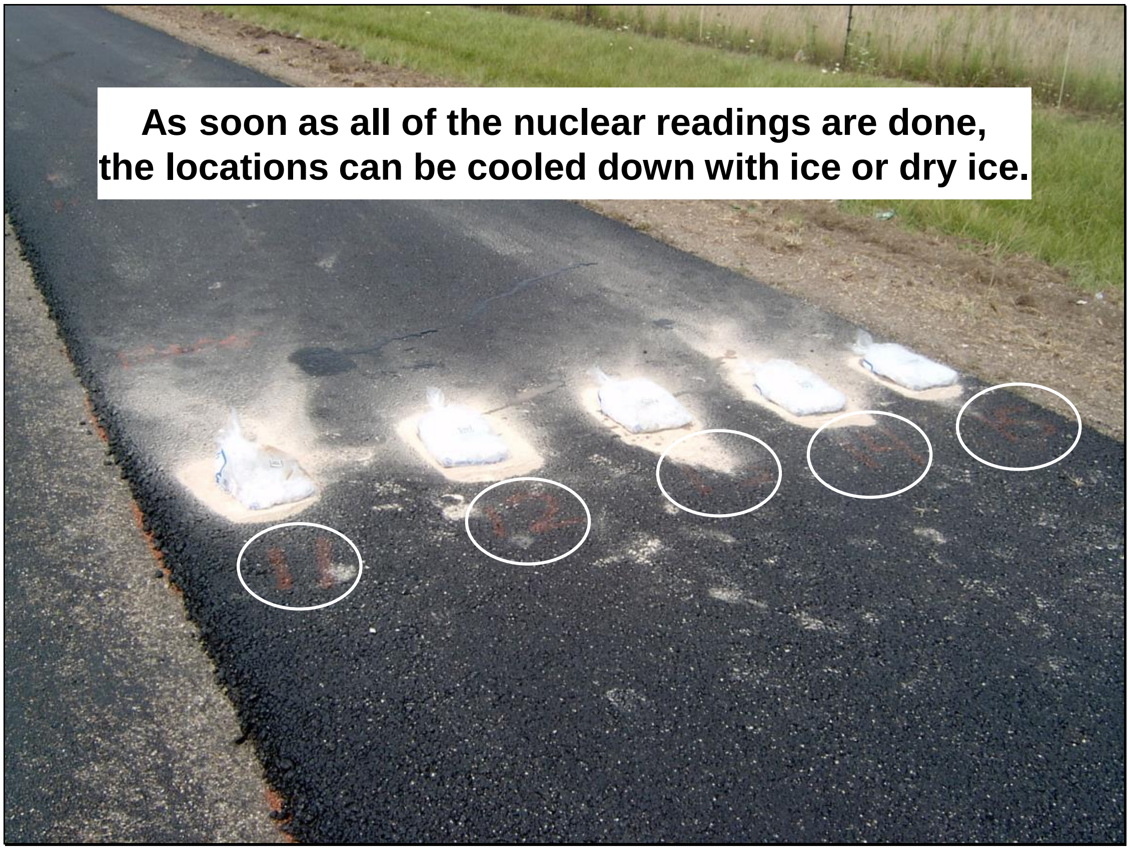

Nuclear/Core Correlation
Repeat the procedure for the second and third locations
1ft
1ft
1ft
1ft
1ft
1ft

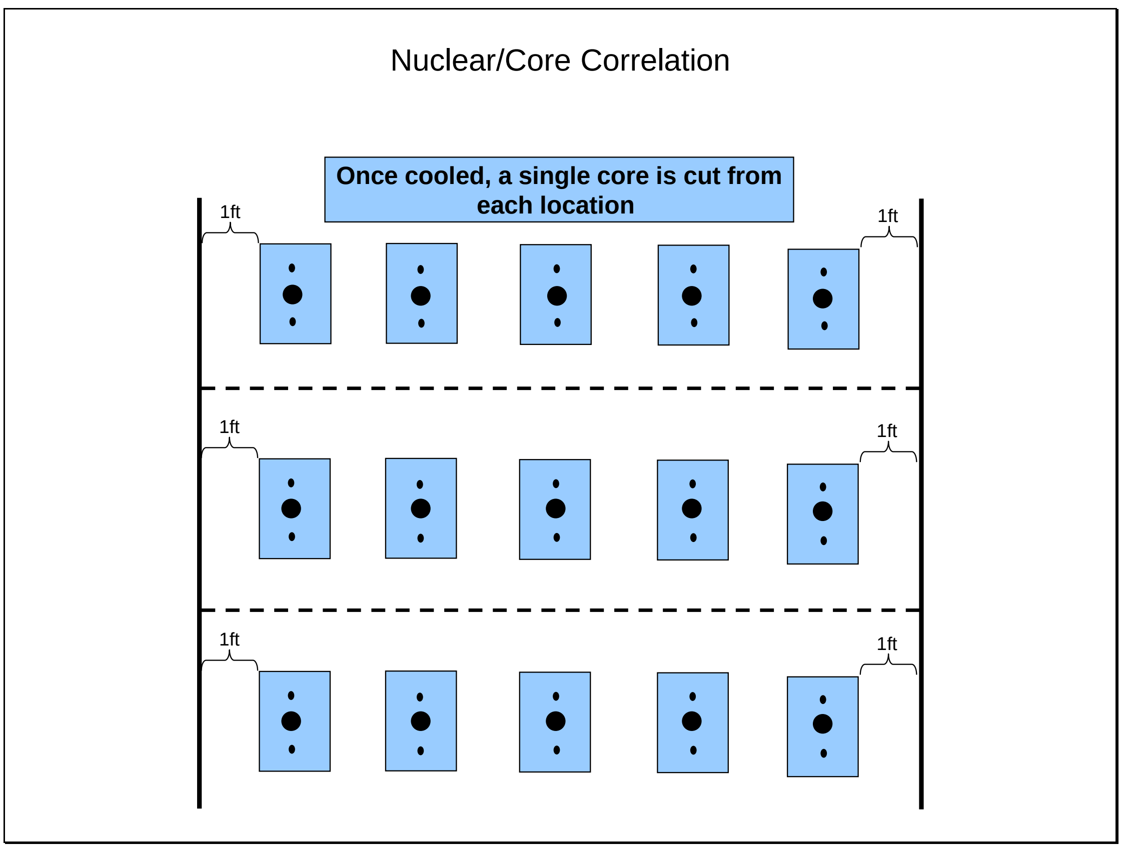

Nuclear/Core Correlation
1ft
1ft
First location area
is from the
first growth curve


Nuclear/Core Correlation
1ft
1ft
Second location area
is from the
second growth curve

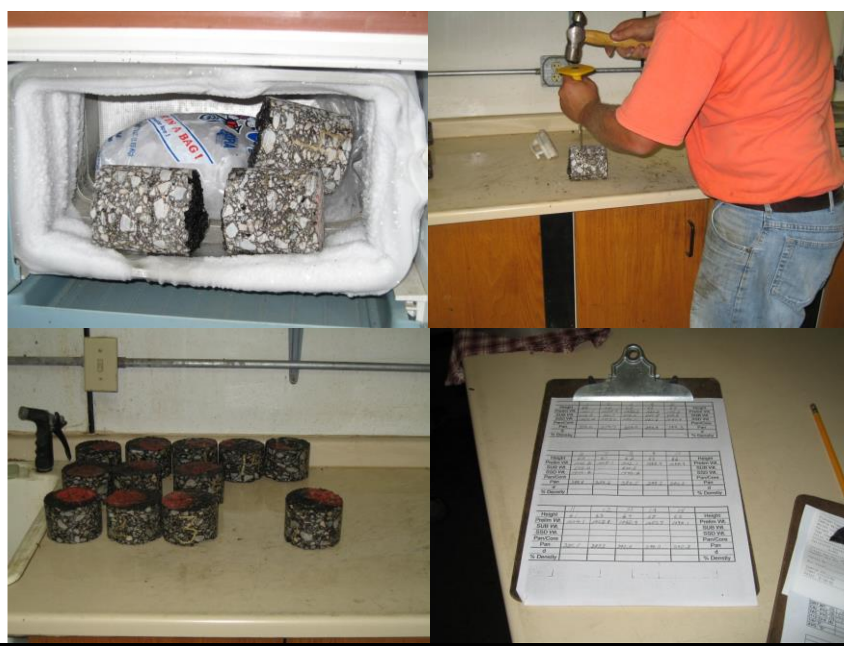

Nuclear/Core Correlation
1ft
1ft
1ft
1ft
1ft
1ft
Third location coincides with the truck from which the second plant sample is sampled from


Nuclear/Core Correlation
Make sure the coring locations are properly identified and matched to the correct nuclear readings from where the cores are to be cut
1ft
1
2
3
4
5
1ft
1ft
6
7
8
9
10
1ft
1ft
11
12
13
14
15
1ft


As soon as all of the nuclear readings are done,
the locations can be cooled down with ice or dry ice.
11
12


Nuclear/Core Correlation
Once cooled, a single core is cut from each location
1ft
1ft
1ft
1ft
1ft
1ft

Lab Work – Running Core Densities



Lab Work – Running Core Densities

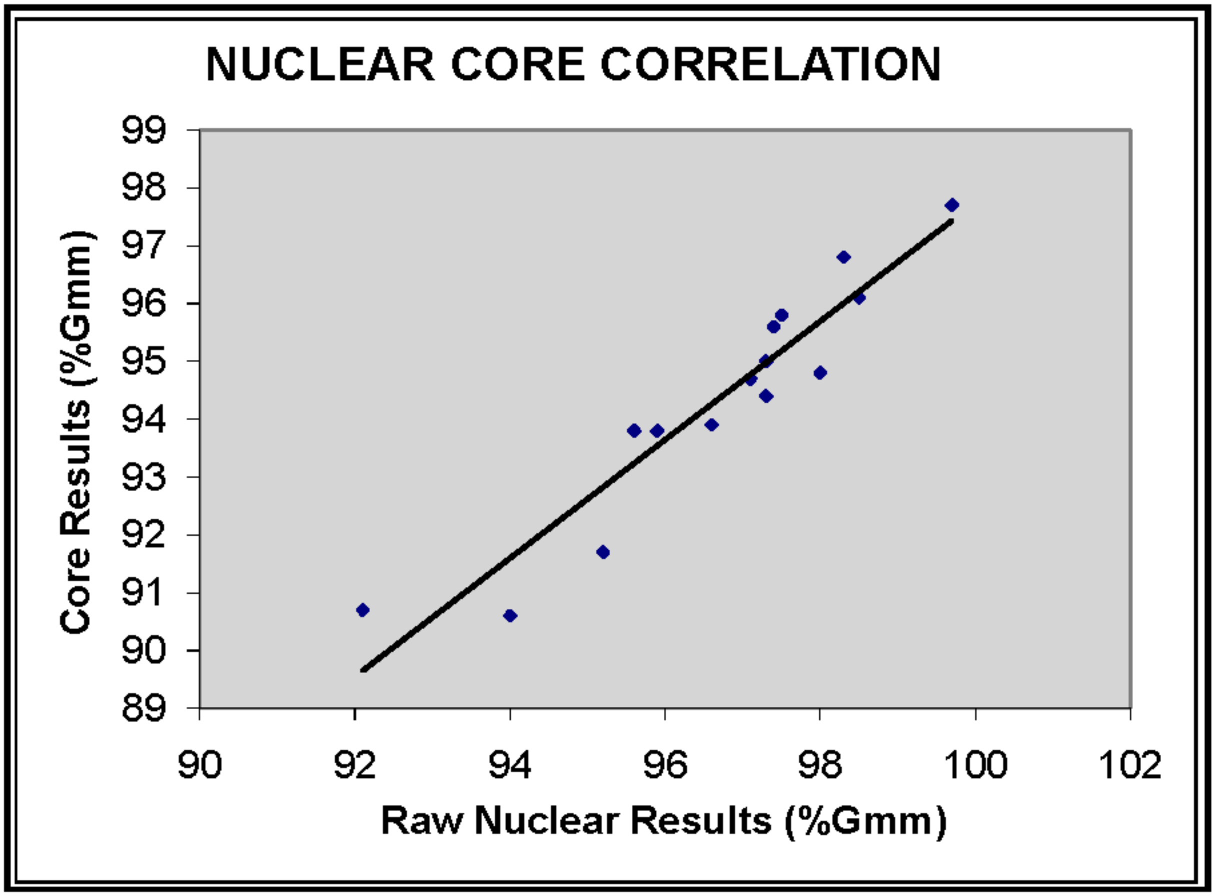


Lab Work – Running Core Densities



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.:	C9701418
Contract No.:	74226
RE:	M. Weidner
Material Code:	19523MR-9.5
Material Desc.:	BIT CONC SCS N70 C REC
Field Mix #:	87BIT1010
Test Date:	07/19/2018
Base Material:	Milled Surface
Lift Number:	.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:	C9701419
Contract No.:	74226
RE:	M. Weidner

Material Code:	19523 -9.5
Material Desc:	BIT CONC SCS N70 C REC
Field Mix #:	87BIT1019
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

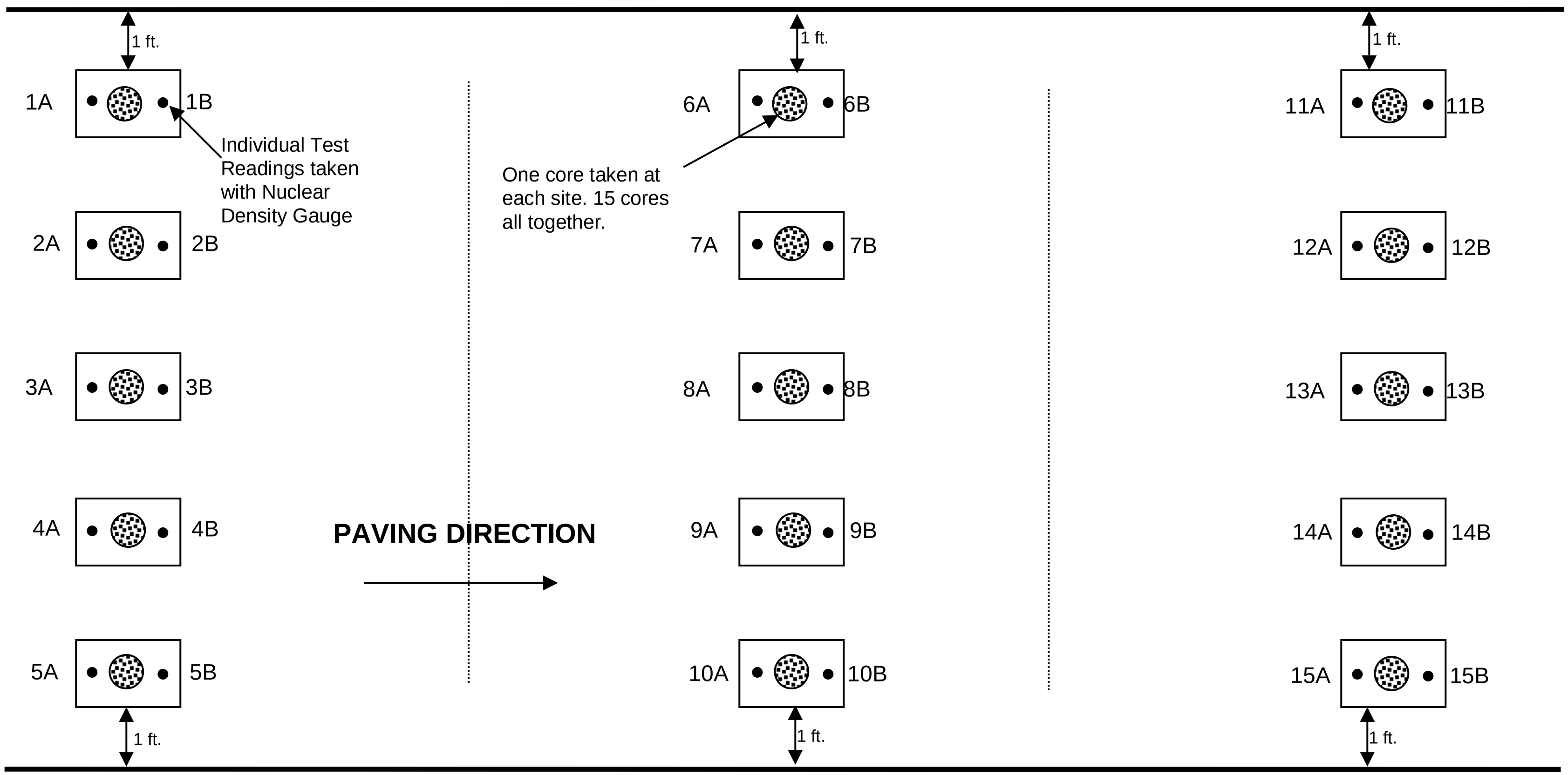
EXAMPLE OF COMPLETED NUCLEAR CORE CORRELATION

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.

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.

(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.

See Example of Determination of Random Density Test Site Locations on following page.

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.

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.

<u>Calculation to determine the number of station locations</u>

- ________________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? _______________

<u>Calculate the length of the partial unit</u>

- ________________ X _________________ = ________________ feet.
  (partial unit length in decimal form) (frequency of tests in feet) (length of partial unit)

2. Calculate the stations for the required tests.

1 mile =________ feet ½ mile = _________ feet 1 Station = 100 feet = 1 +00

If the beginning station is 2+00 for the days paving, calculate the beginning and ending stations for each area.

________ (Length of Area 1)	________ (Length of Area 2)	________ (Length of Area 3)	________ (Length of Area 4)
Area 1	Area 2	Area 3	Area 4

_____+_____ _____+______ ______+_____ ______+_____ ______+_____

Area 1 __________ × ______feet = _________feet
(Random) (Length) (Dist into Area)

__________feet +_____________feet =______________=Sta_____________
(Dist into Area) (Beg Sta of Area in feet) (Total feet)

Area 2 __________ × ______feet = _________feet
(Random) (Length) (Dist into Area)

__________feet +_____________feet =______________= Sta_____________
(Dist into Area) (Beg Sta of Area in feet) (Total feet)

Area 3 __________ × ______feet = _________feet
(Random) (Length) (Dist into Area)

__________fee t+ _____________feet =______________= Sta_____________
(Dist into Area) (Beg Sta of Area in feet) (Total feet)

Area 4 __________ × ______feet = _________feet
(Random) (Length) (Dist into Area)

__________feet +_____________feet =______________= Sta_____________
(Dist into Area) (Beg Sta of Area in feet) (Total feet)

Notes:

1) See next page 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 and revised April 1, 2016.

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

HOT-MIX ASPHALT - DENSITY TESTING OF LONGITUDINAL JOINTS (BDE)

Effective: January 1, 2010
Revised: August 1, 2018

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.
>
> When a longitudinal joint sealant (LJS) is applied, longitudinal joint density testing will not be required on the joint(s) sealed."

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

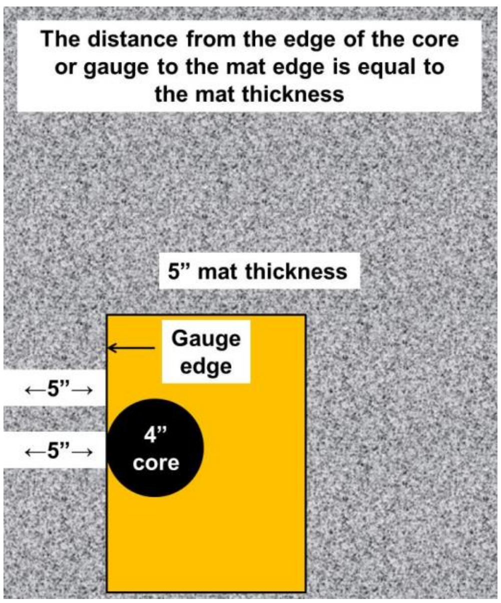
This table replaces the table on page 78.

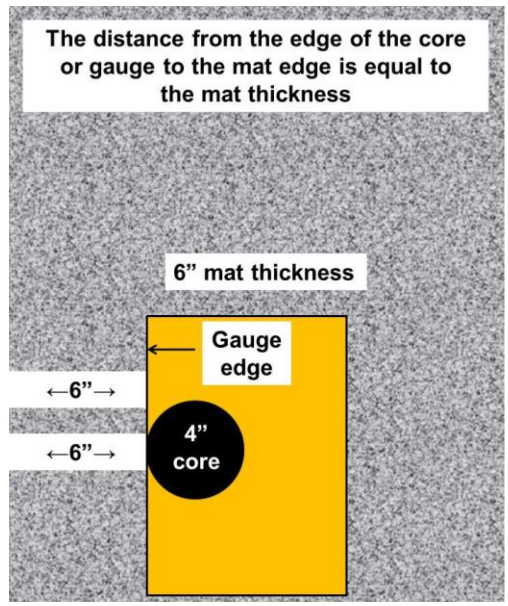
New Nuclear Density Test Site Locations Specification

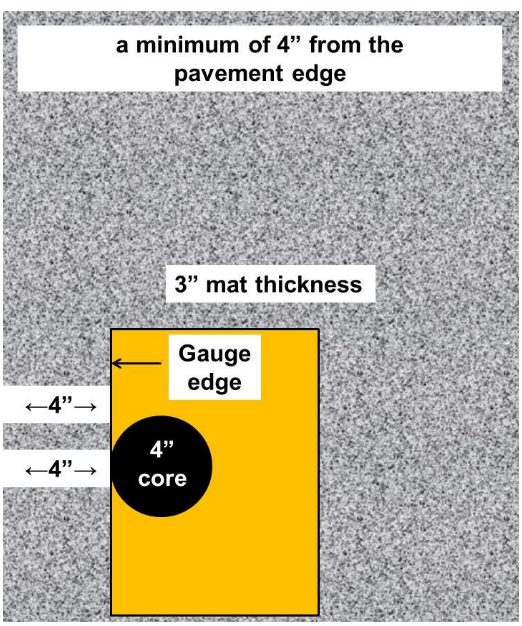
Random Test Determination Layout

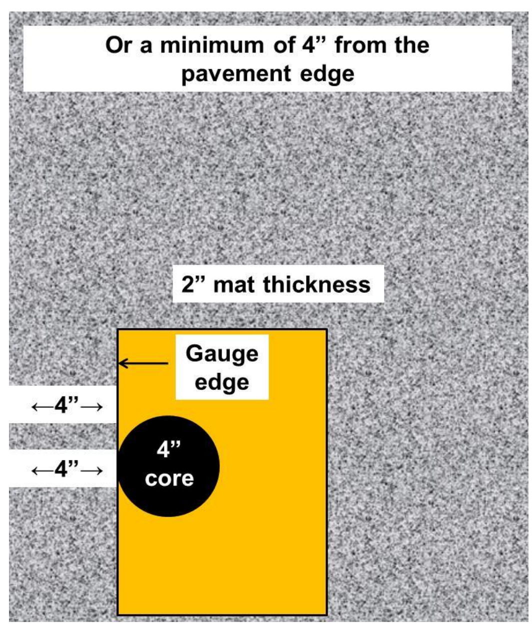
Nuclear density testing will be completed by cutting cores or using a correlated nuclear density gauge at random locations provided by the contractor or IDOT inspector. Density testing will include determinations diagonally across the center of the mat and longitudinally on the outside edges. The layout configuration and density control limits at each test location is dependent upon whether the lifts of HMA being placed have confined (typically an inlay) or unconfined edges.

All nuclear density longitudinal test determinations, confined or unconfined, will be located at 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:





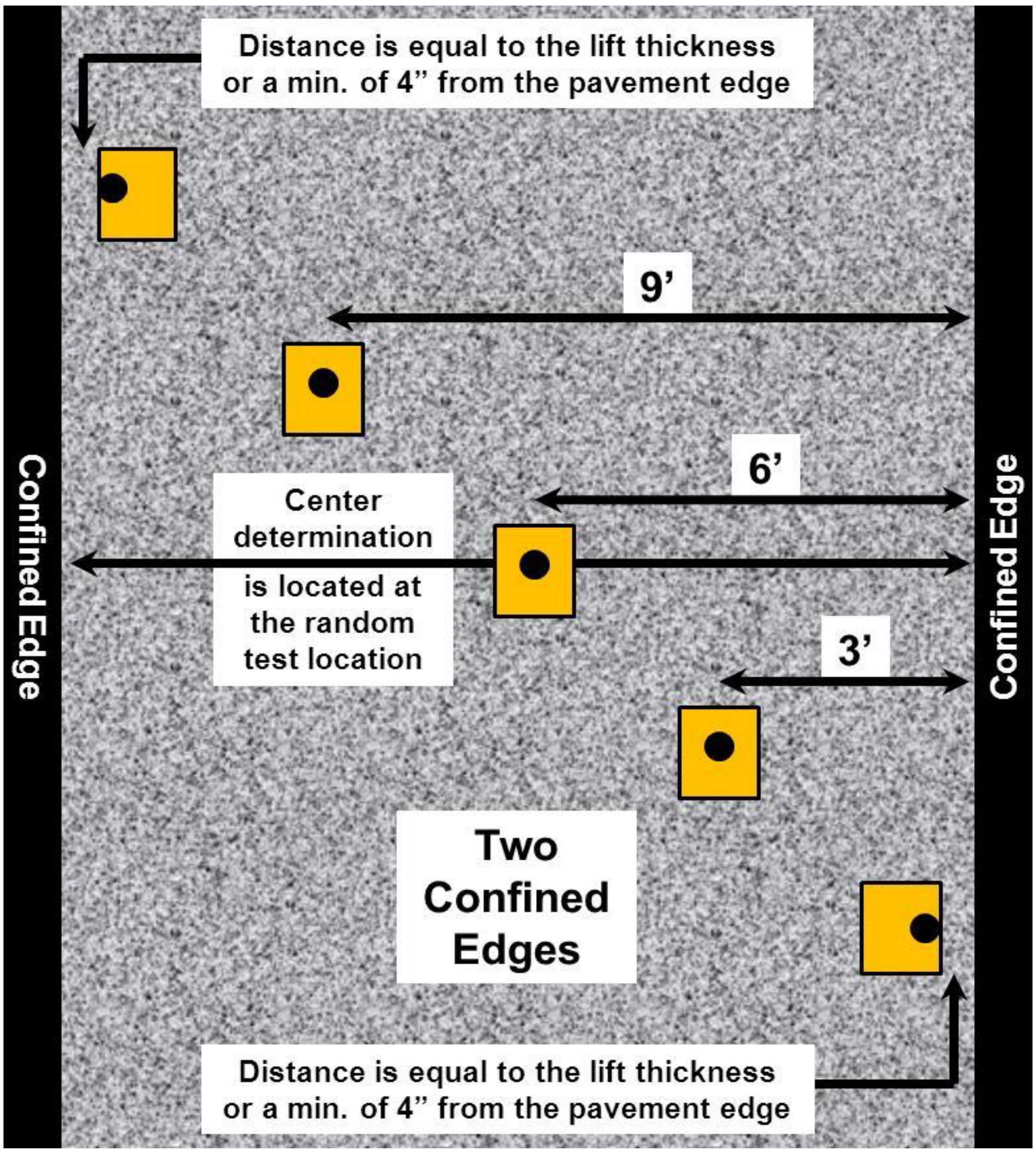




Random Test Determination Layout for Two Confined Edges (Inlay)

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 average 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.

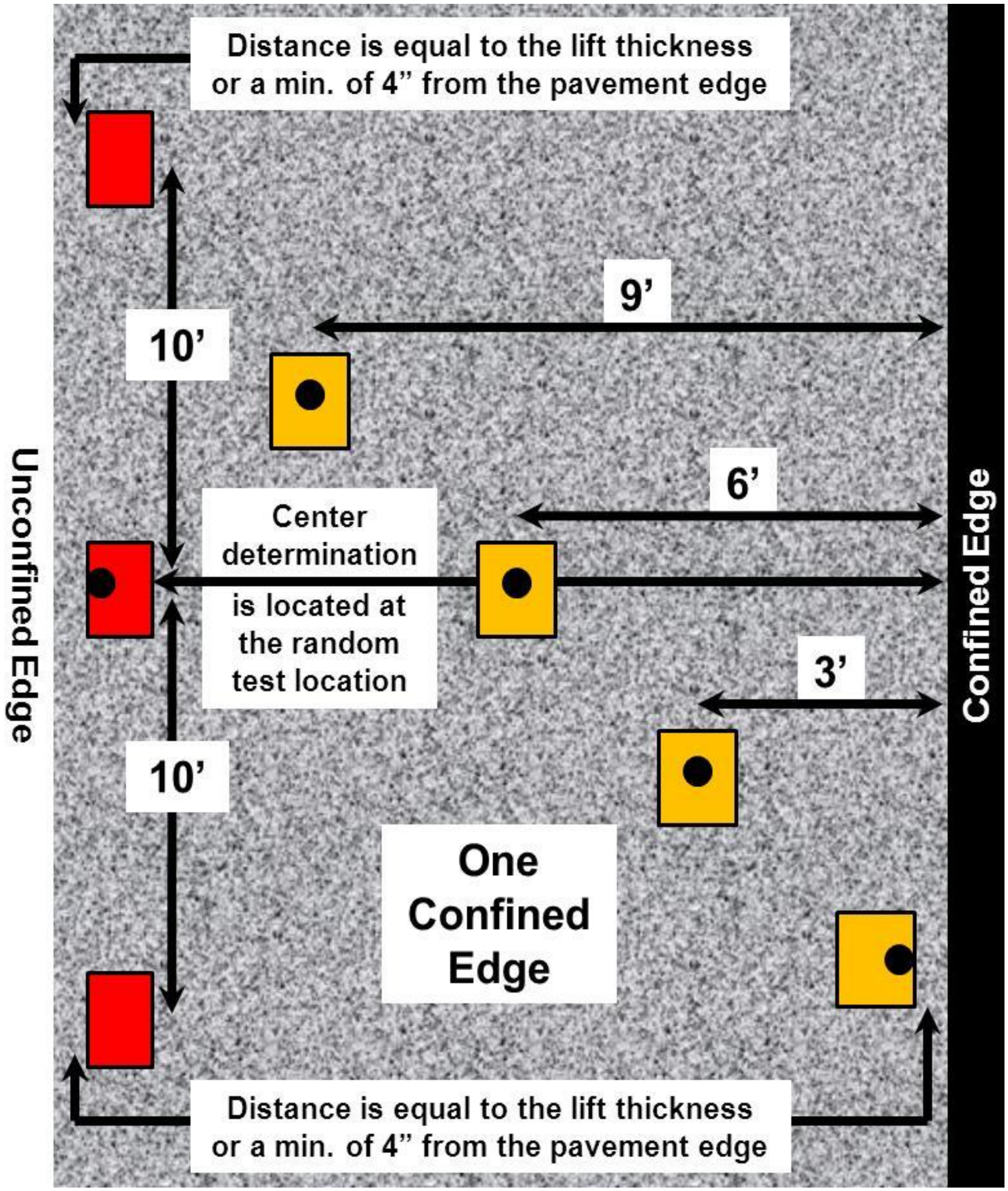
2. When testing with a nuclear density gauge, a total of three determinations will be taken longitudinally along the unconfined edge of the pavement at the required layout locations.

   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.

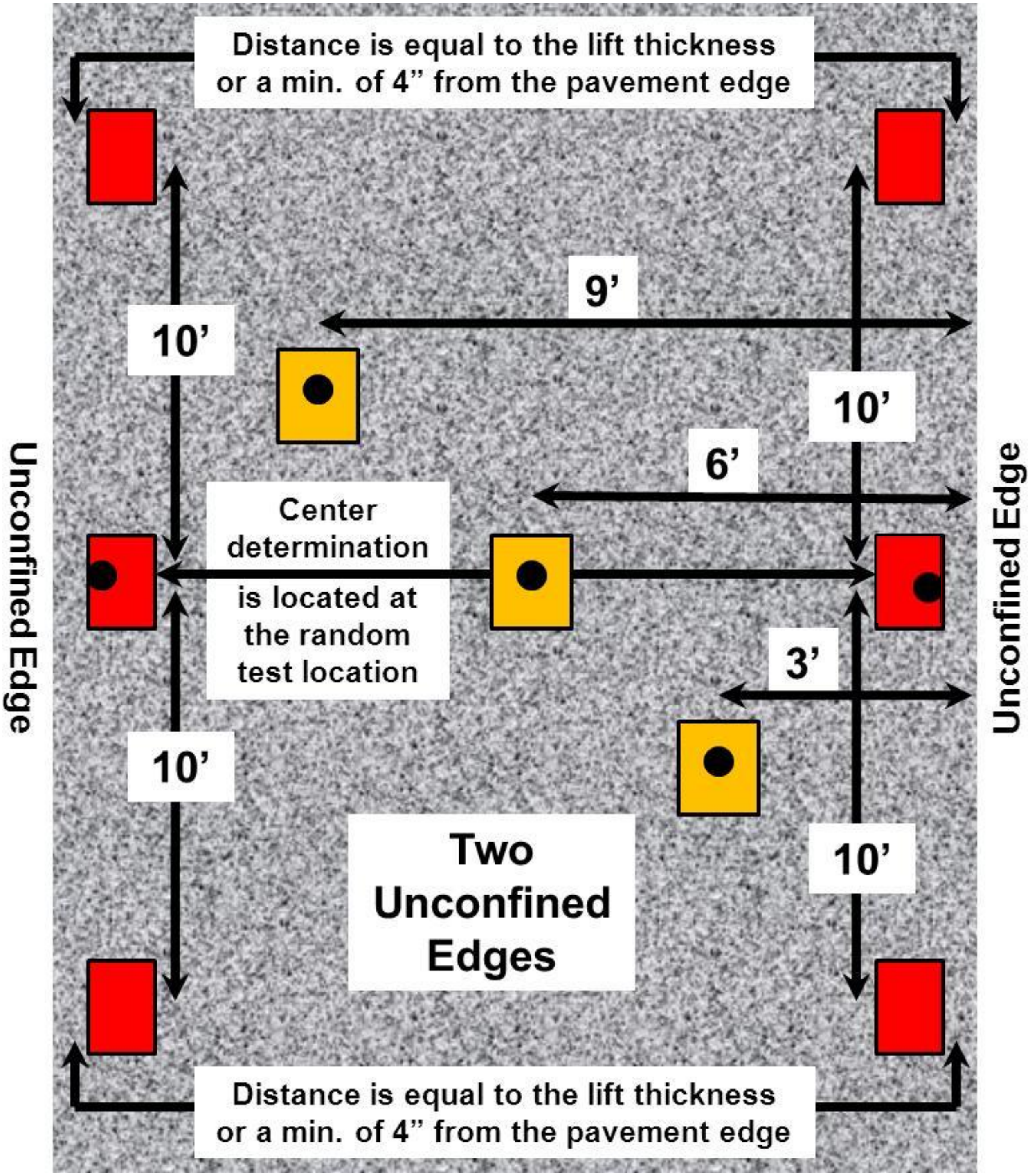
2. When testing with a nuclear density gauge, a total of three determinations will be taken longitudinally along each unconfined edge of the pavement at the required layout locations.

   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'
Unconfined Edge
Unconfined Edge
Center determination is located at the random test location
3'
10'
10'
Two Unconfined Edges
Distance is equal to the lift thickness or a min. of 4" from the pavement edge

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.

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.

"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. (9.5 mm) 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.

(a.) 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 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 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 noncompliance, 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.

1030.08 Transportation. Vehicles used in transporting HMA shall have clean and tight beds. The beds shall be sprayed with asphalt release agents from the Department's approved list. In lieu of a release agent, the Contractor may use a light spray of water with a light scatter of manufactured sand (FA 20 or FA 21) evenly distributed over the bed of the vehicle. After spraying, the bed of the vehicle shall be in a completely raised position and it shall remain in this position until all excess asphalt release agent or water has been drained.

When the air temperature is below 60 °F (15 °C), the bed, including the end, endgate, sides and bottom shall be insulated with fiberboard, plywood, or other approved insulating material and shall have a thickness of not less than 3/4 in. (20 mm). When the insulation is placed inside the bed, the insulation shall be covered with sheet steel approved by the Engineer. Each vehicle shall be equipped with a cover of canvas or other suitable material meeting the approval of the Engineer which shall be used if any one of the following conditions is present.

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

(b) The weather is inclement.

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

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

Illinois Department of Transportation

Memorandum

To: Regional Engineers

From: Jack A. Elston

Subject: Special Provision for Hot-Mix Asphalt – Pay for Performance Using Percent Within Limits – Jobsite Sampling

Date: July 26, 2019

This special provision was developed to provide a method of constructing hot-mix asphalt pavements utilizing pay adjustments based on percent within limits statistical calculations. It has been revised to incorporate the IL-9.5FG and SMA 9.5 mixture compositions and to eliminate references to leveling binder.

This special provision should be inserted into interstate, freeway and expressway resurfacing and full-depth projects having a minimum quantity of 8000 tons (7260 metric tons) per mix. Pay for performance may be considered for smaller projects where a more accurate measure of quality is desired. This special provision should not be used on:

1. Incidental surfacing (e.g. driveways, entrances, minor sideroads, and sideroad returns)
2. Temporary pavements
3. Shoulders unless they are used as auxiliary lanes
4. Patching
5. Turn lanes less than 500 ft (150 m) in length
6. Shared-use paths or bike lanes unless paved with the mainline pavement

The districts should include the BDE Check Sheet marked with the applicable special provisions for the November 8, 2019 and subsequent lettings. The Project Coordination and Implementation Section will include a copy in the contract.

This special provision will be available on the transfer directory July 26, 2019.

80347m

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

Effective: November 1, 2014
Revised: July 2, 2019

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 and the special provision, "Hot-Mix Asphalt Binder and Surface Course" 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, IL-9.5FG, IL-4.75	90.0 – 98.0 %
	SMA 12.5, SMA 9.5	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 [1/]	
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

1/ When a longitudinal joint sealant (LJS) is applied, the additional pay adjustments for unconfined edge density will not apply to the joint(s) sealed.

80347

Illinois Department of Transportation

Memorandum

To:	Regional Engineers
From:	Jack A. Elston
Subject:	Special Provision for Hot-Mix Asphalt – Quality Control for Performance
Date:	July 26, 2019

This special provision was developed 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 incorporate the IL-9.5FG and SMA 9.5 mixture compositions and to eliminate references to leveling binder.

This special provision should be inserted into HMA contracts utilizing the QCP quality management program.

QCP should be used for the following.

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.

QCP should NOT be used for the following.

1. Incidental surfacing, driveways, entrances, minor sideroads, sideroad returns, etc.
2. Patching.
3. Turn lanes less than 500 ft (150 m) in length.
4. Temporary pavement.
5. Shared-use paths or bike lanes unless paved with the mainline pavement.

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 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 8, 2019 and subsequent lettings. The Project Coordination and Implementation Section will include a copy in the contract.

This special provision will be available on the transfer directory July 26, 2019.

80383m

Pay For Performance (PFP) Specifications

HOT MIX ASPHALT – QUALITY CONTROL FOR PERFORMANCE (BDE)

Effective: April 1, 2017
Revised: July 2, 2019

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 and the special provision, "Hot-Mix Asphalt Binder and Surface Course" 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 initial 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 and QCP 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 the QA results for a sublot meet the precision limits listed in Table 3, the QA results will be defined as the final mixture QA results for that sublot. If QA results for a sublot 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 and will be defined as the final mixture QA results for that sublot.

If the final mixture QA results for the random sublot do not meet the 100 percent sublot pay factor limits or do not compare to QC results within the precision limits in Table 3, the Engineer will test all split sublot 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-19.0, IL-9.5, IL-9.5FG, IL-4.75	90.0 – 98.0%
	SMA 12.5, SMA 9.5	92.0 – 98.0%
Dust / AC Ratio		0.4 – 1.6 2/

1/ Based on minimum required VMA from mix design

2/ Does not apply to SMA.

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

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
$0.6 \le X \le 1.2$	$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.

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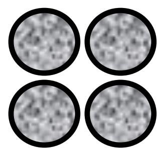
Density Requirements for cores for PFP and QCP

PFP (> 8000 tons) – Density Requirements

- Lift thickness equal to or less than 3 in. every 0.2 miles (320 m) or 1056 ft.
- Lift thickness greater than 3 in. every 0.1 miles (160 m) or 528 ft.

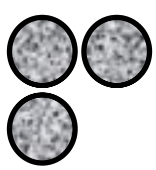
Four cores are taken at the designated random site determined by the Engineer. (1 for District, 1 for Contractor, 1 for backup and 1 for dispute)



QCP (1200 - 8000 tons) – Density Requirements

- Lift thickness equal to or less than 3 in. every 0.2 miles (320 m) or 1056 ft.
- Lift thickness greater than 3 in. every 0.1 miles (160 m) or 528 ft.

Three cores are taken at the designated random site determined by the Engineer. (1 for District, 1 for Contractor, 1 for backup)



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NUCLEAR DENSITY

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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/m^3 (100 pcf) or greater, with 15% or less moisture. The bottom of the gauge and the top of the reference block must be clean. The gauge must be situated between the raised edges, and with the control panel end of the gauge firmly against the metal butt plate.

(3) Run Standard Count - Once gauge is in position on reference block, remove padlock from the handle and 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

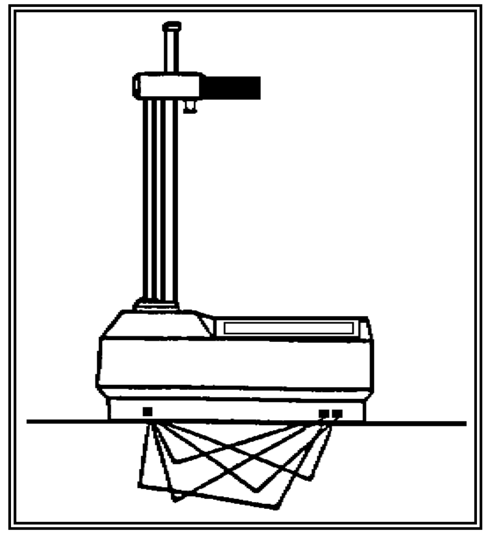
(1) Selecting Count Time - Most nuclear density gauges will allow the time for *test counts* to be set for 15 seconds, 1 minute, or 4 minutes. The confidence level of the gauge is affected by the length of time a *test count* is run. A 15 second *test count* will only provide a 37% confidence level. 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.

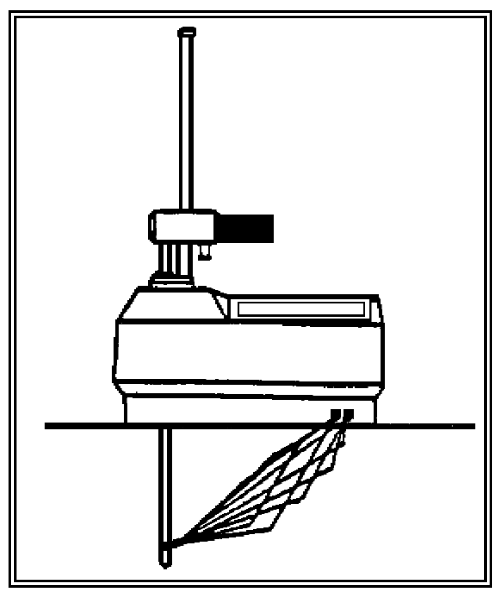
This method involves placing the density gauge on the surface and lowering the probe so that is resting on the material to be tested. The probe does not penetrate the surface of the material.



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 71 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 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 WD 40, gasoline, kerosene, and diesel fuel. Contact gauge manufacturer for specific cleaning procedures.

It is important, to use proper safety equipment and procedures to minimize exposure to toxic cleaning solvents, and radiation. Begin by tipping the gauge on its side with the bottom facing away. Reach around with one hand and wipe the bottom of the gauge clean with a cleaning rag and solvent. Remove the bottom plate with a screwdriver.***** Wipe plate and scraper ring (mounted in the plate) clean. Remove the sliding tungsten shield (spring loaded block)*. With tungsten shield removed, clean the open cavity, and inspect the tip of the source rod.***** If the tip of the source rod is contaminated, with anything other than grease, lower the source rod into the cavity just far enough to allow the tip to be cleaned.

***** It is recommended to use a mirror to minimize exposure to radiation, when cleaning bottom plate, the open cavity, or the tip of the source rod.
To reassemble gauge, make sure the source rod is retracted into the safe position. Install the sliding tungsten block with angled side up. Replace bottom plate.
Caution: Do not over-tighten screws in the aluminum base.

CORRELATION

Density results from a nuclear gauge are relative. If an approximation of core densities is required, a correlation must be developed to convert nuclear density to core density. Refer to the Department's "Standard Test Method For Correlating Nuclear Gauge Densities With Core Densities", for correlation requirements and procedure for correlating nuclear gauge densities with core densities.

TEST SITES

Density tests must be performed at random locations according to the Department's "Determination of Random Density Test Site Locations".

REPORT FORM AND INSTRUCTIONS

Upon the completion of a nuclear density test, complete the Quality Assurance Nuclear Density Report QC/QA form herein.

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,
19512	Binder	IL 19.0	N50	Ndesign <90
19513	Surface	C	N50	93.0% - 97.4%
19514	Surface	D	N50	
19515	Surface	E	N50	IL-9.5 & IL 9.5L,
19516	Surface	F	N50	Ndesign <90
19522	Binder	IL 19.0	N70	92.5% - 97.4%
19523	Surface	C	N70	
19524	Surface	D	N70	IL-19.0,
19525	Surface	E	N70	Ndesign = 90
19526	Surface	F	N70	93.0% - 96.0%
19532	Binder	IL 19.0	N90	
19533	Surface	C	N90	IL-9.5,
19534	Surface	D	N90	Ndesign = 90
19535	Surface	E	N90	92.0% - 96.0%
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 -9.5
Material Desc:	BIT CONC SCS N70 C REC
Field Mix #:	87BIT1019
Lift Number:	.1

Route:	IL 32
Section:	(1,2) RS-3
County:	Moultrie
Job No:	C9701419
Contract No.:	74226
RE:	M. Weidner

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

Field Worksheet

DATE:	**09/12/2019**			
CONTRACT:	**74226**		**Gauge #**	**28769**
JOB #:	**C9701419**		**Layer Thickness**	**2.5”**
ROUTE:	**IL 32**		**Gmm**	**2.444**
BASE MATERIAL:	**Milled Surface**	(milled, binder, aggregate)		
MIX #:	**87BIT1019**		**Nuclear**	
MIX CODE:	**19523**		**Densities**	
USE:	**Surface**	(surf., 1st lift binder...)		

Reading 1

STATION: **17+21**

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 ________ 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 ________ 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)

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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 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: 040812 for April 8, 2012

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 material.
For example, take G_{mm} * 1000 * 0.930 for a material code of 19522 with Ndesign of 70.

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. **WORKSHEET:** This sheet may be used to do the required calculations; otherwise, actual calculations must accompany completed form.

34. **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.

35. **COPIES:** Distribution of copies: District, Resident Engineer, Contractor

36. **TESTER:** Producer and IDOT use signature of the person doing the testing

37. **AGENCY:** Tester's employer (contractor/consultant/IDOT).

38. **INSPECTOR:** Producer use signature of the person responsible for quality control. IDOT use tester's supervisors signature, or leave blank.

39. **AGENCY:** Producer use inspectors employer (contractors or consultant name)

    IDOT leave blank

ATTACHMENT "A"
MISTIC CODE REFERENCE SHEET

LABORATORY LOCATIONS	LAB CODES
PRODUCER PLANT SITE LABORATORY	PP
PRODUCER NON-PLANT SITE LABORATORY	PL
PRODUCER CONSTRUCTION SITE	PC **(Nuclear Density)**
PRODUCER QUARRY LABORATORY	PQ
INDEPENDENT PLANT SITE LABORATORY	IP
INDEPENDENT NON-PLANT SITE LABORATORY	IL
INDEPENDENT CONSTRUCTION SITE	IC **(Nuclear Density)**
INDEPENDENT QUARRY LABORATORY	IQ
IDOT PLANT SITE LABORATORY	FP
IDOT CONSTRUCTION SITE	FC **(Nuclear Density)**
IDOT QUARRY LABORATORY	FQ
DISTRICT LABORATORY	DI
DISTRICT SATELLITE LABORATORY	DS
CENTRAL BUREAU MIXTURE LABORATORY	BM (50 RESP LOC ONLY)
CENTRAL BUREAU CHEMICAL LABORATORY	BC (50 RESP LOC ONLY)
CENTRAL BUREAU AGGREGATE LABORATORY	AG (50 RESP LOC ONLY)

"TYPE TEST"

PRELIMINARY (PRIOR TO PRODUCTION) TEST (To be used on start-up nuclear density [use type equipment code N] and core test results that are used for correlation.)	**PRE**
CONTRACTOR/CONSULTANT PROCESS CONTROL TEST	**PRO**
IDOT ASSURANCE TEST	**IND**
CONSULTANT PERFORMING IDOT ASSURANCE TEST	**IND**
SPECIAL IDOT INVESTIGATIVE TEST	**INV**

RESAMPLE OF FAILED TEST SAME AS ORIGINAL (PRO, IND)

DO NOT USE "RES"

"SAMPLED BY"

PRODUCERS: USE DISTRICT DESIGNATION THEN 0000000
EXAMPLE: DISTRICT 4 PRODUCER = 940000000

IDOT: USE SOCIAL SECURITY NUMBER

LOCAL AGENCY: USE 9 PLUS DISTRICT NUMBER FILLED
EXAMPLE: DISTRICT 3 LOCAL AGENCY = 933333333

CONSULTANTS: USE TAX NUMBER (left justified, right filled with zeros)
EXAMPLE: 123450000 FOR TAX NUMBER 12345

“TYPE EQUIPMENT”

FOR DENSITY:	**CORES**	**C**
	NUCLEAR GAUGE DETERMINATION	**N**
	ADJUSTED NUCLEAR DETERMINATINO	**A**
MARSHALL/AC	**REFLEX EXTRACTION**	**R**
	VACUUM EXTRACTION	**V**
	MARSHALL AND NUCLEAR AC OR NUCLEAR AC ONLY	**N**
	MARSHALL TESTS ONLY	**X**

“SAMPLED FROM”

STOCKPILE	**SP**	**PRODUCTION**	**PR**
COLD FEED	**CF**	**ON BELT (STOPPED)**	**OB**
HOT BIN	**HB**	**BELT STREAM**	**BE**
TRUCK	**TK**	**RAIL CAR**	**CR**
ROAD	**RD**	**BARGE**	**BR**
TRUCK DUMP	**TD**	**BIN/SILO**	**SI**

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Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised Date: 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.
	  ○ One "individual test result" representing the average of four density readings across the mat, including the one confined edge and excluding the unconfined edge density readings.
	  ○ One "individual test result" representing the average of three density readings on the unconfined edge.
	• If two unconfined edges are present, three "individual test" results shall be reported for each density test location.
	  ○ One "individual test result" representing the average of three density readings across the mat, excluding the unconfined edge density readings.
	  ○ One "individual test result" representing the average of three density readings on the unconfined edge.
	  ○ One "individual test result" representing the average of three density readings on the opposite unconfined edge.
	
	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/ft³].[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

PFP and QCP Random Density Procedure
Appendix E.3

Effective: April 1, 2009
Revised: August 1, 2018

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 1.0 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 or cold joints between lanes, the **paving lane** is defined as the total combined width of the lanes paved in that single pass. If the **paving lane** width is greater than 20 ft, 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).

Longitudinal Location: 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.

Transverse Offset: Determine the random transverse offset as follows:

1. PFP. The effective lane width of the paving lane 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.) The effective lane width is reduced by 1.0 ft for each confined longitudinal joint with longitudinal joint sealant (LJS) (i.e. If a 12.0 ft wide paved lane has one confined edge with LJS and one confined edge with LJS, the effective lane with 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.

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Effective: April 1, 2009
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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 is unconfined or located immediately above LJS, 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 without LJS 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.

2. QCP. The entire width of the paving lane shall be used in calculating the transverse offset in all cases except those with LJS applied at the longitudinal joint. If the LJS is applied, the effective lane width is reduced 1.0 ft for each longitudinal joint with LJS. If the left edge is located immediately above LJS, it will be omitted by adding 1.0 ft to the calculated transverse offset measurement. No offset movement is to be used for random locations that lie within 1.0 ft from an unconfined edge without LJS. Cores taken within 1.0 ft from an unconfined edge without LJS 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

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Effective: April 1, 2009
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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 without LJS and the right edge unconfined with LJS. 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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Appendix E.3

Effective: April 1, 2009
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The random locations for the first mile measured from the beginning of the lot and the left (confined) edge of the paved mat to the near edge of the core barrel 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 with LJS and the right edge unconfined without LJS. 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 minus 1.0 ft for the left edge confined with LJS (13.0 ft).

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Appendix E.3

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The random locations for the first mile measured from the beginning of the lot and the left (confined) edge of the paved mat to the near edge of the core barrel are as follows:

Core #	Longitudinal Location	Cumulative Distance	Transverse Location
1	1056 x 0.904 = 955 ft	1056 x (1-1) + 955 = 955 ft	(12.0 x 0.007) + 1.0 = 1.1 ft
2	1056 x 0.231 = 244 ft	1056 x (2-1) + 244 = 1300 ft	(12.0 x 0.059) + 1.0 = 1.7 ft
3	1056 x 0.517 = 546 ft	1056 x (3-1) + 546 = 2658 ft	(12.0 x 0.996) + 1.0 = 13.0 ft = **12.7 ft**[1/]
4	1056 x 0.253 = 267 ft	1056 x (4-1) + 267 = 3435 ft	(12.0 x 0.515) + 1.0 = 7.2 ft
5	1056 x 0.040 = 42 ft	1056 x (5-1) + 42 = 4266 ft	(12.0 x 0.101) + 1.0 = 2.2 ft

1/ The 13.0 ft offset for Core #3 was moved 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

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Appendix E.3

Effective: April 1, 2009
Revised: August 1, 2018

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.