Nuclear Density Tester Course

LAKE LAND COLLEGE

2024-2025

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 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 10, 2025, the last date to retest is August 29, 2025.)** 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

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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.)

Specification Contents

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

MoTP = Manual of Test Procedures
BDE = BDE Special Provisions

This Page Is Reserved

SECTION 1030. HOT-MIX ASPHALT

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

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

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

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

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

1030.02 Materials. Materials shall be according to the following.

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

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

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

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

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

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

1030.03 Equipment. Equipment shall be according to the following.

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

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

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

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

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

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

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

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

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

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

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

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

(d) Bureau of Materials Policy Memorandums.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

(d) Additional Contractor and Department Duties.

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

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

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

(a) Definitions.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

2/ Does not apply to SMA.

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

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

(a) Definitions.

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

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

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

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

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

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

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

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

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

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

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

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

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

When establishing the target density, the HMA maximum theoretical specific gravity (G_{mm}) will be based on the running average of four Department test results. Initial G_{mm} will 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 will be used.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

2/ Does not apply to SMA.

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

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

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

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

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

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

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

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

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

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Revised: December 1, 2021

Density quality control and verification tests shall be performed at random test locations based on the frequency specified in Article 1030.09 of the Standard Specifications. The random test locations shall be determined as follows:

1. By the Contractor for quality control using a nuclear density gauge at intervals as specified in 1030.09(b).

   A) The beginning station number shall be established daily and the estimated paving distance computed for the day's production. The total distance to be paved shall then be subdivided into density testing intervals. A minimum of one interval is required for each half day’s production.

      For patching, estimate the number of patches to be completed for each half of the day’s production.

   B) The length of each paving interval shall be multiplied by the three digit random number expressed as a decimal from the "Random Numbers" table on the following page or from the Department's Quality Management Program (QMP) Package. The number obtained shall be added to the beginning station number for the interval to determine the longitudinal test location. This process shall be repeated for the subsequent intervals for the day's production using new random numbers to identify each test location.

      The remaining partial length of paving at the end of each day shall be treated as an interval with the test location determined by multiplying the partial distance by the next random number.

      For patching, multiply each of the estimated half day’s production of patches by the three digit random number. If necessary, round these numbers up to the next whole number. The numbers obtained shall be the patches that shall be tested, starting the count over at each half day’s production.

   C) Nuclear density test sites shall be equally positioned five (5) across all paved mat widths. The outer test sites shall be 4 in. (100 mm) from the edges of the mat. When LJS has been used, the outer test site shall be adjusted in 1 ft (300 mm).

      For patching, only a single test site centered in the randomly selected patch shall be tested.

   D) The average of all nuclear density readings at each location shall be reported on the Department’s MI 303N QC Nuclear Density Report form.

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2. By the Engineer for verification testing using cores or a nuclear density gauge as specified in 1030.09(h). The test location will be the center of the core or nuclear density gauge.

   A) Prior to paving or patching, the random test locations for density will be determined by the Engineer using the random numbers. The values are to be considered confidential and are not to be disclosed to anyone outside of the Department until finish rolling is complete. Once random test locations are determined by the Engineer, it may be necessary to alter the random test locations due to quantity adjustments, sequencing changes, or other alterations made by the Department or Contractor. The Engineer will document any changes to the random test locations.

   B) For all paving, each test location will be randomly determined longitudinally. For paving less than 3 ft (1 m) wide, the transverse location will be centered in the paving width. For paving wider than or equal to 3 ft (1 m), each test location will also be randomly determined transversely within each density testing interval. Each test location will be determined with two random numbers. The first random number is used to determine the longitudinal distance to the nearest 1.0 ft (300 mm) into the density testing interval. The second random number is used to determine the transverse offset to the nearest 0.1 ft (30 mm) from the left edge of the paving. The direction of the paving lane will be the same as the direction of the traffic.

      1) Longitudinal Location: Determine the random longitudinal location by multiplying the length of the prescribed density interval by the random number selected.

      2) Transverse Offset to Center of Core: For paving wider than or equal to 3 ft (1 m), determine the random transverse location by multiplying the width of the paving by the random number selected from the Random Numbers table or the Department's QMP Package. The effective lane width of the paving lane will be used in calculating the transverse offset. The effective lane width is determined by first subtracting 1.0 ft (300 mm) for each longitudinal joint with LJS from the entire lane width. The effective lane width is then reduced 4.0 in. (100 mm) for each joint that does not have LJS. The effective lane width is further reduced by 4.0 in. (100 mm) for the diameter of the core barrel.

         Effective lane width of pavement = pavement lane width – 1.0 ft (300 mm) for each edge with LJS – 4.0 in. (100 mm) for each edge without LJS – 4.0 in. (100 mm) for core barrel

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The transverse offset is determined by first multiplying the effective lane width by the selected random number. If the left edge is located immediately above LJS, 1.0 ft (300 mm) will be added to the calculated transverse offset measurement. If the left edge is confined but without LJS, 4.0 in. (100 mm) will be added to the calculated transverse offset measurement. An additional 2 in. (50 mm) will be added to the calculated transverse offset measurement to account for the distance from the edge of the core barrel to the center of core. The transverse offset is measured from the left physical edge of the paved lane to locate the center of the core on the pavement.

Transverse Offset to Center of Core = effective lane width x random number + 1.0 ft (300 mm) if left edge has LJS + 4.0 in. (100 mm) if left edge does not have LJS + 2.0 in. (50 mm) for core barrel

Density taken within 1.0 ft (300 mm) from an unconfined edge without LJS will have 2.0% added.

For patching, the random density locations will be determined based on the number of patches estimated for the project multiplied by a random number. If necessary, round any calculated fraction up to the next whole number. The test location will be centered in the patch.

C) The intervals used to determine the random locations for density verification are dependent on mixture use as specified in 1030.09(h).

D) This process shall be repeated for all density intervals on a given project.

E) Moving test locations.

There are two scenarios in which a random test location may be moved longitudinally using the same random transverse offset. The first scenario is to avoid only the obstacles listed in Case 1 below. The second scenario is to avoid pavement defects in the surface being overlaid as described in Case 2 below.

1) Case 1. In the event the random test location has an obstruction that will not allow the necessary compactive effort to be applied, the Engineer will adjust the longitudinal location of the density test in order to avoid the obstacle. Using the same random transverse offset, the test location will be moved longitudinally, ± 15 ft (5 m) to avoid the following obstacles only:

    a) Structures or Bridge Decks
    b) Detection loop or other pavement sensors
    c) Manholes or other utility appurtenances

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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 identify longitudinal locations where a defect is present. In the case of an asphalt scab (i.e. thin layer of less than 0.5 in. (12 mm) of asphalt pavement remaining after milling) the temporary markings shall show the extent or length of the defect. These pavement defect locations will be approved by the Engineer. If a random test location lands at the same longitudinal location as a temporary mark, the test location will be moved 5 ft (1.5 m) in the direction toward the paver at the same transverse offset.

F) Example Calculations for Identifying Density Verification Test Locations for QC/QA Paving and Patching Projects.

Example 1.

This example illustrates the determination of density verification test locations for a QC/QA overlay project.

Given: A mixture is to be paved as a 6.0 ft wide shoulder 3.5 in. thick for 1 mile with LJS placed at the pavement/shoulder joint.

This paving thickness will require a density testing interval of 0.2 miles. The shoulder consists of a 6.0 ft-wide mat with the left edge confined with LJS and the right edge unconfined without LJS. The random numbers selected for the longitudinal direction are: 0.904, 0.231, 0.517, 0.253, and 0.040. The random numbers for the transverse direction are: 0.003, 0.052, 0.998, 0.510 and 0.109.

The individual longitudinal density test interval distances can be converted to the cumulative random distance using the following equation:

$$CD_n = [D \times (n-1)] + R_n$$

Where:

n = the density interval number
CD = cumulative distance
D = density testing interval length (typically 1056 ft (0.2 mile))
R = random distance within the given density testing interval

The longitudinal locations are determined by multiplying the longitudinal random numbers by 1056 ft (0.2 mile). The transverse offsets are determined by multiplying the transverse random number by the width of the paving minus 1.0 ft for the left edge confined with LJS (5.0 ft).

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Determine the effective shoulder width by subtracting 1.0 ft for each edge with LJS and 4.0 in. (0.33 ft) for each edge without LJS from the 6.0 ft paved shoulder width. In this case the right edge of the shoulder is unconfined without LJS, so subtract 4.0 in. (0.33 ft), and the left edge is confined with LJS so subtract 1.0 ft. Then subtract 4.0 in. (0.33 ft) for the width of the core barrel.

Effective Shoulder Width = 6.0 ft - 1.0 ft - 0.33 ft – 0.33 ft = 4.34 ft

The calculated transverse offset distances are determined by multiplying the effective shoulder width of 4.34 ft by the random numbers and adding 1.0 ft for the left confined edge with LJS plus 2.0 in. (0.17 ft) for the core barrel (1.0 ft + 0.17 ft = 1.17 ft). The random locations for the first mile measured from the beginning of the lot and the left edge of the paved shoulder to the center of the core barrel are as follows:

Test Site #	Random Distance	Cumulative Distance	Center of Core Transverse Location 1/
1	1056 x 0.904 = 955 ft	1056 x (1-1) + 955 = 955 ft	(4.34 x 0.003) + 1.17 = 1.2 ft
2	1056 x 0.231 = 244 ft	1056 x (2-1) + 244 = 1300 ft	(4.34 x 0.052) + 1.17 = 1.4 ft
3	1056 x 0.517 = 546 ft	1056 x (3-1) + 546 = 2658 ft	(4.34 x 0.998) + 1.17 = 5.5 ft
4	1056 x 0.253 = 267 ft	1056 x (4-1) + 267 = 3435 ft	(4.34 x 0.510) + 1.17 = 3.4 ft
5	1056 x 0.040 = 42 ft	1056 x (5-1) + 42 = 4266 ft	(4.34 x 0.109) + 1.17 = 1.6 ft

1/ Transverse location of the center of the core measured from the left physical edge of the shoulder.

Example 2.

This example illustrates the determination of density verification test locations for a QC/QA widening project.

Given: A mixture is to be paved as a 2.0 ft wide shoulder 1.5 in. thick for 4 miles.

This paving width will require a density testing interval of 1 mile. The shoulder consists of a 2.0 ft wide mat with the left edge confined and the right edge unconfined. No LJS was used. The random numbers for the longitudinal direction are: 0.821, 0.345, 0.623 and 0.140. As the paving is less than 3 ft, the transverse location will be centered.

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The individual density test interval distances can be converted to the cumulative random distance using the following equation:

$$CD_n = [D \times (n-1)] + R_n$$

Where:

n = the density interval number
CD = cumulative distance
D = density testing interval length (1 mile)
R = random distance within the given density testing interval

The longitudinal locations are determined by multiplying the longitudinal random numbers by 5,280 ft (1 mile). The transverse offsets are determined by dividing the width of the paving in half (by 2).

The random locations measured from the beginning of shoulder paving and the left (confined) edge of the paved mat to the center of the nuclear gauge are as follows:

Test Site #	Random Distance	Cumulative Distance	Transverse Location
1	5280 x 0.821 = 4,335 ft	5280 x (1-1) + 4,335 = 4,335 ft	2.0 / 2 = 1.0 ft
2	5280 x 0.345 = 1,822 ft	5280 x (2-1) + 1,882 = 7,162 ft	2.0 / 2 = 1.0 ft
3	5280 x 0.623 = 3,289 ft	5280 x (3-1) + 3,289 = 13,849 ft	2.0 / 2 = 1.0 ft
4	5280 x 0.140 = 739 ft	5280 x (4-1) + 739 = 16,579 ft	2.0 / 2 = 1.0 ft

Example 3.

This example illustrates the determination of density verification test locations for a QC/QA patching project.

Given: On an 8 mile full-depth patching project it is estimated that 140 patches will be constructed.

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Patching projects require 1 nuclear density test for every 50 patches. The first random number is 0.289. The second is 0.760 and the third 0.444. The individual density test interval distance can be converted to the cumulative random patch using the following equation:

$$CP_n = [D \times (n-1)] + P_n$$

Where:

n = the density interval number
CP = cumulative patch
D = density testing interval (typically 50 patches)
P = random patch within the given density testing interval

The longitudinal locations are determined by multiplying the longitudinal random numbers by 50 patches or when less than 50 patches remain, the number of remaining patches. The test location is then centered in the identified patch.

Nuclear #	Random Patch[1]	Cumulative Patch	Transverse Location
1	50 x 0.289 = 15	50 x (1-1) + 15 = 15	Center of patch
2	50 x 0.760 = 38	50 x (2-1) + 38 = 88	Center of patch
3	40 x 0.444 = 18	50 x (3-1) + 18 = 118	Center of patch

1/ If necessary, round any calculated fraction up to the next whole number.

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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 QUALITY CONTROL RANDOM DENSITY LOCATIONS

Example: The Contractor is paving a distance of 1.6 miles today at a thickness of 2.5 inches.

1. **At what frequency will the Contractor take random tests?** ____________ ft.

Calculation to determine the number of station locations

- ________________ miles X 5280 ft/mile = _______________ feet.
  (distance to be paved) (distance to be paved in feet.)

- ________________ ÷ ________________ = ________________
  (dist. to be paved in feet) (frequency of tests in feet) (number of tests needed to the nearest tenth.)

- How many total tests will be needed? ________________

Calculate the length of the partial unit

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

2. Calculate the stations for the required tests.

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

If the beginning station is 1+50 for the days paving, calculate the beginning and ending stations for each area.

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

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

Area 1 __________ (Random) × ______ (Length) feet = _________ (Dist into Area) feet

__________ (Dist into Area) feet +______________ (Beg Sta of Area in feet) feet =_______________ (Total feet) =Sta______________

Area 2 __________ (Random) × ______ (Length) feet = _________ (Dist into Area) feet

__________ (Dist into Area) feet +______________ (Beg Sta of Area in feet) feet =_______________ (Total feet) = Sta______________

Area 3 __________ (Random) × ______ (Length) feet = _________ (Dist into Area) feet

__________ (Dist into Area) fee t+ ______________ (Beg Sta of Area in feet) feet =_______________ (Total feet) = Sta______________

Area 4 __________ (Random) × ______ (Length) feet = _________ (Dist into Area) feet

__________ (Dist into Area) feet +______________ (Beg Sta of Area in feet) feet =_______________ (Total feet) = Sta______________

Notes:

1) See page 30 for layout of random density test site locations with a nuclear gauge or cores on Hot-Mix Asphalt, which requires different configurations based on confined/unconfined longitudinal joints. Refer to Article 1030.09 Section (b) (1) Required Density Tests, Paving.

2) A failing nuclear density test requires a resample half way between the failed test and finish roller location.

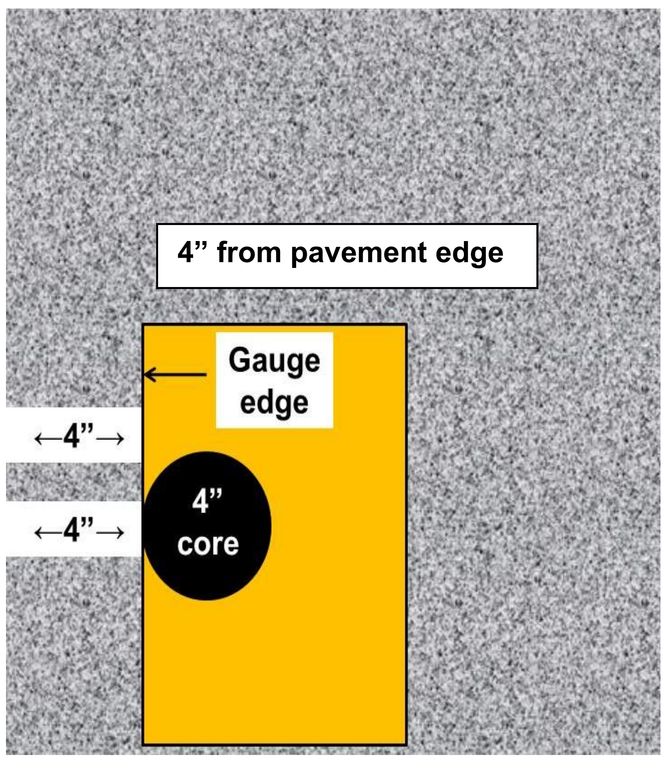
3) IDOT QC/QA software package will calculate the station locations or your random densities for you if you wish it to do so.

New Nuclear Density Test Site Locations Specification

Random Test Determination Layout

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

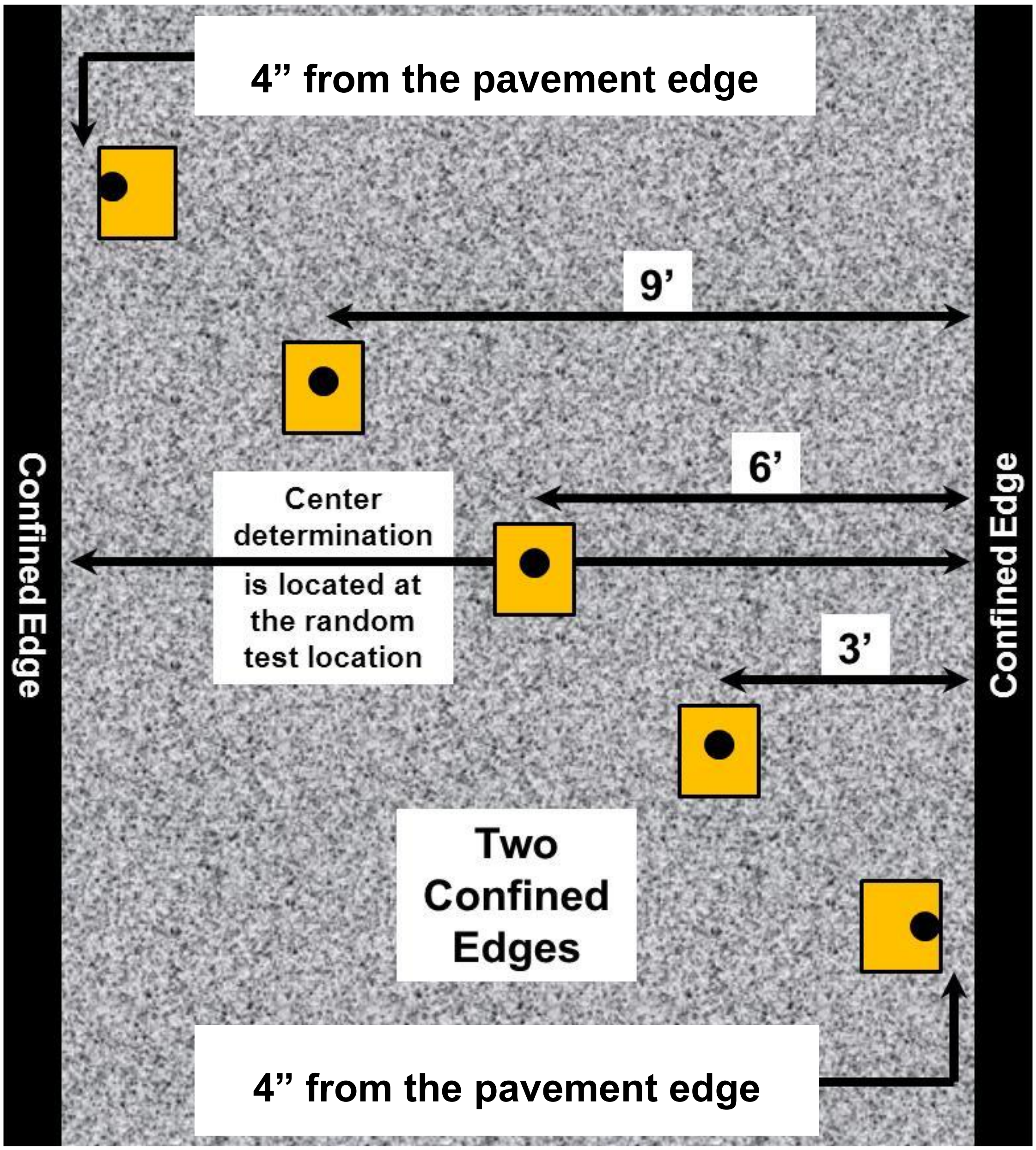
All nuclear density longitudinal test determinations, confined or unconfined, will be located at a distance equal to 4 in. (100 mm), from the edge of the nuclear density gauge or edge of the core from the pavement edge. See examples below:



Random Test Determination Layout for Two Confined Edges (Inlay)

When testing a random test location located in an inlay or in an area with two confined edges, a total of five determinations will be taken or five cores will be cut diagonally across the mat at the required layout locations. The results of all five determinations or cores are averaged to achieve one individual test which is required to meet the Density Control Limits for the mixture being tested.

A total of five nuclear density determinations will be taken or five cores will cut at this location. One density requirement is to be met in this situation.



Random Test Determination Layout for One Confined Edge

When testing a mat with one confined edge:

1. Either four determinations will be taken or four cores will be cut, diagonally across the mat, at the required layout locations on the side nearest to the confined edge.

   The results of these four nuclear density determinations or cut cores will be averaged to achieve one individual test result which is required to meet the Density Control Limits for the mixture being tested as an “Individual Test (includes confined edges)” specification.

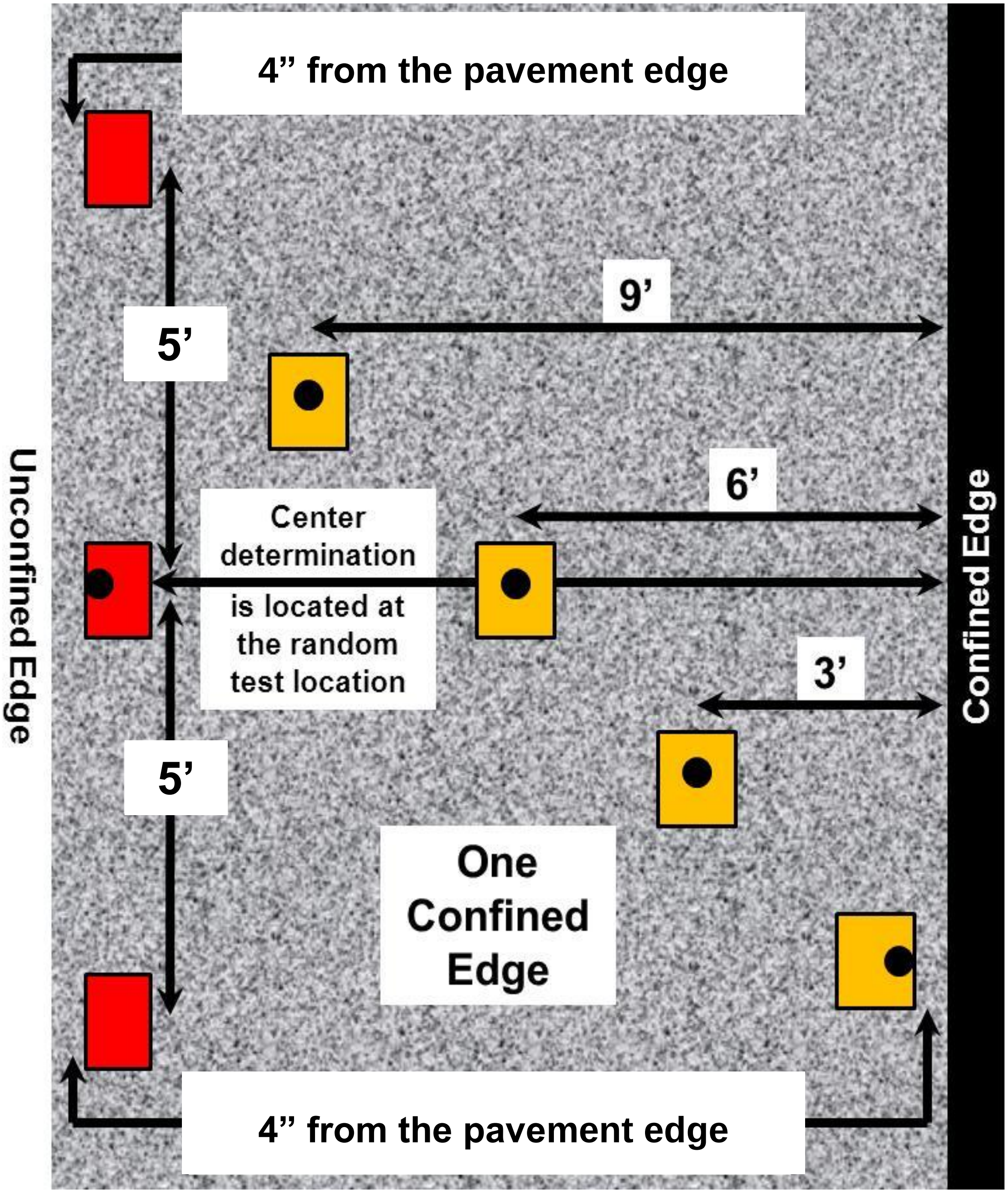
2. When testing with a nuclear density gauge, a total of three determinations will be taken longitudinally along the unconfined edge of the pavement at the required layout locations.

   The middle determination will be located at the random test location and the other two determinations will be spaced longitudinally apart in line with the middle determination at the required layout locations.

   The results of the three determinations will be averaged to achieve one individual test which is required to meet the Density Control Limits for the mixture being tested for as an “Unconfined Edge Joint Density Minimum” specification.

3. When cutting cores, a single core (the middle determination from #2) will be cut at the required layout location. This single core will be required to meet the density Control Limits for the mixture being tested for as an “Unconfined Edge Joint Density Minimum” specification.

A total of seven nuclear density determinations or five cores will be taken at this location. Two separate density requirements are to be met in this situation, one for the four confined locations and one the unconfined edge.


4" from the pavement edge
9'
5'
6'
Unconfined Edge
Center determination is located at the random test location
Confined Edge
3'
5'
One Confined Edge
4" from the pavement edge

Random Test Determination Layout for Two Unconfined Edges

When testing a mat with two unconfined edges:

1. Either three nuclear density determinations will be taken or three cores will be cut, diagonally, at the required layout locations in the center of the mat.

   The results of these three nuclear density determinations or cut cores will be averaged to achieve one individual test result which is required to meet the Density Control Limits for the mixture being tested as an "Individual Test (includes confined edges)" specification.

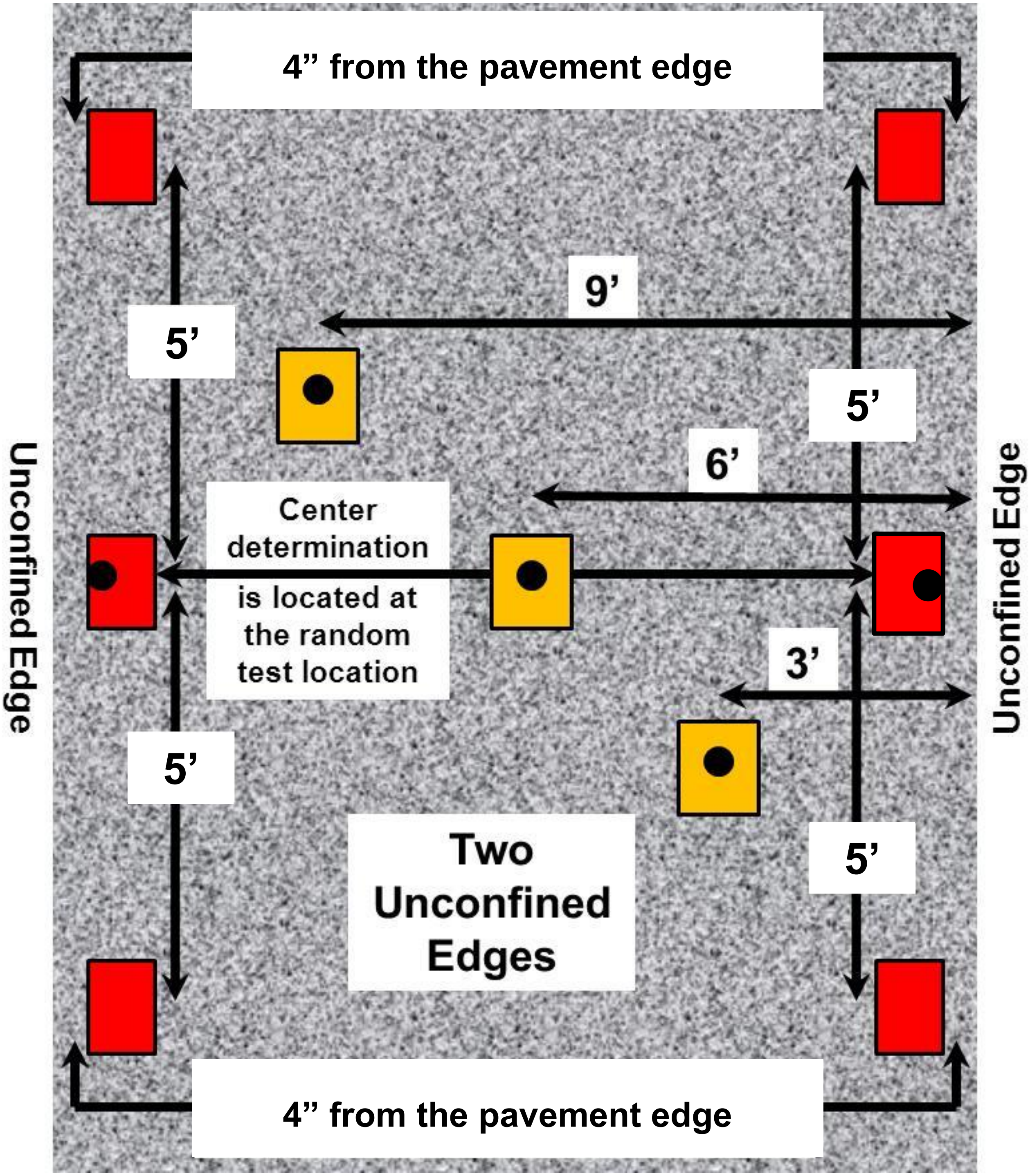
2 When testing with a nuclear density gauge, a total of three determinations will be taken longitudinally along each unconfined edge of the pavement at the required layout locations.

   The middle determination will be located at the random test location and the other two determinations will be spaced longitudinally apart in line with the middle determination at the required layout locations on the pavement edges.

   The results of the three determinations, on one side of the pavement, will be averaged to achieve one individual test which is required to meet the Density Control Limits for the mixture being tested for as an "Unconfined Edge Joint Density Minimum" specification. Each unconfined edge has its own requirement to meet.

3. When cutting cores, a single core (the middle determination) will be cut at the required layout location on each pavement edge. Each single core will be required to meet the Density Control Limits for the mixture being tested for as an "Unconfined Edge Joint Density Minimum" specification separately for each pavement edge.

A total of nine nuclear density determinations or five cores will be taken at this location. Three separate density requirements are to be met in this situation, one for the center pavement location and one on each of the unconfined edges.

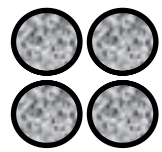

4" from the pavement edge
5'
9'
5'
6'
Center determination is located at the random test location
3'
5'
5'
Unconfined Edge
Unconfined Edge
Two Unconfined Edges
4" from the pavement edge

Density Verification Cores for PFP, QCP and QC/QA

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.

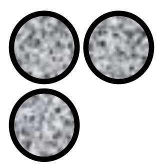
Four cores are taken at the designated random site determined by the Engineer. (1 for District, 1 for Contractor, 1 for backup and 1 for dispute)



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)



QC/QA (Less than 1200 tons)

The density testing interval for paving wider than or equal to 3 ft. wide will be:

- Lift thickness equal to or less than 3 in. every 0.5 miles (800 m) or 2640 ft.
- Lift thickness greater than 3 in every 0.2 miles (320 m) or 1056 ft.

The density testing interval for paving less than 3 ft. wide will be:

- Every 1 mile (1600 m) or 5280 ft.

A density verification test will be the result of a single core or the average of the nuclear density tests at one location.

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

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

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

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

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

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

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

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

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

(g) Additional Contractor Duties.

(1) The Contractor shall complete the sampling as required for the Department's random mixture verification tests. One sample weighing approximately 150 lb (70 kg) shall be collected for each 3,000 tons (2,720 metric tons) of mix, with a minimum of one per mixture for mixtures with less than 3,000 tons (2,720 metric tons). The mixture shall be sampled according to the document, "Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples".

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

(3) The Contractor shall provide personnel and equipment to collect density verification cores for the Engineer. Core locations will be determined by the Engineer following the document "Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations" at density verification intervals defined in Article 1030.09(b). After the Engineer identifies a density verification location and prior to opening to traffic, the Contractor shall cut a 4 in. (100 mm) diameter core. With the approval of the Engineer, the cores may be cut at a later time.

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

(1) The Engineer will determine the random verification mixture sample locations according to the document "Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples". The Engineer will randomly identify one sample for each 3,000 tons (2,720 metric tons) of mix, with a minimum of one sample per mix. The Engineer will witness, secure and take possession of the verification mixture sample. Department mixture testing will be completed on asphalt binder content, bulk specific gravity, maximum specific gravity and field VMA. If an anti-strip additive was used in the mixture, the Department will also test for stripping according to Illinois Modified AASHTO T 283. If the mixture fails to meet the minimum tensile strength and TSR criteria as specified in Article 1030.05(d), no further mixture will be accepted until the Contractor takes such action as is necessary to furnish a mixture meeting the criteria.

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

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

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

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

Density verification test locations will be determined according to the document "Hot-Mix Asphalt QC/QA Procedure for Determining Random

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

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

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

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

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

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

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

2/ Does not apply to SMA.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The limitations between the JMF and AJMF are as follows.

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

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

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

Production is not required to stop after a growth curve has been constructed for PFP and QCP mixtures. For QC/QA mixtures, volumetric test results that are within Acceptable Limits shall be available to the Engineer before production may resume.

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

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

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Illinois Department of Transportation

Hot-Mix Asphalt Test Strip Procedures
Appendix B.4

Effective: May 1, 1993
Revised: December 1, 2024

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

A. Contractor/Department Test Strip Team

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

The test strip team may consist of the following:

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

Optional:

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

B. Communications

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

C. Test Strip Method

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

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

Illinois Department of Transportation

Hot-Mix Asphalt Test Strip Procedures
Appendix B.4

Effective: May 1, 1993
Revised: December 1, 2024

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

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

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

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

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

   The Contractor shall provide compacted 150 mm (5.91 in.) diameter gyratory cylinders meeting the air void requirements of the respective tests shown in the following table. The number of gyratory cylinders and the height of the gyratory cylinders per test is also specified in the following table. The Hamburg and I-FIT gyratory cylinders have the same volumetric requirements and shall be treated as identical when assigning them to the required tests.

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Hot-Mix Asphalt Test Strip Procedures
Appendix B.4

Effective: May 1, 1993
Revised: December 1, 2024

	TSR	Hamburg Wheel / I-FIT[1/]
IL Modified AASHTO Procedure	T 283	T 324 / T 393
Height of Gyratory Cylinders	95mm (3.74 in.)	160mm (6.30 in.)[2/]
No. Gyratory Cylinders	6	6[3/]

1/ I-FIT Long-Term Aging (LTA) is required for surface mixes
2/ If a contractor does not possess equipment capable of creating 160 mm (6.30) tall gyratory cylinders, twice the required number of 115 mm (4.53 in.) cylinders will be acceptable (a total of 12).
3/ This is the total number of gyratory cylinders required for both tests, and may be reduced by 1 for binder mixtures.

D. Compaction Requirements

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

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

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

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

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Hot-Mix Asphalt Test Strip Procedures
Appendix B.4

Effective: May 1, 1993
Revised: December 1, 2024

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

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

E. Evaluation of Growth Curves

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

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

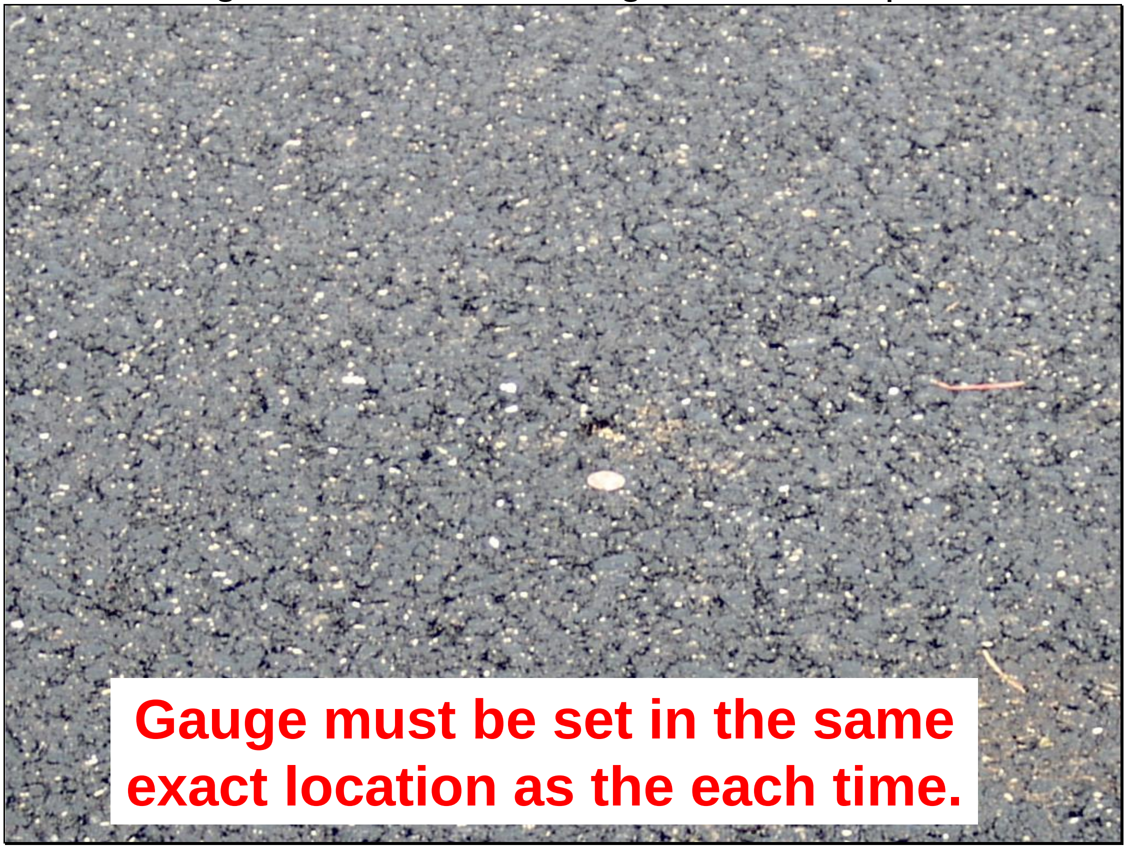
F. Nuclear/Core Correlation

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

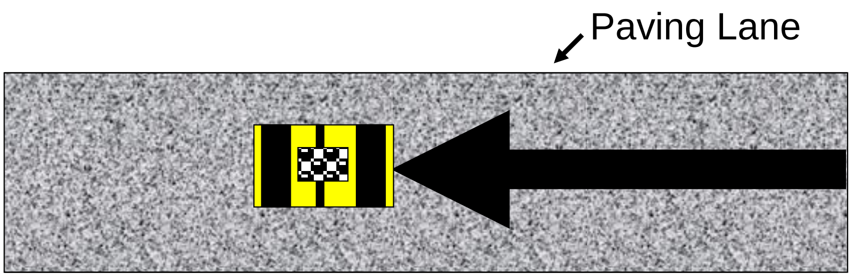
G. Documentation

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

Determining Growth Curve during the Test Strip Procedure

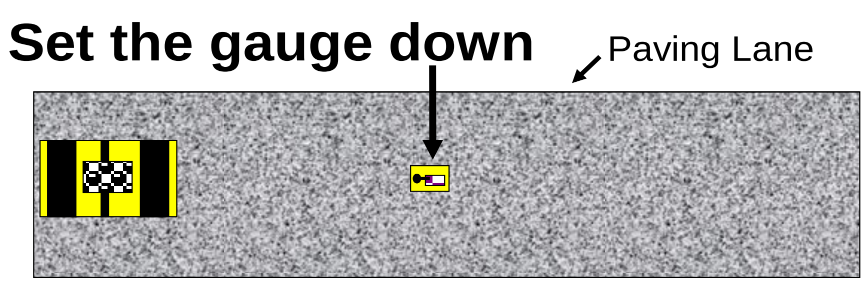


Growth Curve



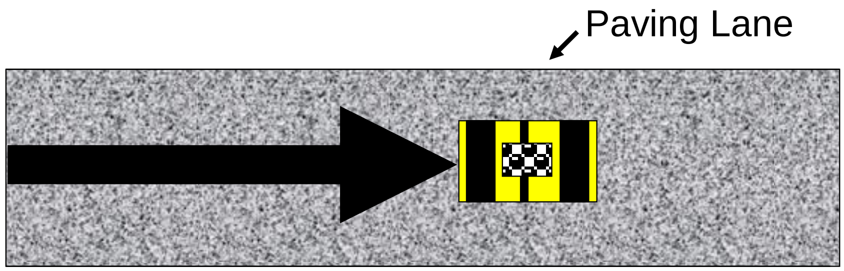
First Roller Pass

Growth Curve



Take first measurement

Growth Curve

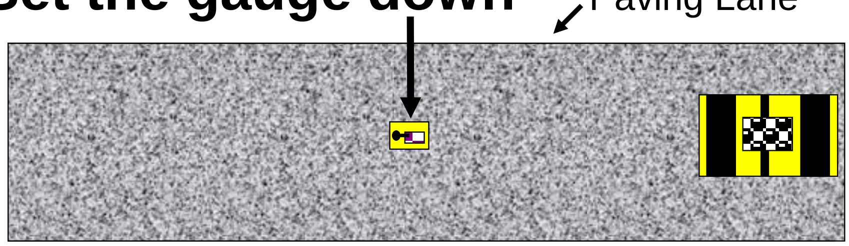


Second Roller Pass

Growth Curve

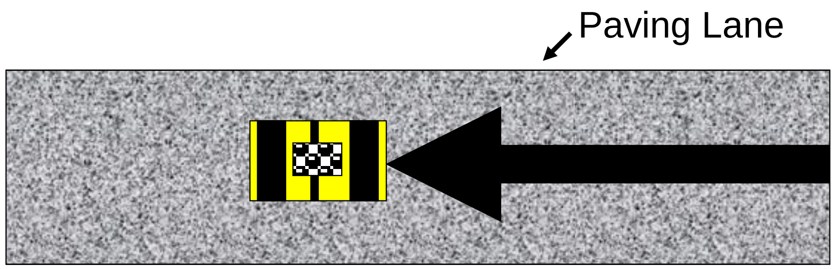
Set the gauge down

Paving Lane



Take second measurement

Growth Curve

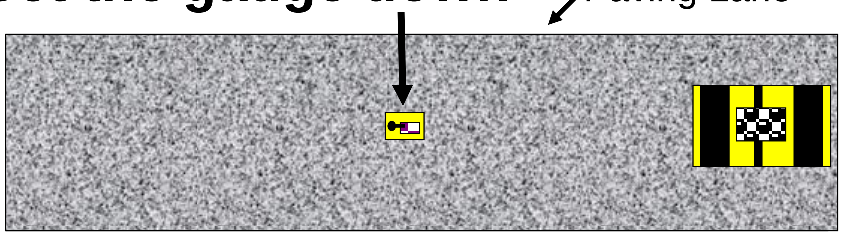


Third Roller Pass

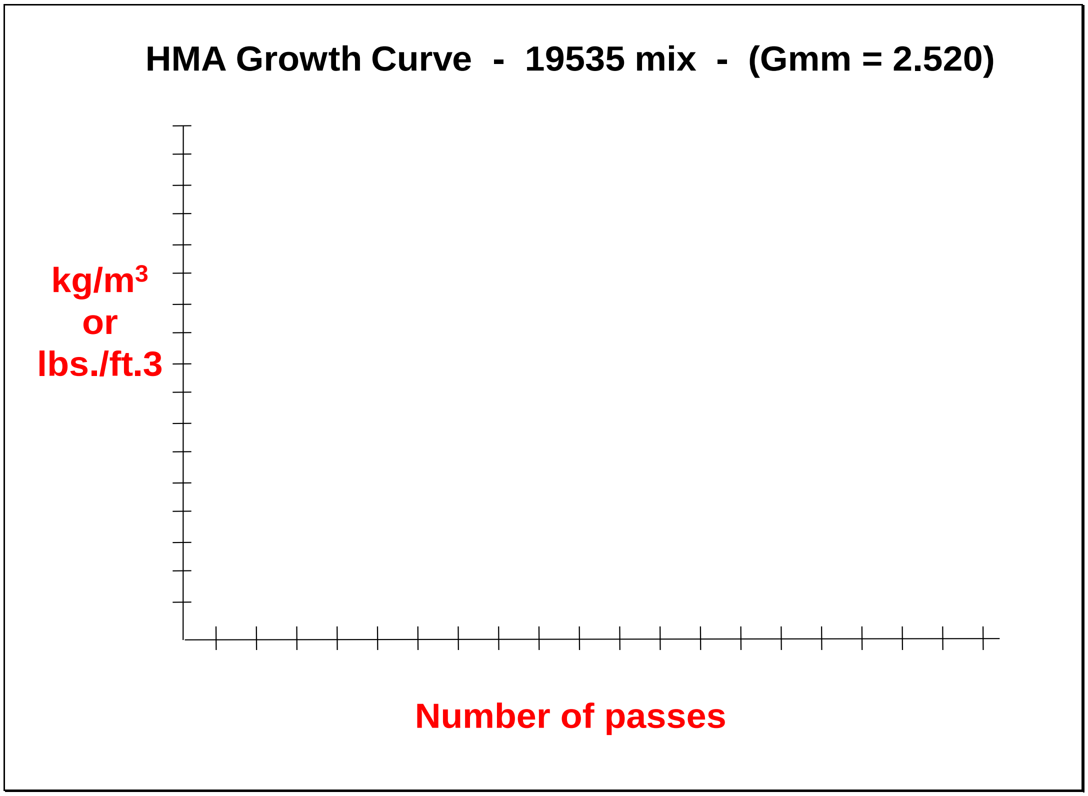
Growth Curve

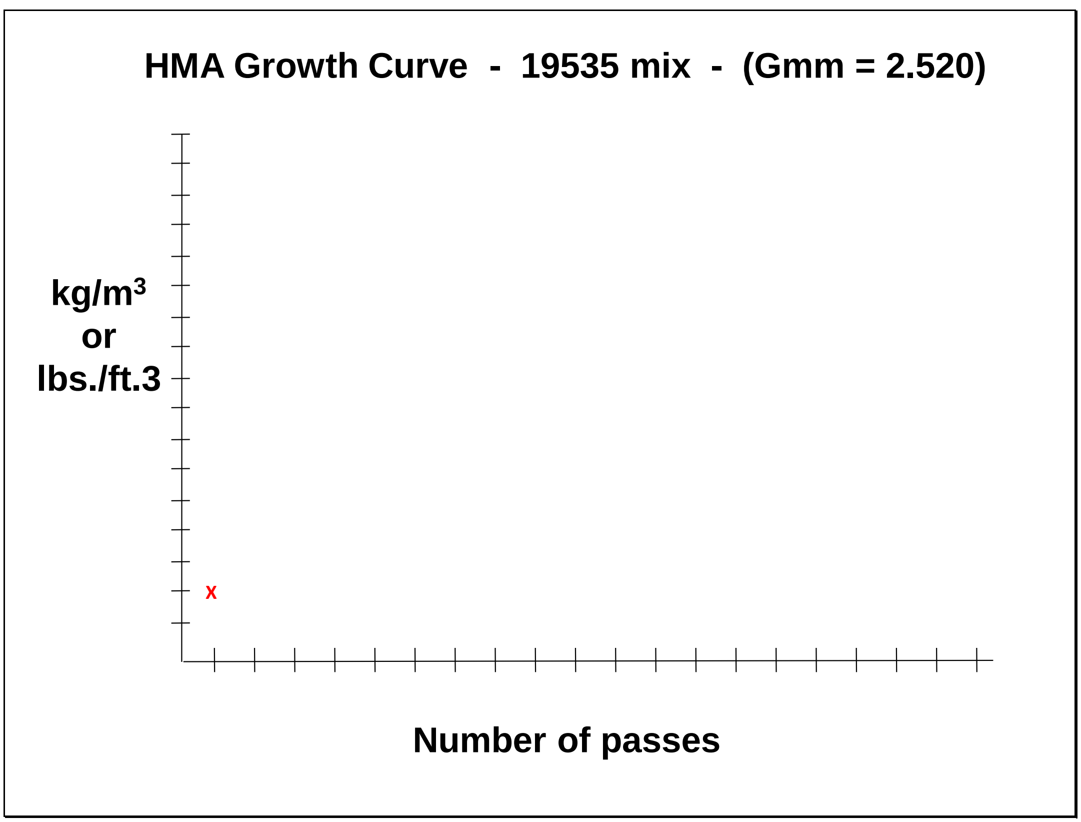
Set the gauge down

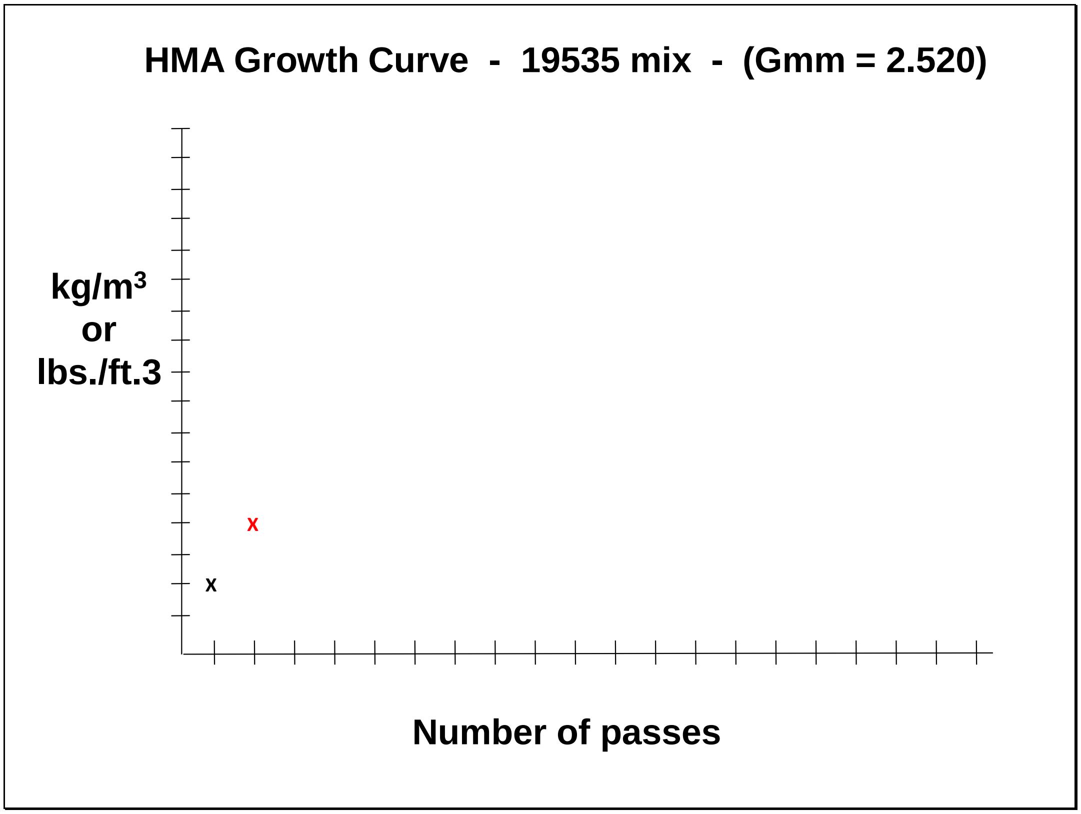
Paving Lane

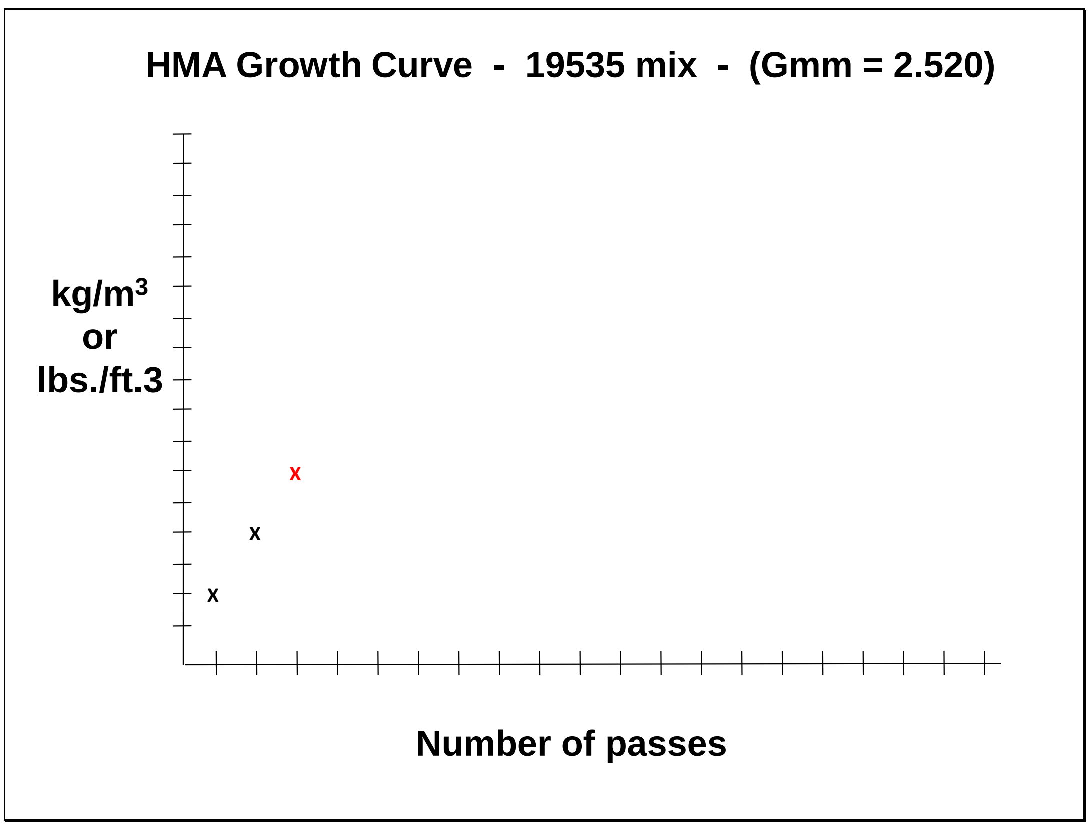


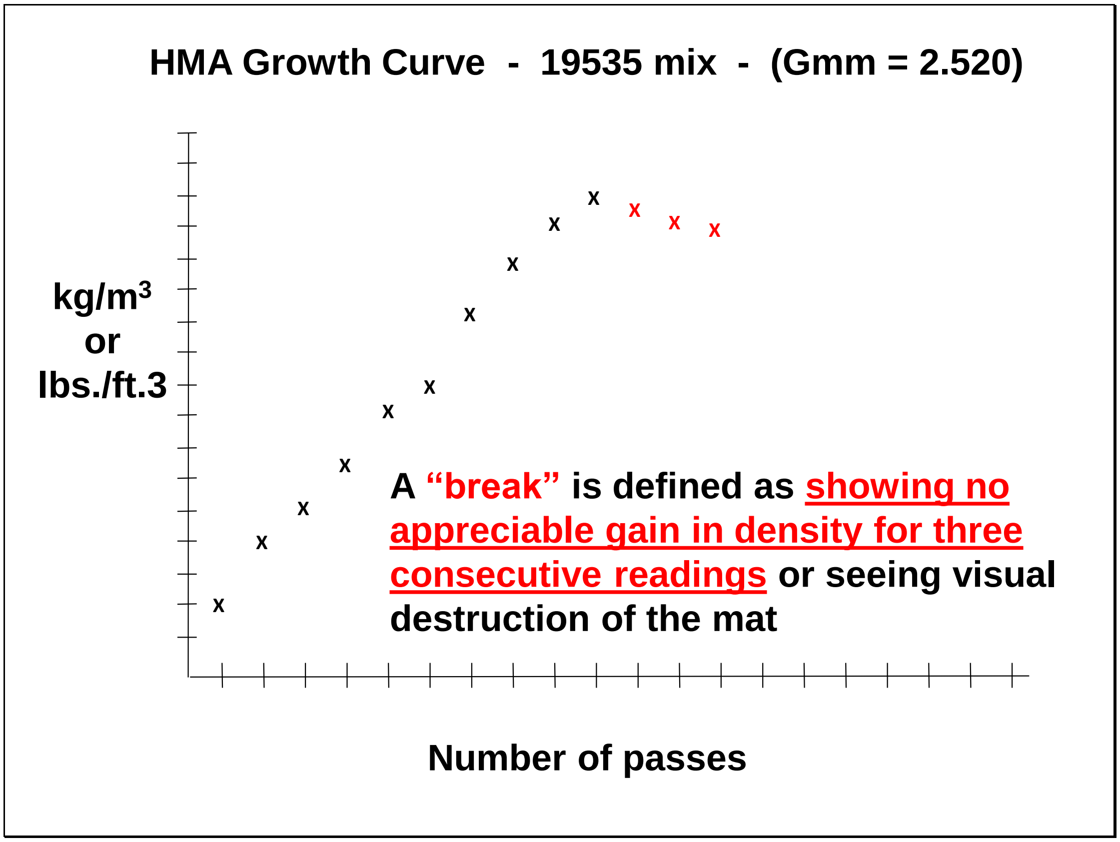
Take third measurement

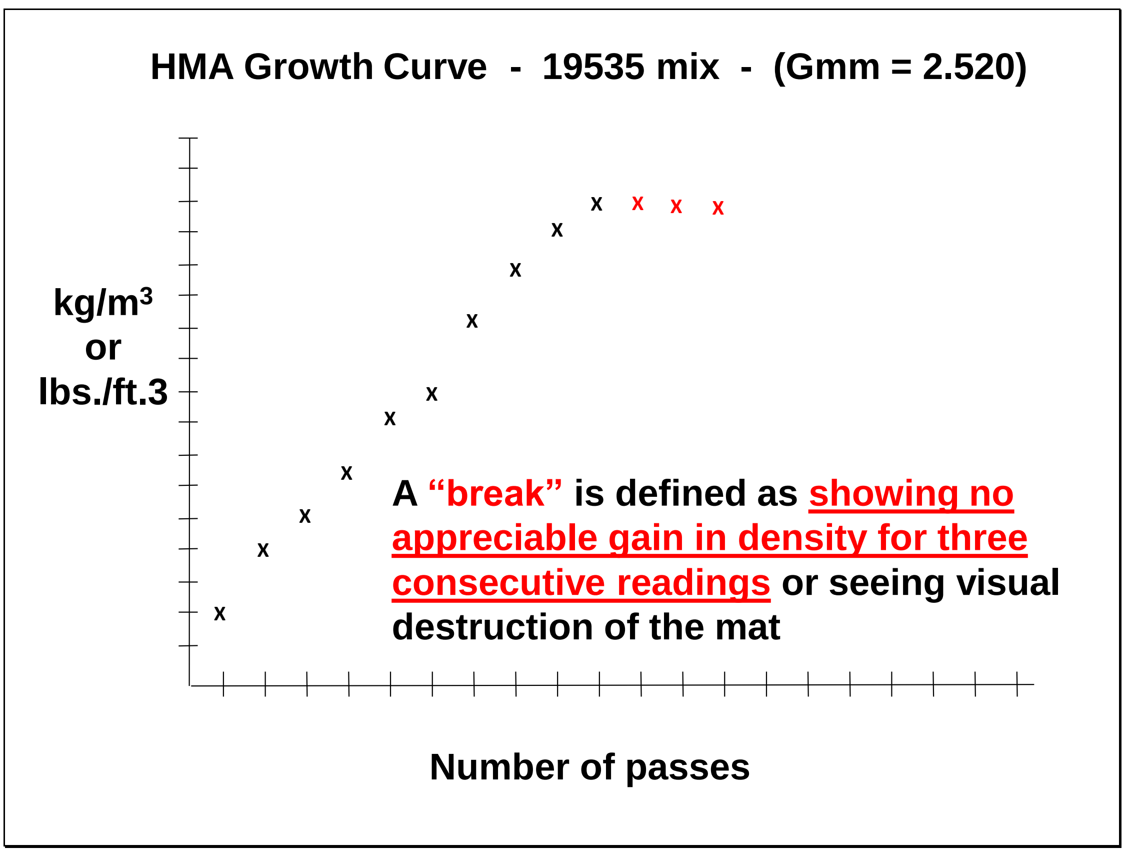

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m3
or
lbs./ft.3
Number of passes

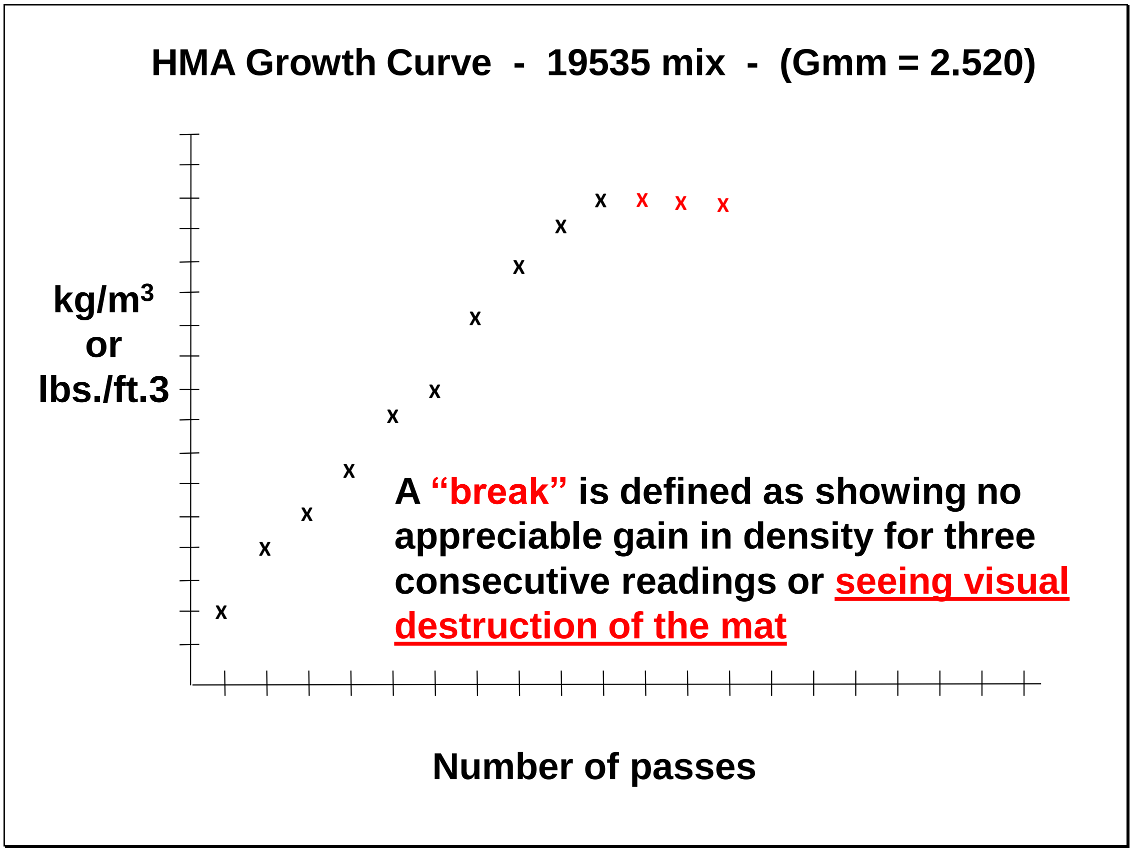

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m3
or
lbs./ft.3
x
Number of passes

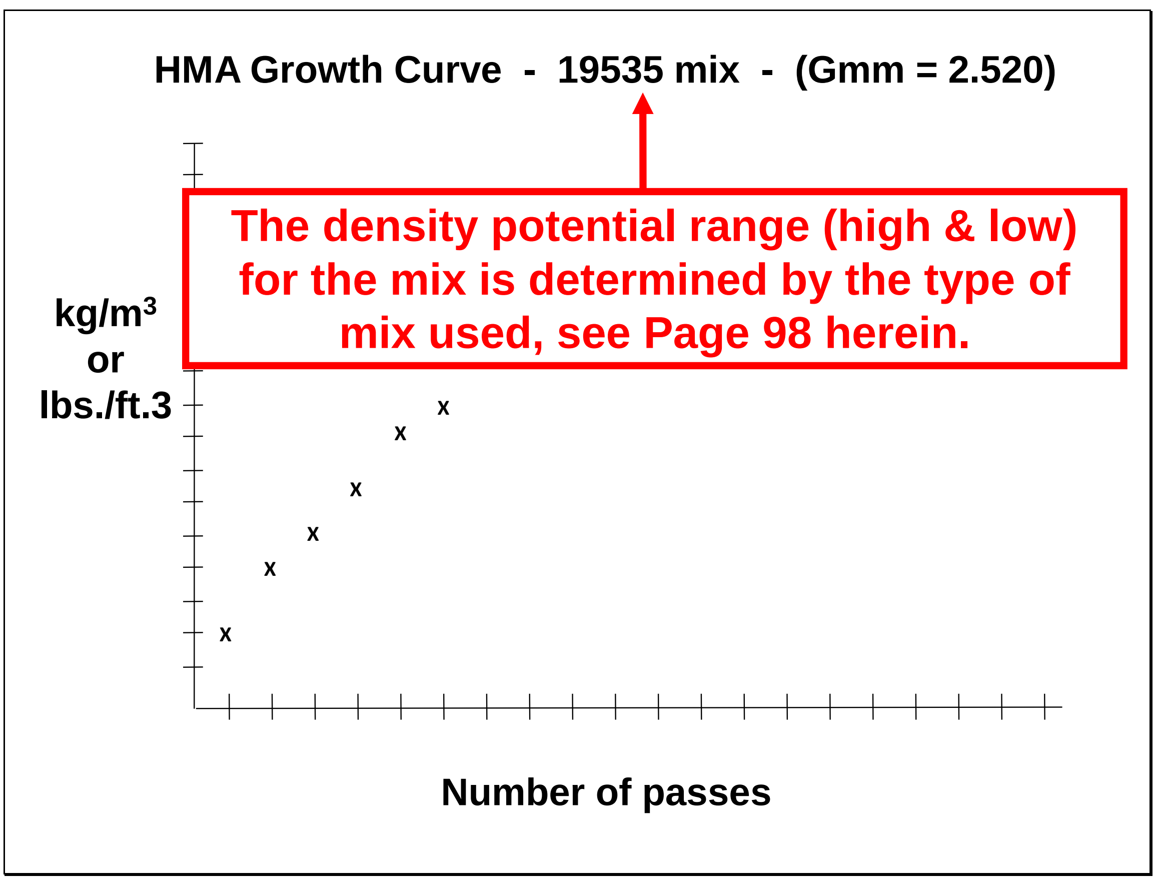

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m3
or
lbs./ft.3
x
x
Number of passes

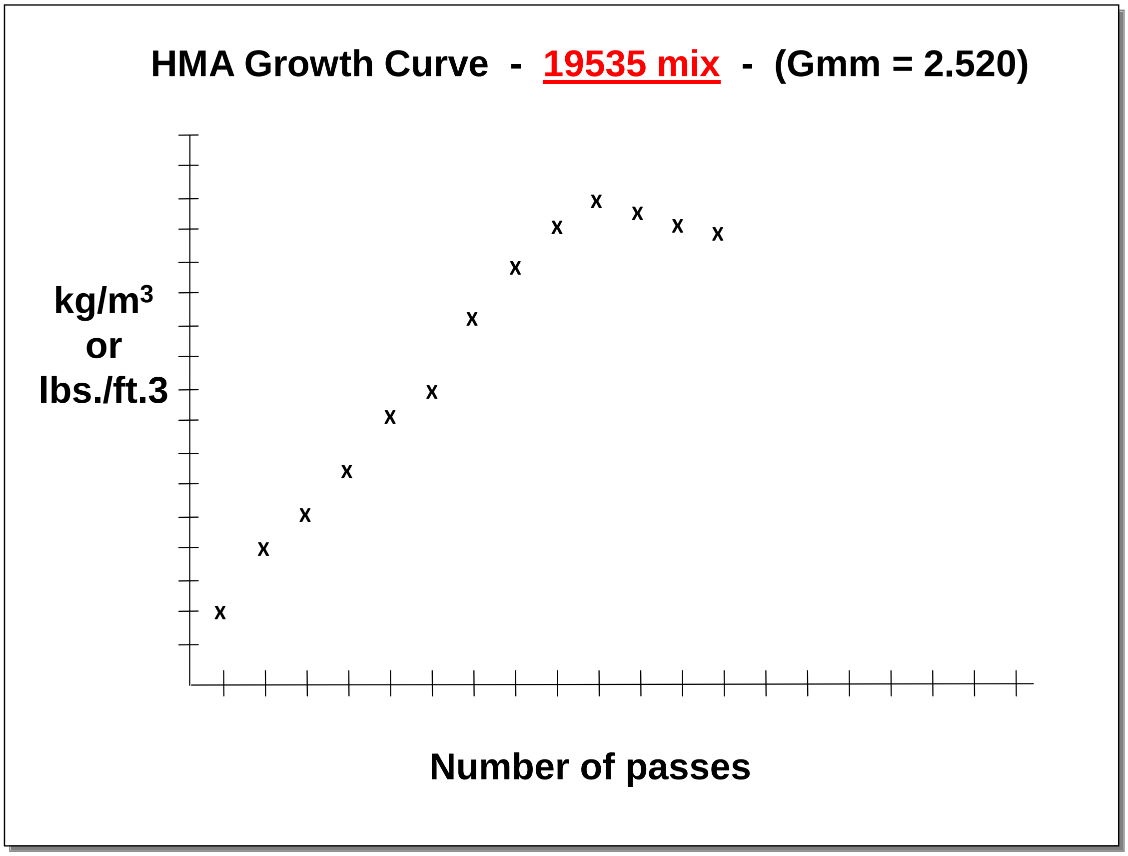

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m3
or
lbs./ft.3
x
x
x
Number of passes

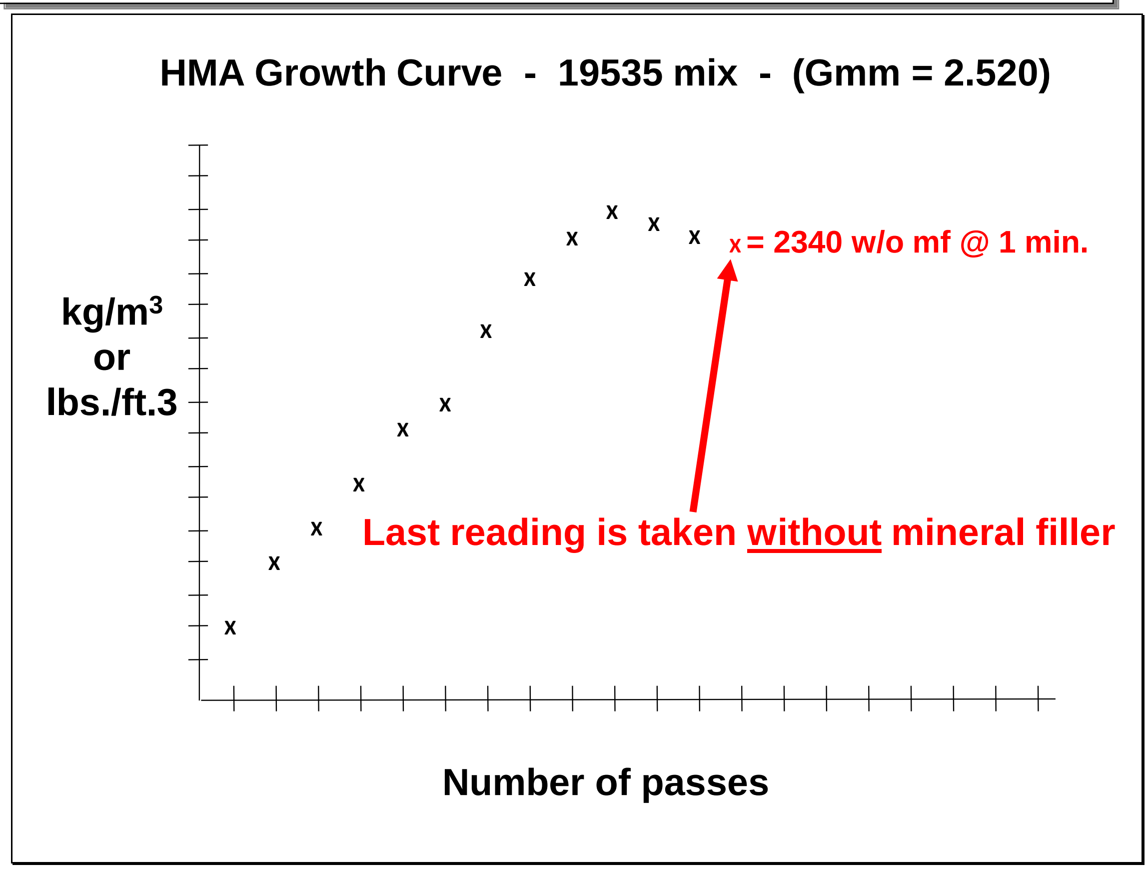

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m3 or lbs./ft.3
A "break" is defined as showing no appreciable gain in density for three consecutive readings or seeing visual destruction of the mat
Number of passes

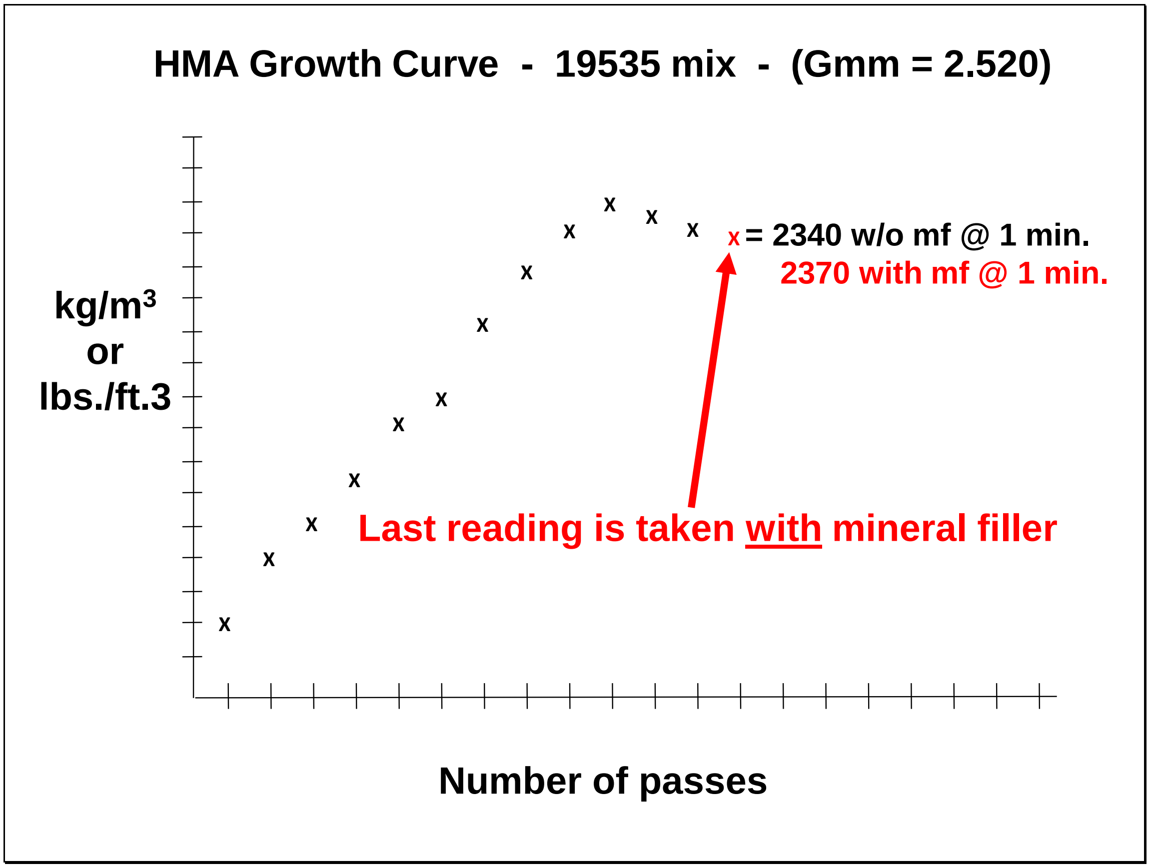

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m3 or lbs./ft.3
A "break" is defined as showing no appreciable gain in density for three consecutive readings or seeing visual destruction of the mat
Number of passes

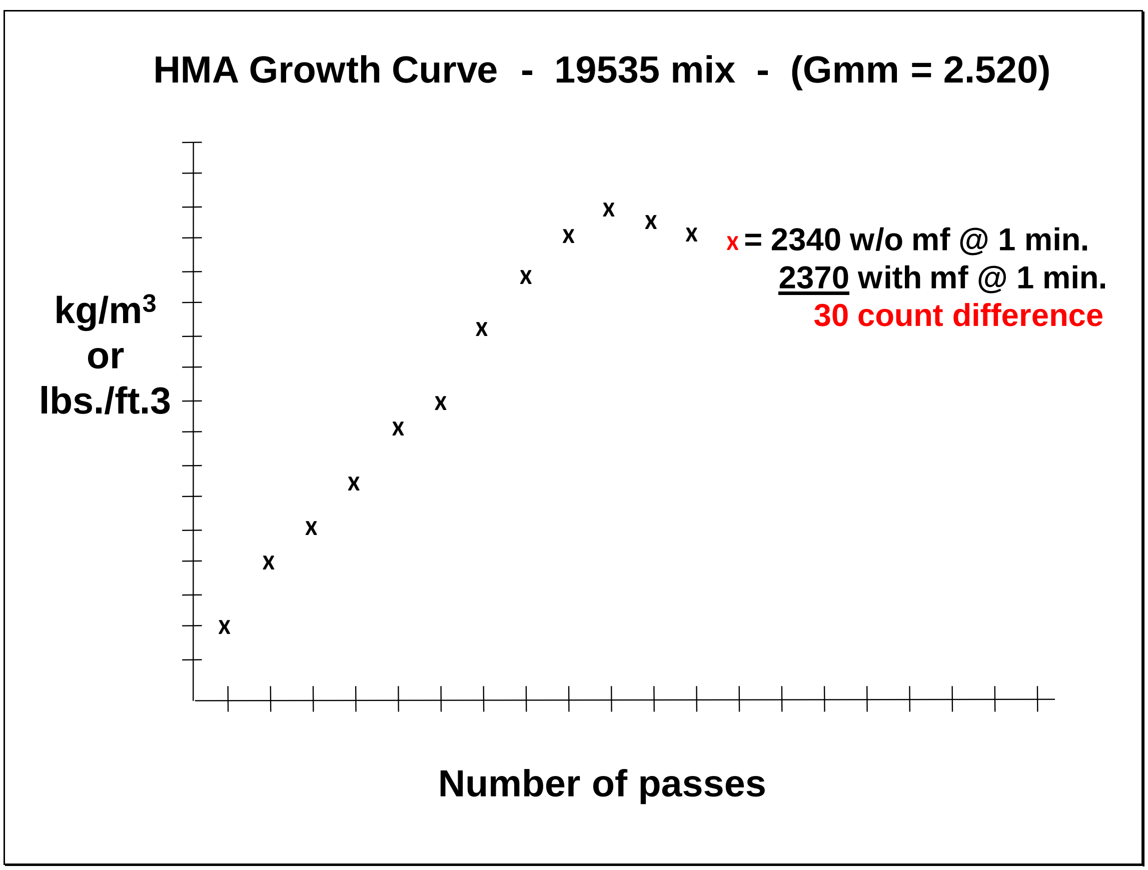

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m3 or lbs./ft.3
A "break" is defined as showing no appreciable gain in density for three consecutive readings or seeing visual destruction of the mat
Number of passes

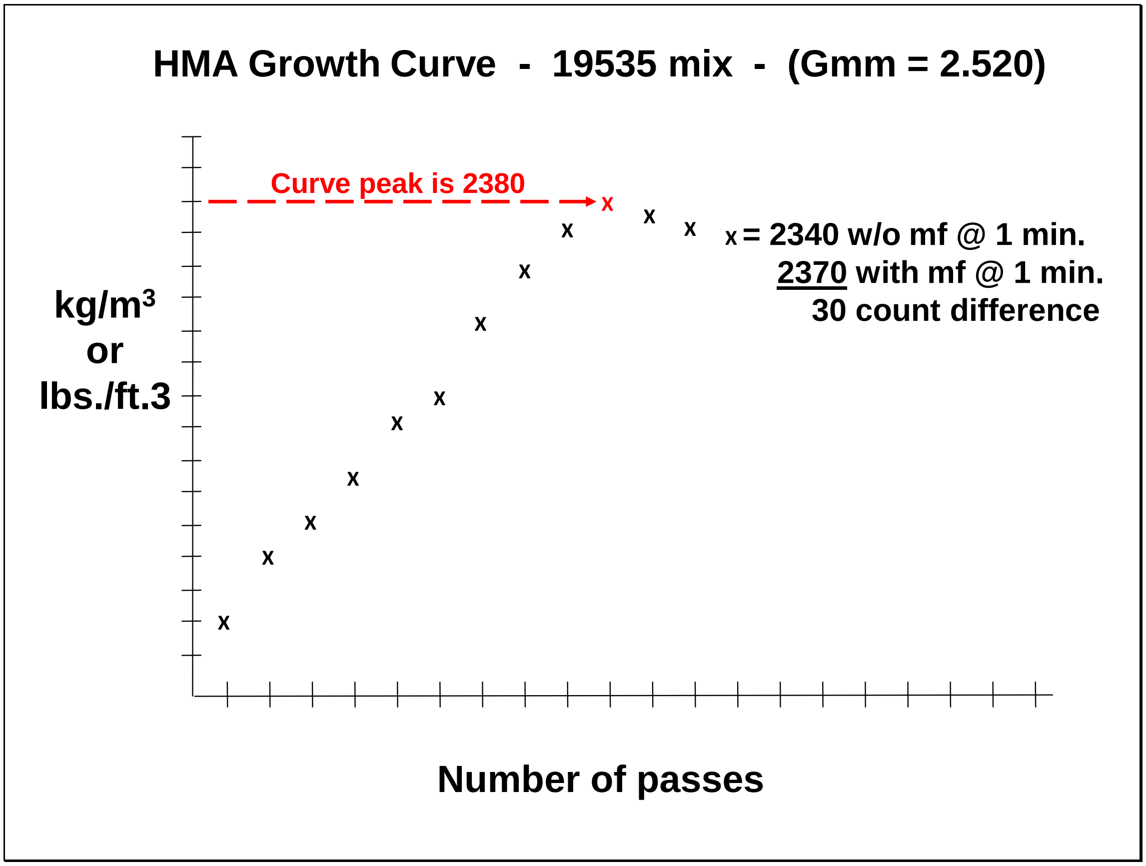

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
The density potential range (high & low) for the mix is determined by the type of mix used, see Page 98 herein.
kg/m3 or lbs./ft.3
Number of passes

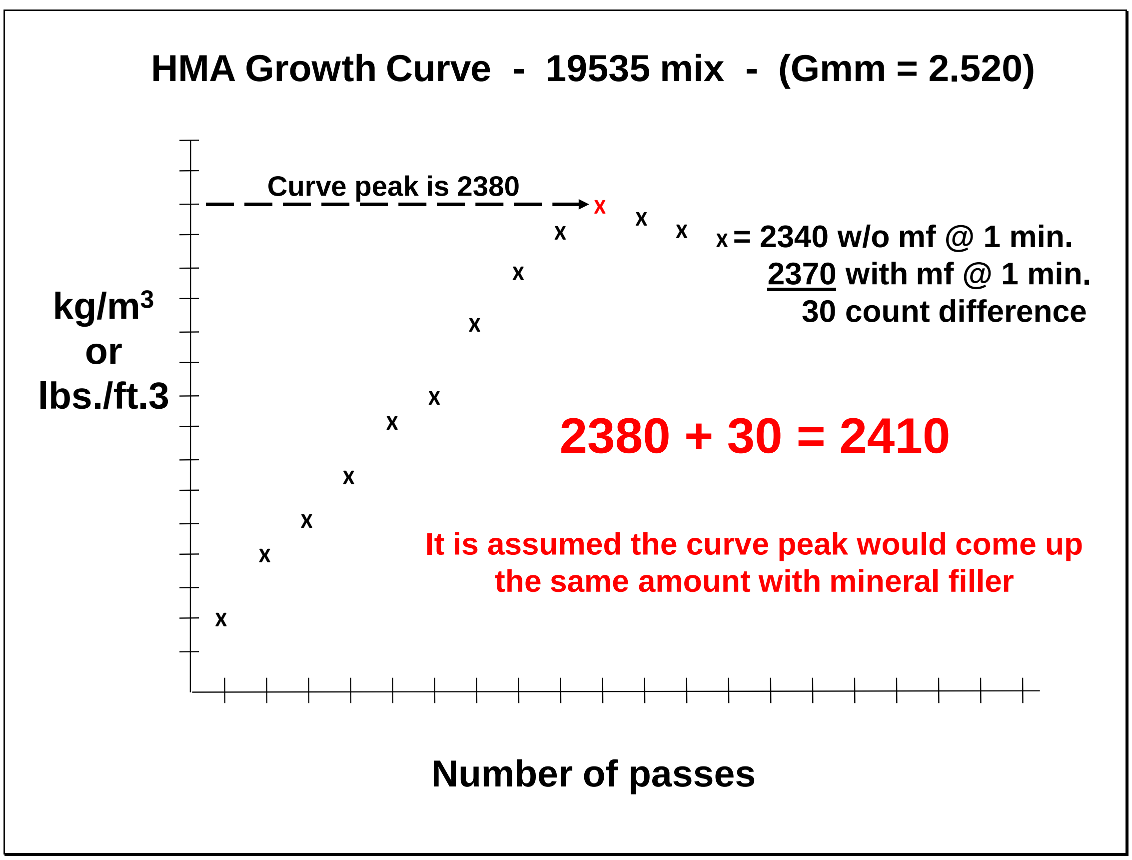

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m³ or lbs./ft.3
Number of passes

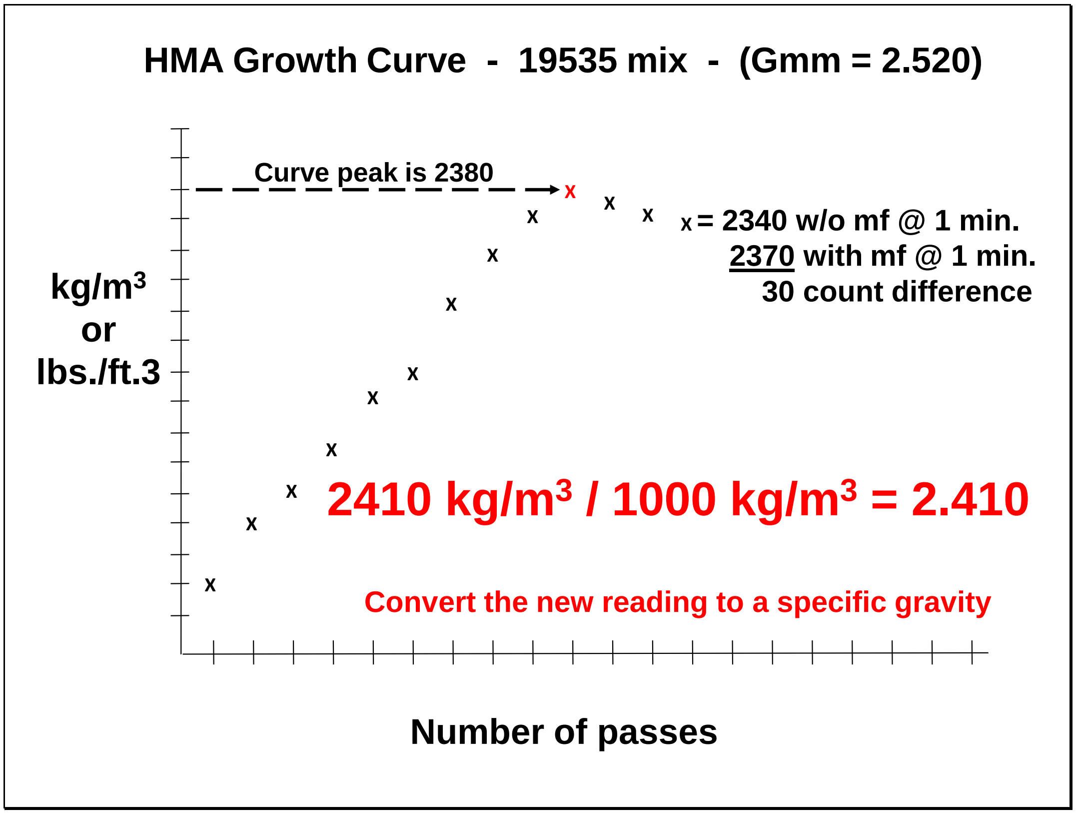

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m³ or lbs./ft.3
x = 2340 w/o mf @ 1 min.
Last reading is taken without mineral filler
Number of passes

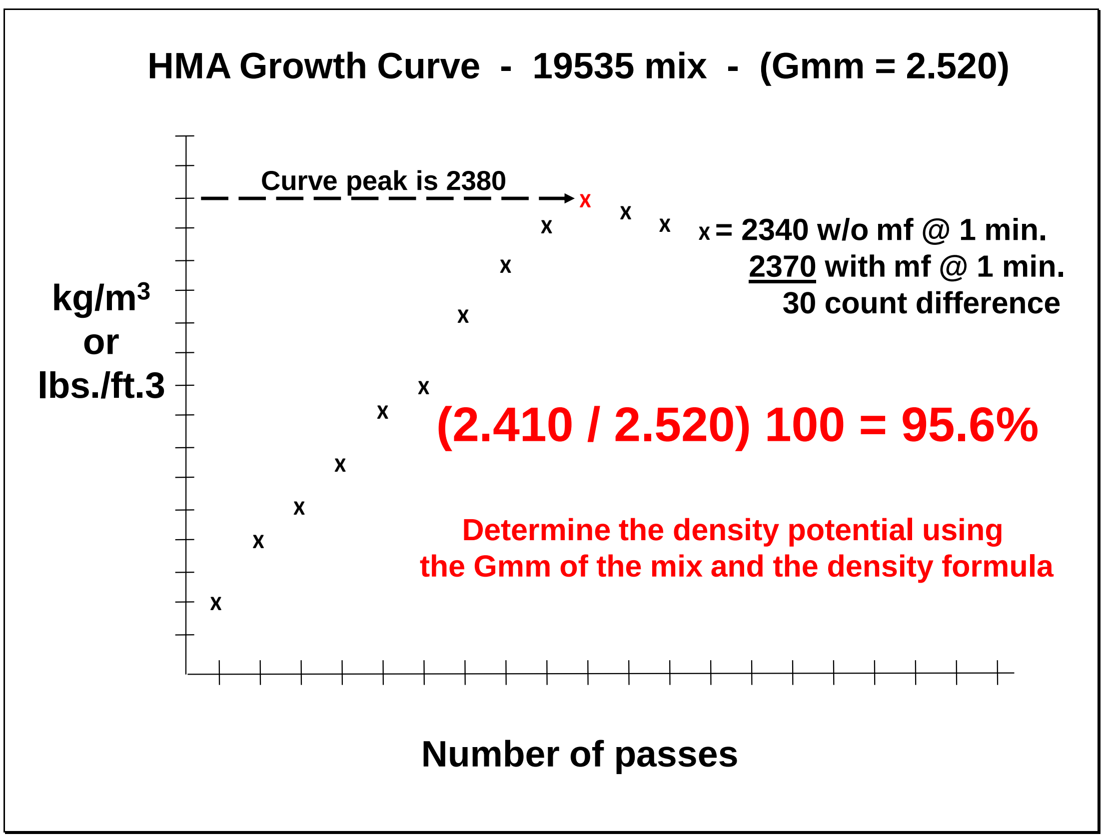

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m3 or lbs./ft.3
x = 2340 w/o mf @ 1 min.
2370 with mf @ 1 min.
Last reading is taken with mineral filler
Number of passes

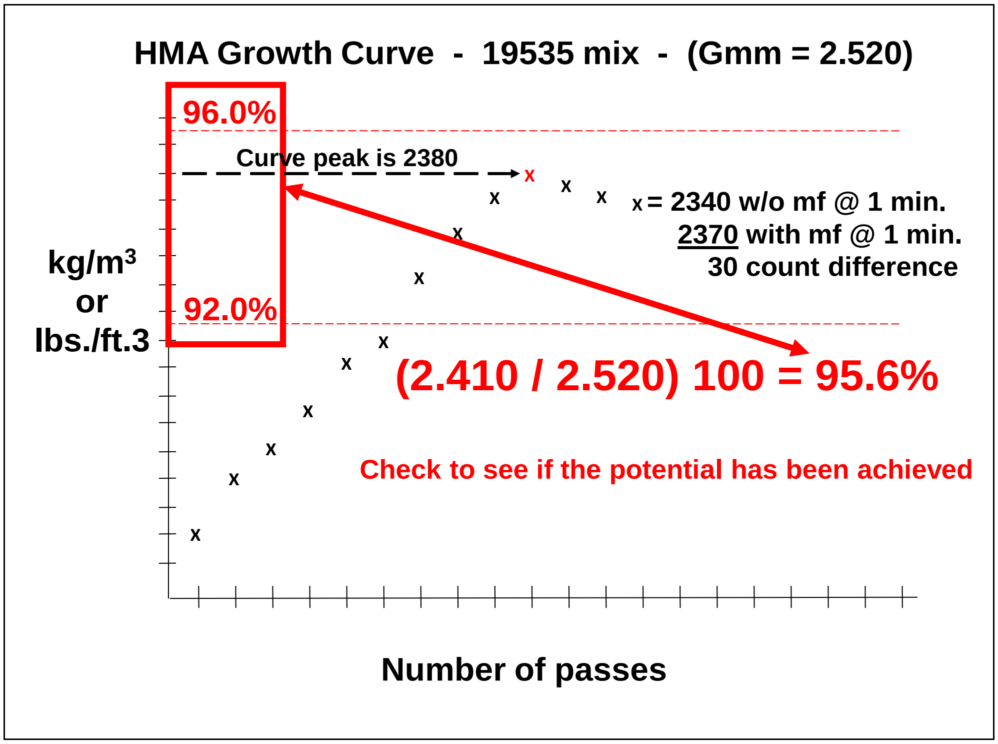

HMA Growth Curve - 19535 mix - (Gmm = 2.520)
kg/m3 or lbs./ft.3
x = 2340 w/o mf @ 1 min.
2370 with mf @ 1 min.
30 count difference
Number of passes


HMA Growth Curve - 19535 mix - (Gmm = 2.520)
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
Number of passes


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


HMA Growth Curve - 19535 mix - (Gmm = 2.520)
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
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)
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
(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

Procedure for Correlating
Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt
Appendix B.3
Effective Date: May 1, 2001
Revised Date: December 1, 2021

A. Scope

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

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

B. Applicable Documents

1. Illinois Department of Transportation Standard Test Methods

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

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

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

C. Definitions

Test Location: The station location for the density testing.

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

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

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

Illinois Department of Transportation

Procedure for Correlating
Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt
Appendix B.3
Effective Date: May 1, 2001
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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 desired, a correlation must be developed to convert the nuclear density to core density.

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

E. Site Selection

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

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

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

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

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

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

Illinois Department of Transportation

Procedure for Correlating
Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt
Appendix B.3
Effective Date: May 1, 2001
Revised Date: December 1, 2021

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

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

G. Mathematical Correlation -- Linear Regression

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

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

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

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

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

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

$$y = mx + b$$

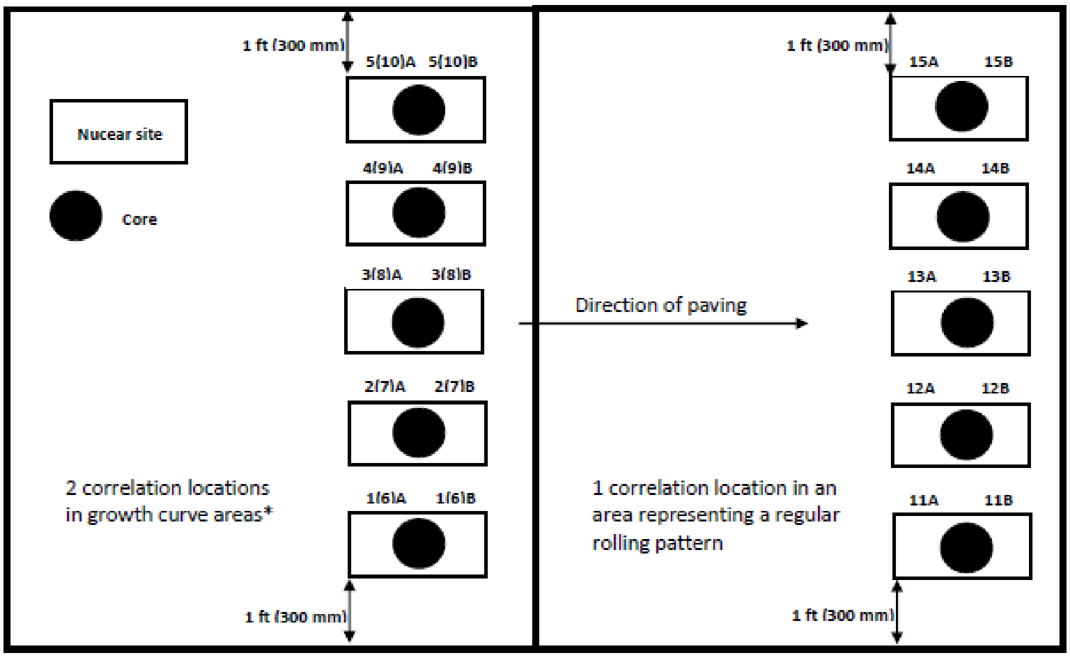
where:

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

Illinois Department of Transportation

Procedure for Correlating
Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt
Appendix B.3
Effective Date: May 1, 2001
Revised Date: December 1, 2021

BACKSCATTER MODE



2 of 3 locations **1 of 3 locations**

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

NUCLEAR /CORE CORRELATION TEST LOCATION LAYOUT

Figure 1

Illinois Department of Transportation

Nuclear / Core Correlation Field Worksheet

Date: ____________________
Contract: ____________________ Gauge No.: ____________
Job No.: ____________________ Layer Thickness: ____________
Route: ____________________ Gmm: ____________
Base Material: ☐ Milled ☐ Binder ☐ Aggregate Other: ____________________
Mix No.: ____________________
Mix Code: ____________________
Use: ____________________ (surface, 1st lift binder, etc.)

Reading 1	**Reading 2**	1.5 lb/ft^3 (23.5 kgs/m^3) tol. **Reading 3** (if applicable)	**Average Nuc.**	**Core Density**
STATION: ____________				
1A)	1B)	1A) 1B)	1)	1)
2A)	2B)	2A) 2B)	2)	2)
3A)	3B)	3A) 3B)	3)	3)
4A)	4B)	4A) 4B)	4)	4)
5A)	5B)	5A) 5B)	5)	5)
STATION: ____________				
6A)	6B)	6A) 6B)	6)	6)
7A)	7B)	7A) 7B)	7)	7)
8A)	8B)	8A) 8B)	8)	8)
9A)	9B)	9A) 9B)	9)	9)
10A)	10B)	10A) 10B)	10)	10)
STATION: ____________				
11A)	11B)	11A) 11B)	11)	11)
12A)	12B)	12A) 12B)	12)	12)
13A)	13B)	13A) 13B)	13)	13)
14A)	14B)	14A) 14B)	14)	14)
15A)	15B)	15A) 15B)	15)	15)

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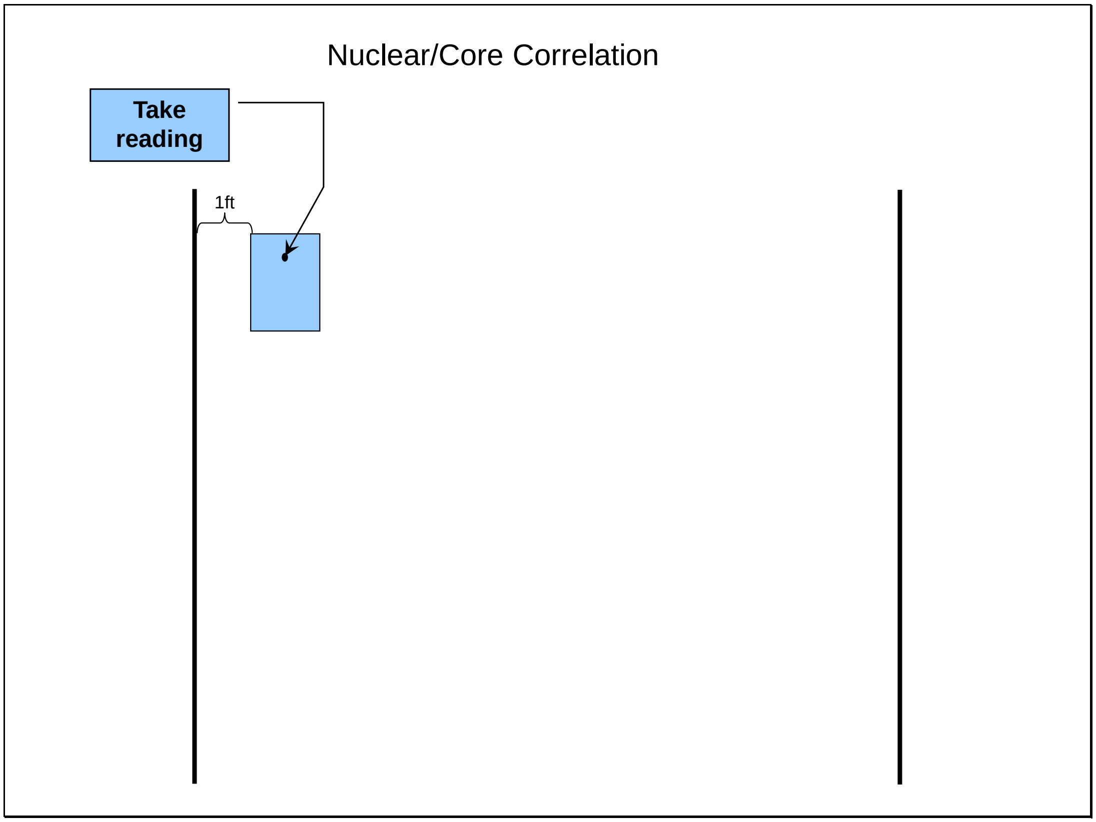
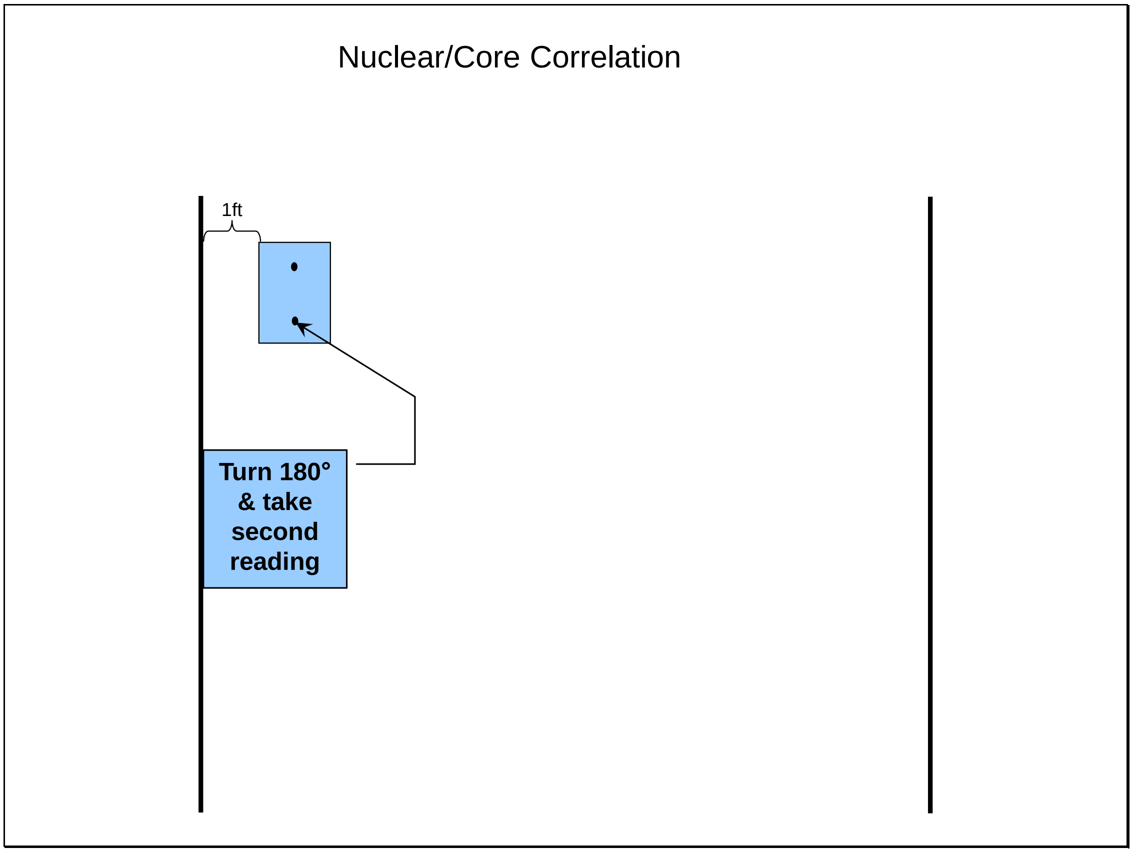
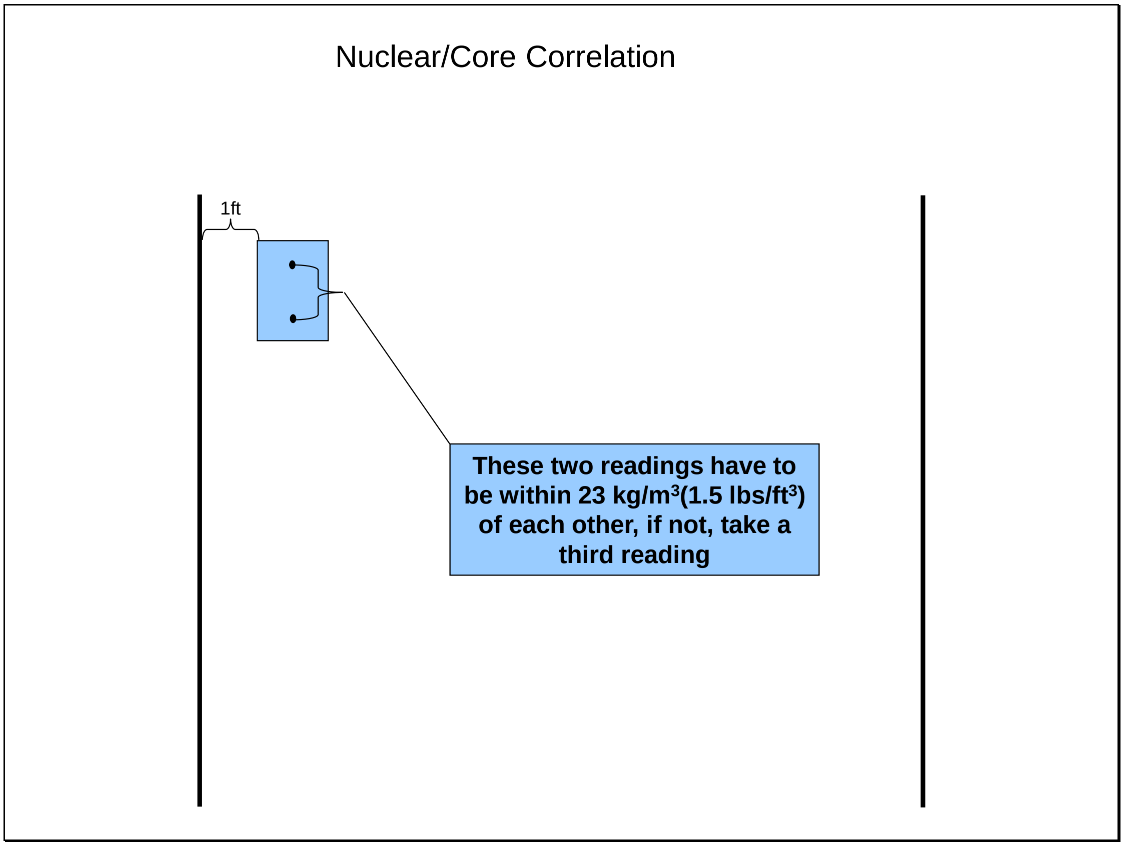
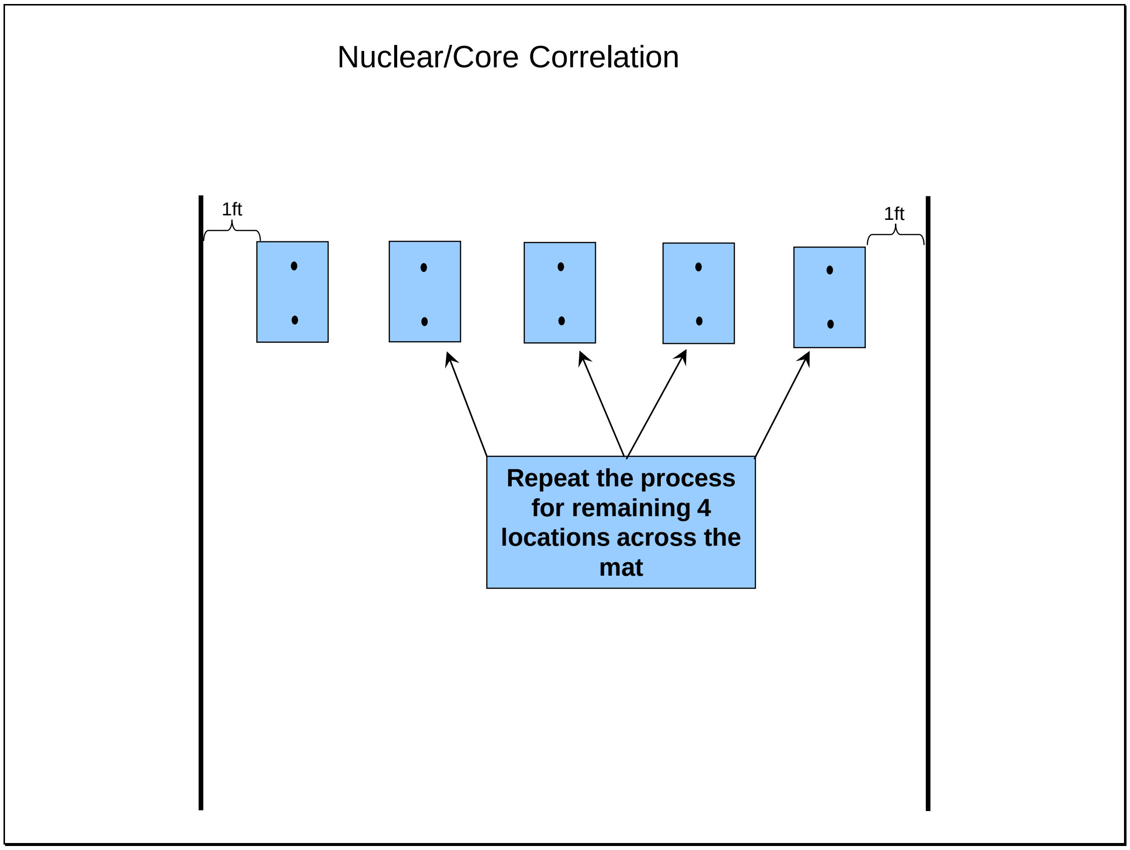
Completing a Nuclear Core Correlation During Test Strip

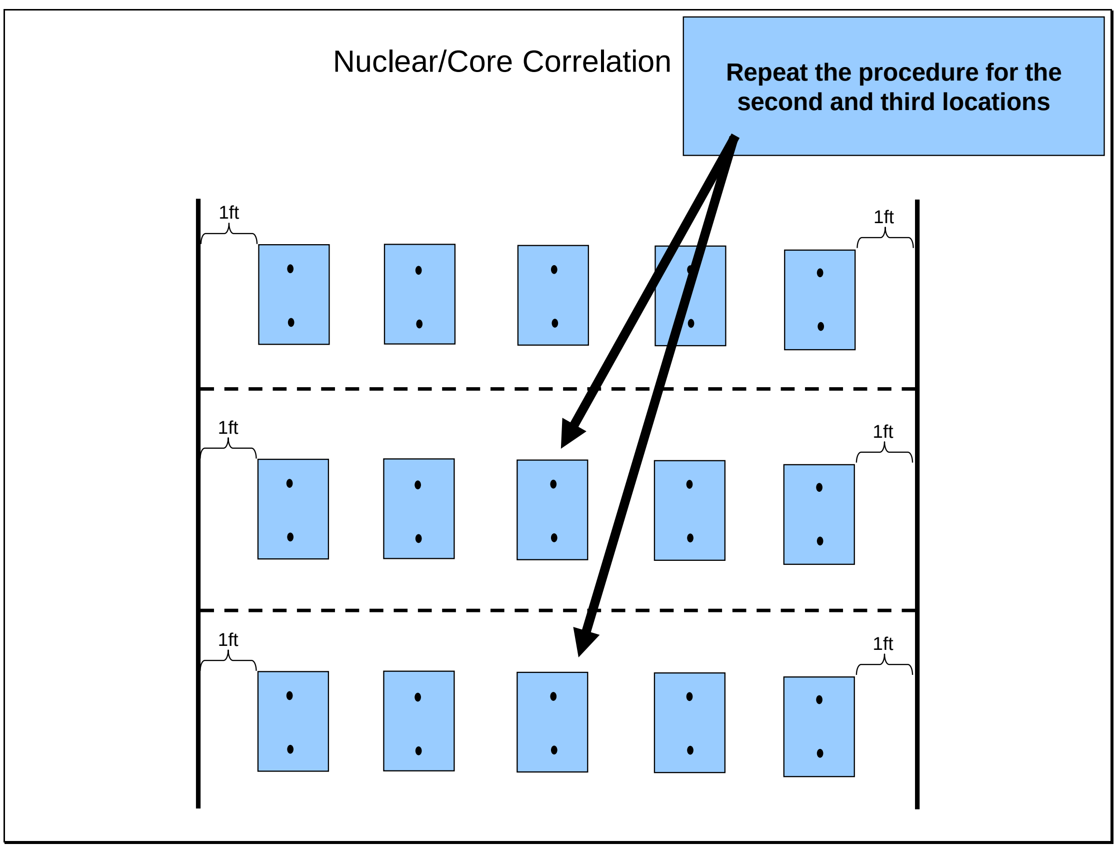


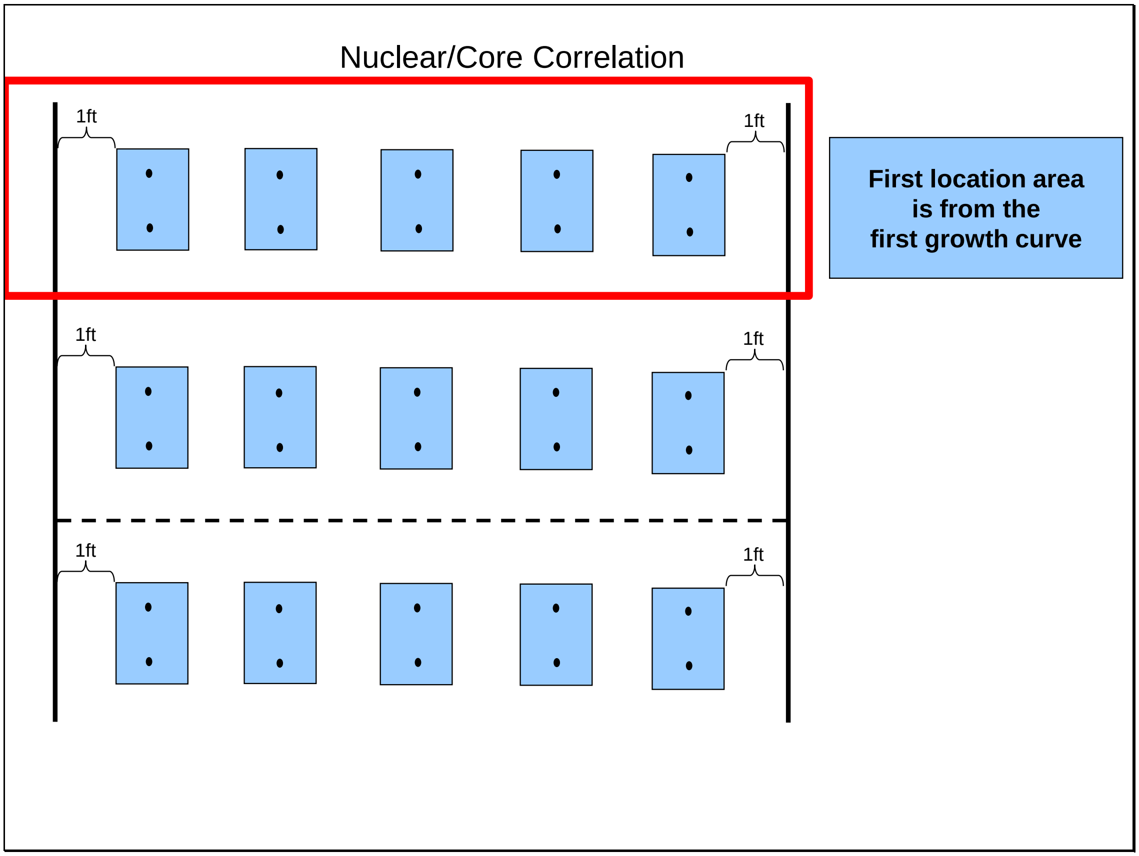

Nuclear/Core Correlation
1ft
Turn 180° & take second reading

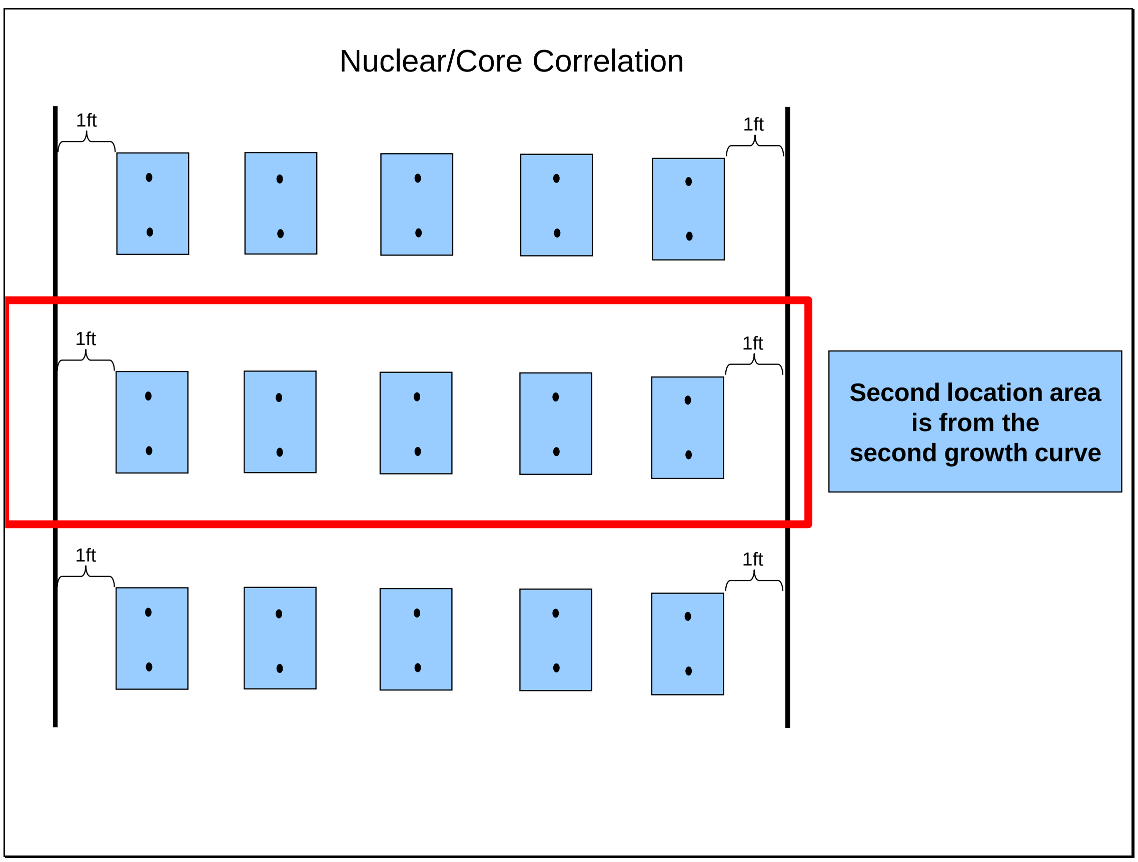

Nuclear/Core Correlation
1ft
These two readings have to be within 23 kg/m3(1.5 lbs/ft3) of each other, if not, take a third reading

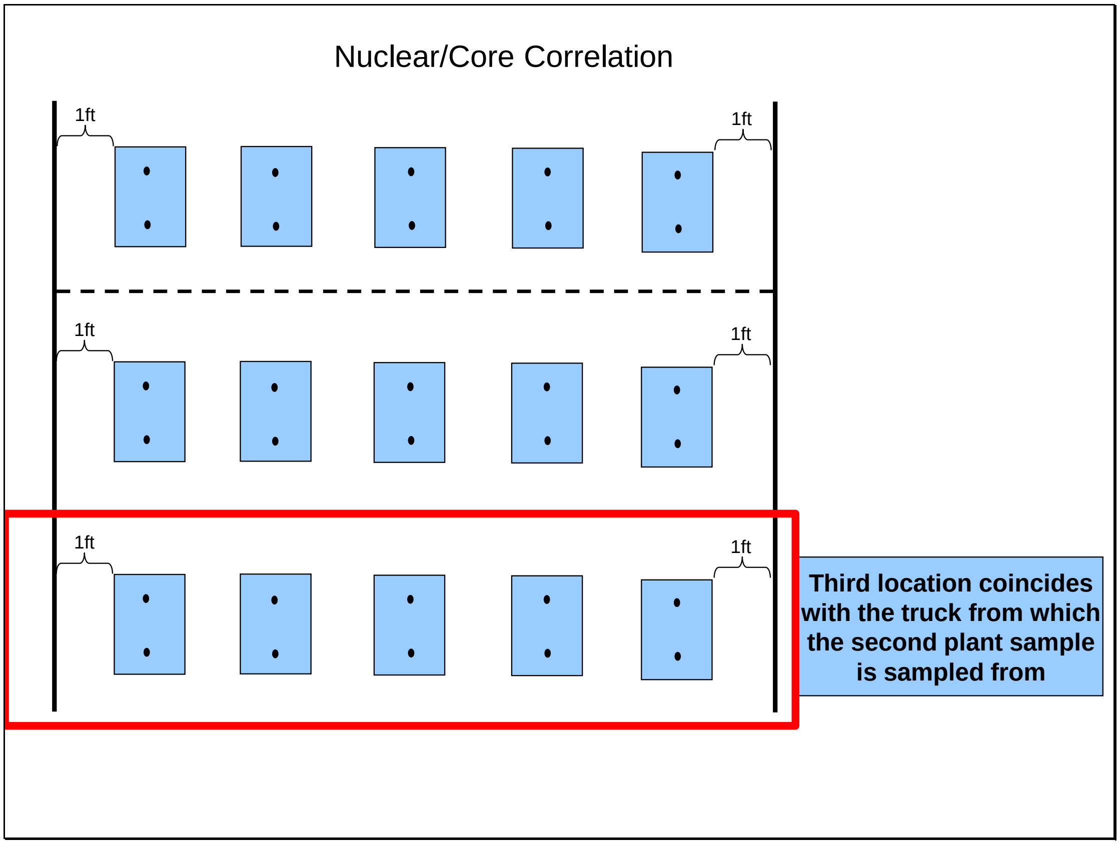

The direction of the gauge is up to the technician for the third measurement

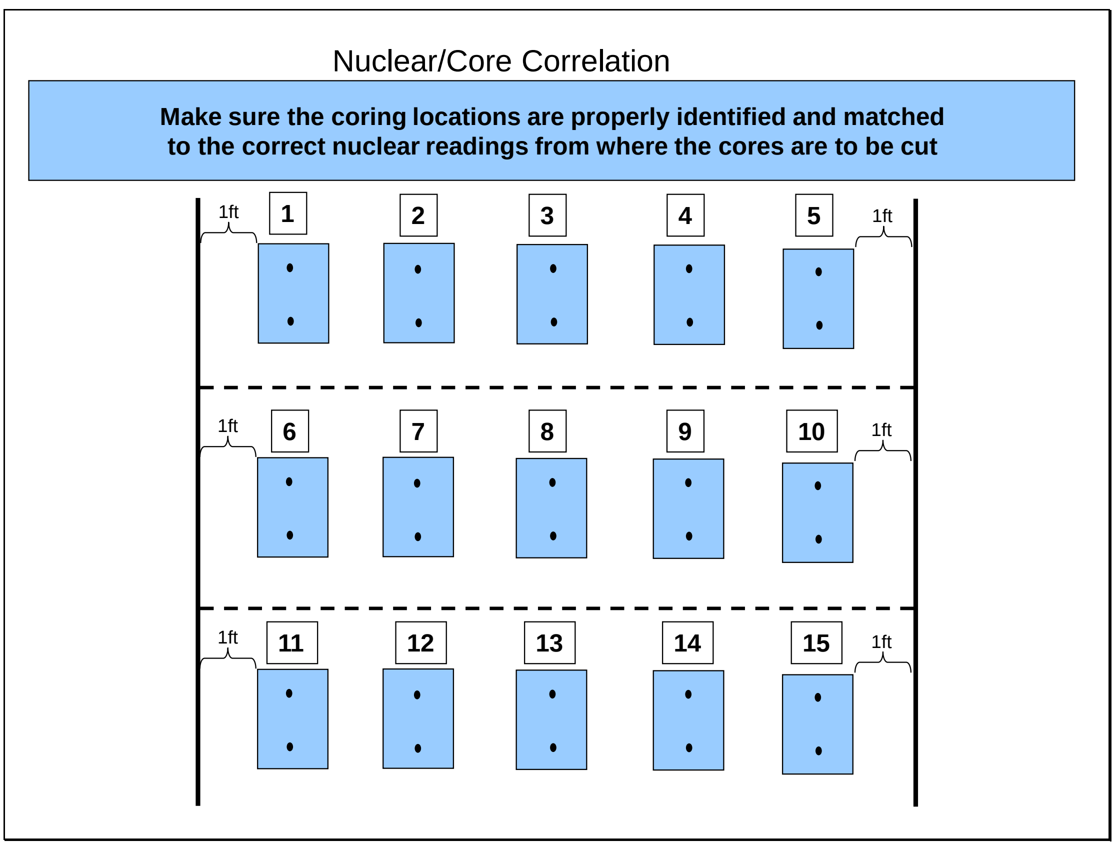

Nuclear/Core Correlation
1ft
1ft
Repeat the process for remaining 4 locations across the mat

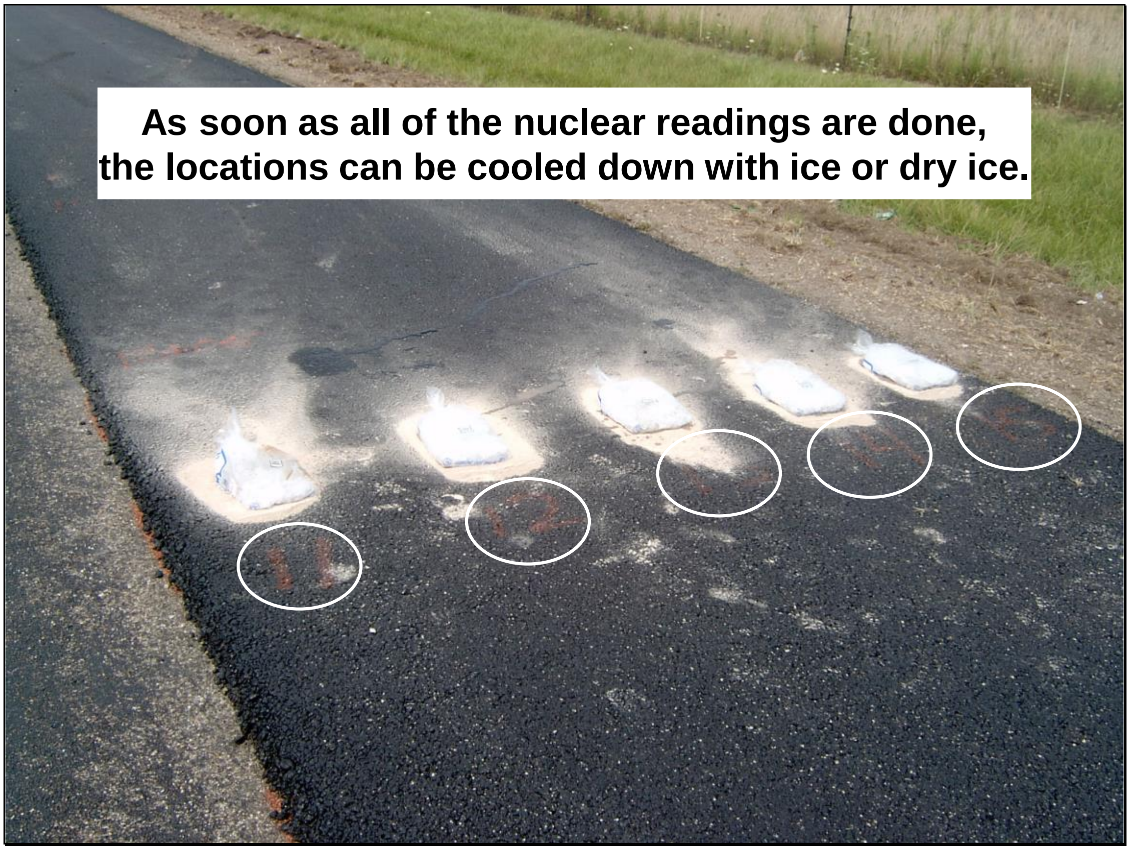

Nuclear/Core Correlation
Repeat the procedure for the second and third locations
1ft
1ft
1ft
1ft
1ft
1ft

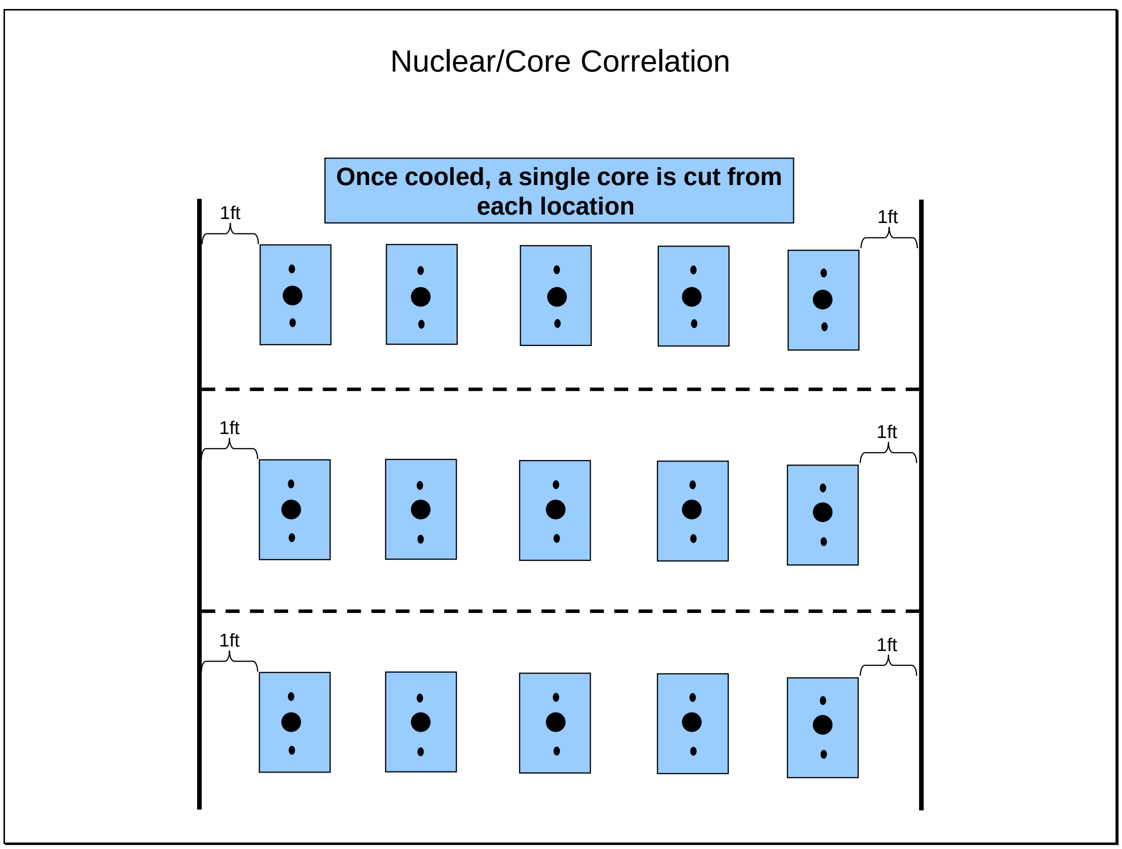

Nuclear/Core Correlation
1ft
1ft
1ft
1ft
1ft
1ft
First location area is from the first growth curve


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

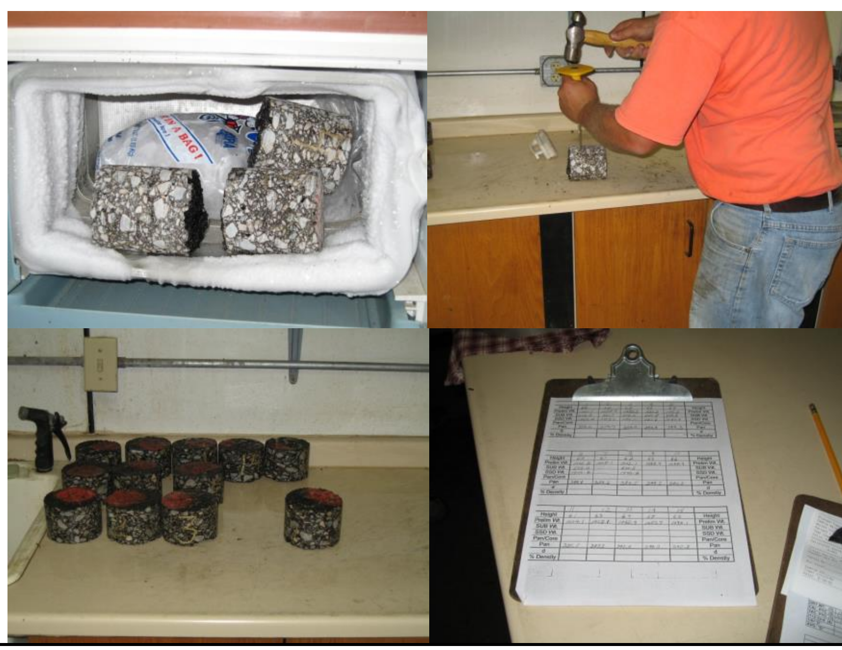

Nuclear/Core Correlation
1ft
1ft
Third location coincides with the truck from which the second plant sample is sampled from


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
6
7
8
9
10
11
12
13
14
15


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


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



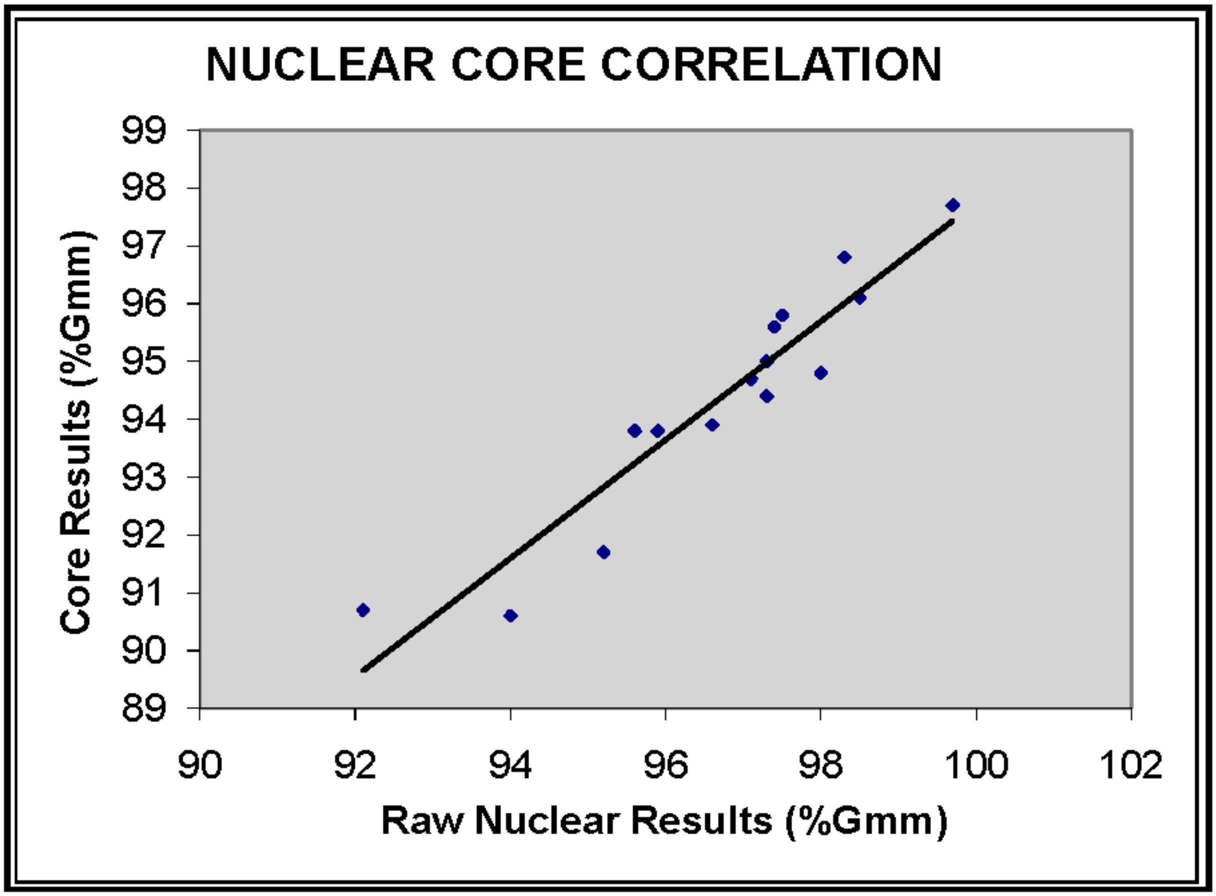
Lab Work – Running Core Densities



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.:	C9701424
Contract No.:	74226
RE:	M. Weidner
Material Code:	19523MR-9.5
Material Desc.:	BIT CONC SCS N70 C REC
Field Mix #:	87BIT1024
Test Date:	10/01/2024
Base Material:	Milled Surface
Lift Number:	0.1

Big D:	2.444



Regression output

Formula: Y = mX+b

m = 1.026
b = -117.9

ρ = 0.985

Statistical Data

Std Err of Y Est = 16.8
Reliability Factor = 0.947

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 #:	87BIT1024
Lift Number:	.1

Route:	IL 32
Section:	(1,2) RS-3
County:	Moultrie
Job No:	C9701424
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

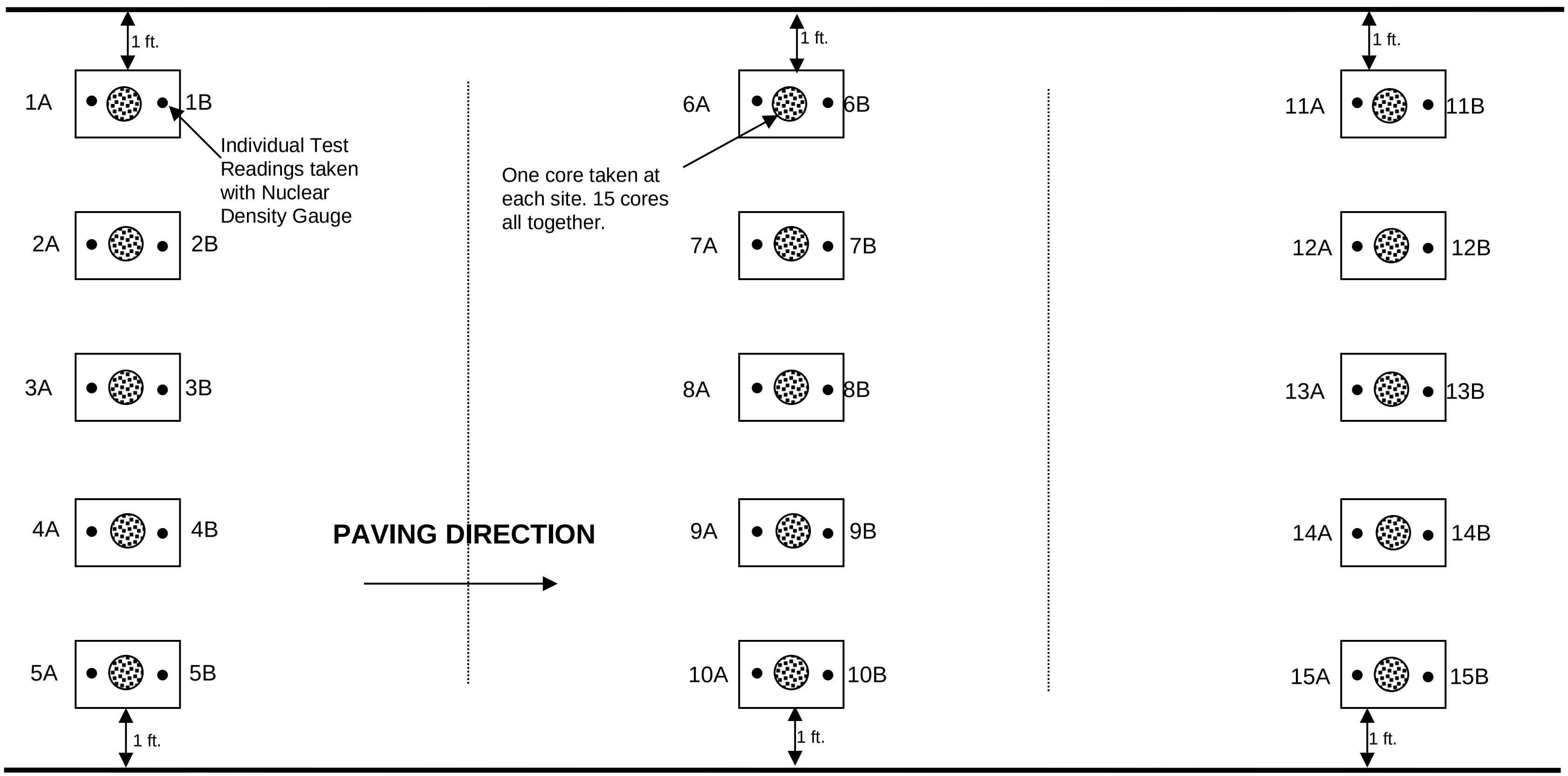
EXAMPLE OF COMPLETED NUCLEAR CORE CORRELATION

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/m³ [1.5 lbs/ft³].** If the 2 readings do not meet this criterion, one (1) additional reading shall be taken in the desired direction. The nuclear densities are to be recorded on the correlation form.

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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

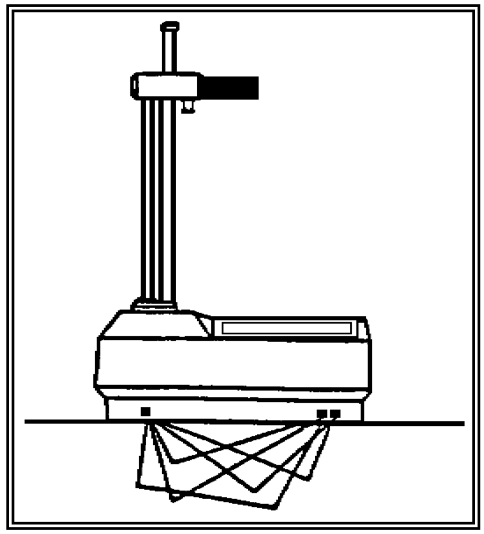
(1) Selecting Count Time - Most nuclear density gauges will allow the time for *test counts* to be set for 15 seconds, 1 minute, or 4 minutes. The confidence level of the gauge is affected by the length of time a *test count* is run. A 15 second *test count* will only provide a 37% confidence level.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

(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 30 for layout of random density test site locations with a nuclear gauge or cores on Hot Mix Asphalt, which requires different configurations based on confined/unconfined longitudinal joints. Refer to Article 1030.09 Section (b) (1) Required Density Tests, Paving.

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.

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MATERIAL CODES

CODE	MIX TYPE	GRADATION/ FRICTION	# GYRATIONS	INDIVIDUAL SPECIFICATION
19504	BINDER	19.0L	N30	93.0 [1/]- 97.4 %-
19504R	BINDER	19.0L (REC)	N30	93.0 [1/]- 97.4 %-
19505	SURFACE	C - 9.5L	N30	92.5 – 97.4 %
19505R	SURFACE	C - 9.5L (Rec)	N30	92.5 – 97.4 %
19510		4.75	N50	93.0 - 97.4 %
19510R		4.75 (Rec)	N50	93.0 - 97.4 %
19512	BINDER	19.0	N50	93.0 [1/]- 97.4 %-
19512R	BINDER	19.0 (Rec)	N50	93.0 [1/]- 97.4 %-
19513	SURFACE	C	N50	92.5 – 97.4 %
19513F	SURFACE	C FG	N50	93.0 – 97.4 %
19513FR	SURFACE	C FG (Rec)	N50	93.0 – 97.4 %
19513R	SURFACE	C (Rec)	N50	92.5 – 97.4 %
19514	SURFACE	D	N50	92.5 – 97.4 %
19514F	SURFACE	D - FG	N50	93.0 – 97.4 %
19514FR	SURFACE	D - FG (Rec)	N50	93.0 – 97.4 %
19514R	SURFACE	D (Rec)	N50	92.5 – 97.4 %
19515	SURFACE	E	N50	92.5 – 97.4 %
19515R	SURFACE	E (Rec)	N50	92.5 – 97.4 %
19516	SURFACE	F	N50	92.5 – 97.4 %
19516R	SURFACE	F (Rec)	N50	92.5 – 97.4 %
19522	BINDER	19.0	N70	93.0 [1/]- 97.4 %-
19522R	BINDER	19.0 (Rec)	N70	93.0 [1/]- 97.4 %-
19523	SURFACE,	C	N70	92.5 – 97.4 %
19523F	SURFACE	C-FG	N70	93.0 – 97.4 %
19523FR	SURFACE,	C-FG (Rec)	N70	93.0 – 97.4 %
19523R	SURFACE	C (Rec)	N70	92.5 – 97.4 %
19524	SURFACE,	D	N70	92.5 – 97.4 %
19524F	SURFACE	D-FG	N70	93.0 – 97.4 %
19524FR	SURFACE	D FG (Rec)	N70	93.0 – 97.4 %
19524R	SURFACE	D (Rec)	N70	92.5 – 97.4 %
19525	SURFACE	E	N70	92.5 – 97.4 %
19525R	SURFACE	E (Rec)	N70	92.5 – 97.4 %
19526	SURFACE	F	N70	92.5 – 97.4 %
19526R	SURFACE	F (Rec)	N70	92.5 – 97.4 %
19532	BINDER	19.0	N90	93.0 – 96.0 %
19532R	BINDER	19.0 (Rec)	N90	93.0 – 96.0 %
19533	SURFACE	C	N90	92.0 – 96.0 %
19533R	SURFACE	C (Rec)	N90	92.0 – 96.0 %
19534	SURFACE	D	N90	92.0 – 96.0 %
19534F	SURFACE	D-FG	N90	92.0 – 96.0 %

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

MATERIAL CODES (Continued)

CODE	MIX TYPE	GRADATION/ FRICTION	# GYRATIONS	INDIVIDUAL SPECIFICATION
19534FR	SURFACE	D-FG (Rec)	N90	93.0 – 97.4 %
19534R	SURFACE	D (Rec)	N90	92.0 – 96.0 %
19535	SURFACE	E	N90	92.0 – 96.0 %
19535R	SURFACE	E (Rec)	N90	92.0 – 96.0 %
19536	SURFACE	F	N90	92.0 – 96.0 %
19536R	SURFACE	F (Rec)	N90	92.0 – 96.0 %
19604	BINDER	9.5	N50	92.5 – 97.4 %
19604F	BINDER	9.5-FG	N50	93.0 – 97.4 %
19604FR	BINDER	9.5-FG (Rec)	N50	93.0 – 97.4 %
19604R	BINDER	9.5 (Rec)	N50	92.5 – 97.4 %
19605	BINDER	9.5	N70	92.5 – 97.4 %
19605F	BINDER	9.5-FG	N70	93.0 – 97.4 %
19605FR	BINDER	9.5-FG (Rec)	N70	93.0 – 97.4 %
19605R	BINDER	9.5-(Rec)	N70	92.5 – 97.4 %
19606	BINDER	9.5	N90	92.0 – 96.0 %
19606F	BINDER	9.5-FG	N90	93.0 – 97.4 %
19606FR	BINDER	9.5-FG (Rec)	N90	93.0 – 97.4 %
19606R	BINDER	9.5 R	N90	92.0 – 96.0 %
19647	SMA SURFACE	9.5 D	N50	93.5 -97.4 %
19647R	SMA SURFACE	9.5-D (Rec)	N50	93.5 -97.4 %
19650	SMA BINDER	12.5	N50	93.5 -97.4 %
19650R	SMA BINDER	12.5 (Rec)	N50	93.5 -97.4 %
19651	SMA SURFACE	12.5 C	N50	93.5 -97.4 %
19651R	SMA SURFACE	12.5-C (Rec)	N50	93.5 -97.4 %
19652	SMA SURFACE	12.5 D	N50	93.5 -97.4 %
19652R	SMA SURFACE	12.5-D (Rec)	N50	93.5 -97.4 %
19653	SMA BINDER	12.5	N80	93.5 -97.4 %
19653R	SMA BINDER	12.5 (Rec)	N80	93.5 -97.4 %
19654	SMA SURFACE	12.5 E	N80	93.5 -97.4 %
19654R	SMA SURFACE	12.5-E (Rec)	N80	93.5 -97.4 %
19655	SMA SURFACE	12.5-F	N80	93.5 -97.4 %
19655R	SMA SURFACE	12.5-F (Rec)	N80	93.5 -97.4 %
19664	SMA SURFACE	9.5-E	N80	93.5 -97.4 %
19664R	SMA SURFACE	9.5-E (Rec)	N80	93.5 -97.4 %
19665	SMA SURFACE	9.5-F	N80	93.5 -97.4 %
19665R	SMA SURFACE	9.5-F (Rec)	N80	93.5 -97.4 %

Notes:
For recycled mixes add an "R" after 5-digit code. - Example: 19534R
For Fine Graded Recycled mixes add an “FR” after 5-digit code – Example: 19534FR

HMA – Hot-Mix Asphalt
SMA – Stone Matrix Asphalt

Gauge No.	28769

m =	1.026
b =	-117.9

Formula Y = mX+b

Material Code:	19523 -9.5
Material Desc:	BIT CONC SCS N70 C REC
Field Mix #:	87BIT1024
Lift Number:	.1

Route:	IL 32
Section:	(1,2) RS-3
County:	Moultrie
Job No:	C9701424
Contract No.:	74226
RE:	M. Weidner

Actual Nuclear Reading	Adjusted Nuclear Reading
2251	2192
2252	2193
2253	2194
2254	2195
2255	2196
2256	2197
2257	2198
2258	2199
2259	2200
2260	2201
2261	2202
2262	2203
2263	2204
2264	2205
2265	2206
2266	2207
2267	2208
2268	2209
2269	2210
2270	2211
2271	2212
2272	2213
2273	2214
2274	2215
2275	2216
2276	2217
2277	2218
2278	2219
2279	2220
2280	2221
2281	2222
2282	2223
2283	2224
2284	2225
2285	2227
2286	2228
2287	2229
2288	2230
2289	2231
2290	2232
2291	2233
2292	2234
2293	2235
2294	2236
2295	2237
2296	2238
2297	2239
2298	2240
2299	2241
2300	2242

Actual Nuclear Reading	Adjusted Nuclear Reading
2301	2243
2302	2244
2303	2245
2304	2246
2305	2247
2306	2248
2307	2249
2308	2250
2309	2251
2310	2252
2311	2253
2312	2254
2313	2255
2314	2256
2315	2257
2316	2258
2317	2259
2318	2260
2319	2261
2320	2262
2321	2263
2322	2264
2323	2265
2324	2267
2325	2268
2326	2269
2327	2270
2328	2271
2329	2272
2330	2273
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2334	2277
2335	2278
2336	2279
2337	2280
2338	2281
2339	2282
2340	2283
2341	2284
2342	2285
2343	2286
2344	2287
2345	2288
2346	2289
2347	2290
2348	2291
2349	2292
2350	2293

Actual Nuclear Reading	Adjusted Nuclear Reading
2351	2294
2352	2295
2353	2296
2354	2297
2355	2298
2356	2299
2357	2300
2358	2301
2359	2302
2360	2303
2361	2304
2362	2306
2363	2307
2364	2308
2365	2309
2366	2310
2367	2311
2368	2312
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2375	2319
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2382	2326
2383	2327
2384	2328
2385	2329
2386	2330
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2389	2333
2390	2334
2391	2335
2392	2336
2393	2337
2394	2338
2395	2339
2396	2340
2397	2341
2398	2342
2399	2343
2400	2345

Actual Nuclear Reading	Adjusted Nuclear Reading
2401	2346
2402	2347
2403	2348
2404	2349
2405	2350
2406	2351
2407	2352
2408	2353
2409	2354
2410	2355
2411	2356
2412	2357
2413	2358
2414	2359
2415	2360
2416	2361
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2430	2375
2431	2376
2432	2377
2433	2378
2434	2379
2435	2380
2436	2381
2437	2382
2438	2383
2439	2385
2440	2386
2441	2387
2442	2388
2443	2389
2444	2390
2445	2391
2446	2392
2447	2393
2448	2394
2449	2395
2450	2396

Field Worksheet

DATE:	**09/11/2024**		
CONTRACT:	**74226**	**Gauge #**	**28769**
JOB #:	**C9701424**	**Layer Thickness**	**2.5"**
ROUTE:	**IL 32**	**Gmm**	**2.444**
BASE MATERIAL:	**Milled Surface**	(milled, binder, aggregate)	
MIX #:	**87BIT1024**	**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 ______

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Quality Assurance
Nuclear Density Report QC/QA

I.D. No. 1

Inspector No.	3	Date Sampled	4	Seq. No.	5	County	2
Bit Mix Plant	6	Bit Mix Code	7	Equip.	8 QA Y	Section	
Contract No.	9	Job No.	10	Target Dens.	11	Route	
Responsible Loc.	12	Lab	13	Standard Court	14	Project	

Start Date	15	Complete Date	16
Gauge #	17	Calib. Date	18
Mode	19	Probe Depth	20

Correlation Data
M=
B= 21

	Date Laid	Station	Ref	Lift No. (Thick)	Lit d (Gmb)	Big D (Gmm)	% Den	Result	Type Insp	Den Kg/m^3	Lot
1	22	23	24	25	26	27	28	29	30	31	32
2											
3											
4											
5											

REMARKS
1 33
2
3
4
5

34

Test No.	1			2			3			4			5		
Offset	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3
Average															

CC: 35 Tester 36 Agency 37
Inspector 38 Agency 39

MISTIC INPUT
Date Entered ____________
Initials ____________

'FOR DTY03303'
MI 303N QC/QA (Rev. 2/99)

This Page Is Reserved

QC/QA
IDOT BITUMINOUS NUCLEAR DENSITY TESTING REPORT FORM
INSTRUCTIONS MI303N FORM

1. **ID NO:** Leave blank MISTIC system will generate Test ID Number.

2. **PROJECT IDENTIFICATION:** Job stamp may be used

3. **SAMPLED BY:** Enter the identification number of the person taking the sample.

    A. **IDOT personnel** are to use their 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)

    <u>The field density LOT Prefix correlates with the plant LOT Prefix.</u>

    <u>However, the field density LOT Suffix identifies each random sample while the plant Lot Suffix is always "-01"</u>

    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**

THIS PAGE IS RESERVED.

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised Date: December 1, 2023

Standard Method of Test
for
Density of Asphalt Mixtures in Place by Nuclear Methods

Reference ASTM D 2950-22

5.2.1	Add the following at the end: The user should recognize that density readings obtained on the surface of thin layers of hot-mix asphalt (HMA) may be erroneous if the density of the underlying material differs significantly from that of the surface course.
5.2.2	Add the following at the end: Accuracy of the nuclear density test is affected by the surface texture and thickness of the mixture and most significantly affected by the underlying material. The number of tests required to determine a satisfactory factor are dependent on the conditions stated above.
5.5	Replace with the following: If samples of the measured material are to be taken for purposes of correlation with other test methods, the procedures described in the Department's "Procedure for Correlating Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt" shall be used.
6.5 New Section	*Readout Instrument,* such as scaler or direct readout meter.
8.1	Add the following at the end: Dated inspection reports shall be kept and be made available to the Engineer upon request.
8.1.1 New Section	The calibration check shall provide proof of five-block calibration. Calibration standards shall consist of magnesium, magnesium/aluminum, limestone, granite, and aluminum. All calibration standards should be traceable to the U.S. Bureau of Standards. Proof shall consist of documented and dated calibration counts accompanied by copies of an invoice from the calibrating facility.
8.1.2 New Section	At least once a year and after all major repairs which may affect the instrument geometry, the calibration curves, tables, or equation coefficients shall be verified or reestablished.
9.2.1	Replace with the following: The reference standard count shall be taken a minimum of 10 m (30 ft.) from another gauge and a minimum of 5 m (15 ft.) away from any other masses or other items which may affect the reference count rate. In addition, the reference count shall be taken on material 1510 kg/m^3 (100 lbs./ft.^{3}) or greater.

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised Date: December 1, 2023

Standard Method of Test
for
Density of Asphalt Mixtures in Place by Nuclear Methods

Reference ASTM D 2950-22

ASTM Section	***Illinois Modification***
9.2.2	Revise the first sentence as follows: Turn on the apparatus prior to standardization and allow it to stabilize, a minimum of 20 minutes.
9.2.3	Replace with the following: All reference standard counts shall consist of a 4-minute count.
9.2.4	Replace with the following: The density reference standard count shall be within 1 percent of the average of the last four daily reference standard counts.
9.2.5 New Section	If four reference standard counts have not been established, then the reference standard count shall be within 2 percent of the standard count shown in the count ratio book.
9.2.6 New Section	If the reference standard count fails the established limits, the count may be repeated. If the second count fails also, the gauge shall not be used. The gauge shall be adjusted or repaired as recommended by the manufacturer.
9.2.7 New Section	Record all daily reference standard counts in a permanent-type book for a gauge historical record. This also applies to direct readout gauges.
9.3	Delete the first sentence.
10.1	Revise as follows: In order to provide more stable and consistent results: (1) turn on the instrument prior to use to allow it to stabilize, a minimum of 20 minutes; and (2) leave the power on during the day's testing.

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised Date: December 1, 2023

Standard Method of Test
for
Density of Asphalt Mixtures in Place by Nuclear Methods

Reference ASTM D 2950-22

ASTM Section	***Illinois Modification***
10.3	Replace with the following: Select a test location, using the Department's "Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations". Each random density test site location shall consist of five equally spaced nuclear density offsets across the mat. These density offsets shall be positioned to provide a diagonal configuration across the mat. The outer density offsets shall be located at a distance equal to 4 in. (100 mm) from the edge of the mat. • If the edge is unconfined, an “individual test result” shall represent the average of three “density readings” spaced 10 feet apart longitudinally along the unconfined edge. • If the edge is confined, the density reading will be averaged with the remaining offset “density readings” to provide an “individual test result” representing everything except unconfined edges.
10.4	Replace with the following: Maximum contact between the base of the instrument and the surface of the material under test is critical. Since the measured value of density by backscatter is affected by the surface texture of the material immediately under the gauge, a smoothly rolled surface should be tested for best results. A filler of limestone fines or similar material, leveled with the guide/scraper plate, shall be used to fill open surface pores of the rolled surface.
10.5	Replace with the following: Place the source in the proper position. All other radioactive sources shall be kept at least 10 m (30 ft.) from the gauge so the readings will not be affected.
Note 7	Delete
10.6	Delete
10.7	Delete
10.8	Delete
Note 8	Delete
Note 9	Delete

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised Date: December 1, 2023

Standard Method of Test
for
Density of Asphalt Mixtures in Place by Nuclear Methods

Reference ASTM D 2950-22

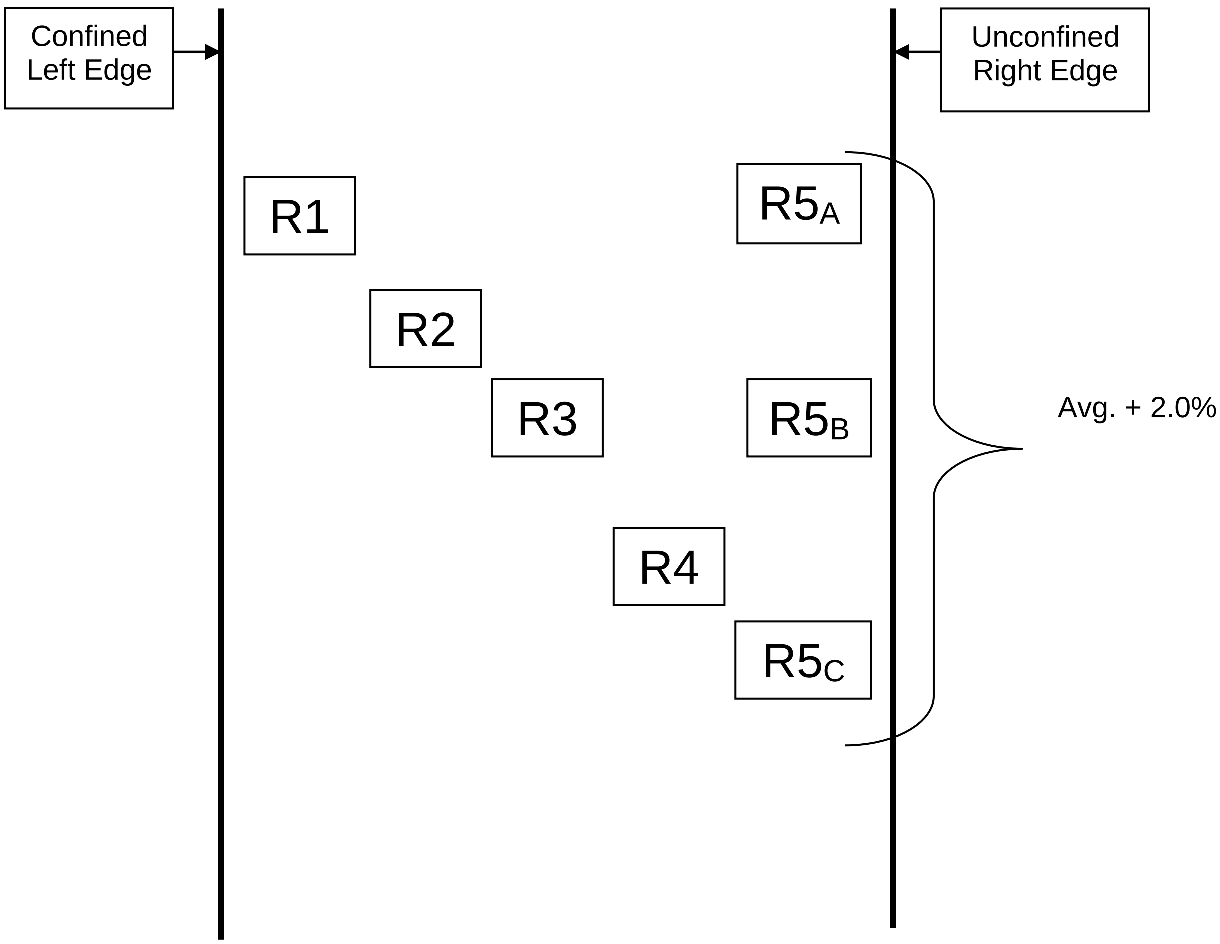
ASTM Section	***Illinois Modification***
11.1	Replace with the following: Determine the in-place density according to the methods stated herein.
11.1.1	Delete.
11.2	Delete.
12.1.1	Replace with the following: Gauge number,
12.1.2	Revise as follows: Date of calibration data,
12.1.5	Revise as follows: Density test site description as follows: (1) project identification number, (2) location, including station and reference to centerline, (3) mixture type(s), including mix design number and surface texture, e.g., open, smooth, roller-tracked, etc., and (4) number and type of rollers
12.1.6	Replace with the following: Layer (bottom lift = .1, second lift = .2, etc.) and thickness of layer,

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised Date: December 1, 2023

Standard Method of Test
for
Density of Asphalt Mixtures in Place by Nuclear Methods

Reference ASTM D 2950-22

Figure 1.



$$\text{Department Density Verification Test (\%)} = \frac{R1 + R2 + R3 + R4 + \left(\left(\frac{R5_A + R5_B + R5_C}{3}\right) + 2.0\right)}{5}$$

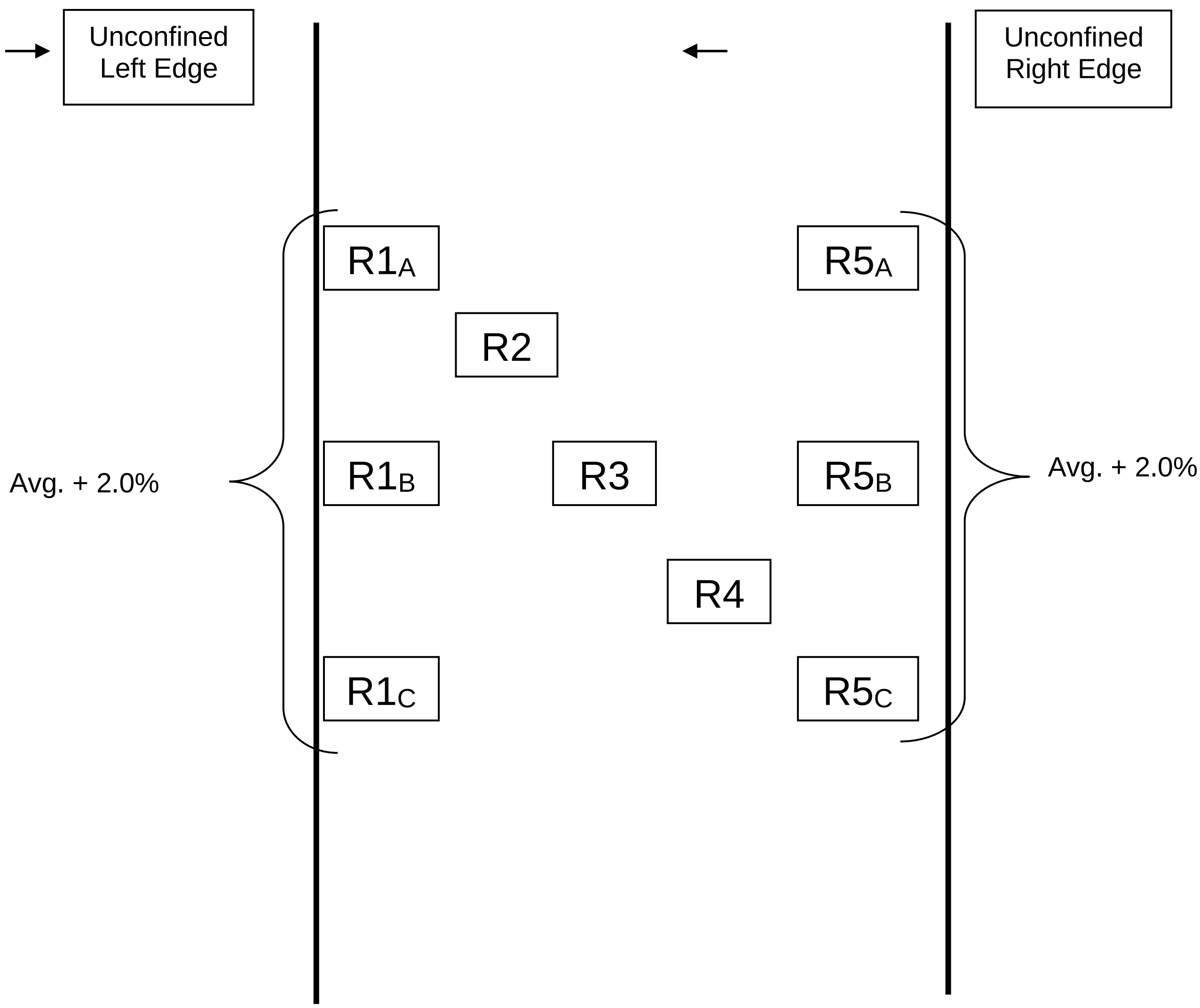
Where R1, R2, R3, R4, $R5_A$, $R5_B$, and $R5_C$ represent nuclear density readings.

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised Date: December 1, 2023

Standard Method of Test
for
Density of Asphalt Mixtures in Place by Nuclear Methods

Reference ASTM D 2950-22

Figure 2.



$$\text{Department Density Verification Test (\%)} = \frac{\left(\left(\frac{R1_A + R1_B + R1_C}{3}\right) + 2.0\right) + R2 + R3 + R4 + \left(\left(\frac{R5_A + R5_B + R5_C}{3}\right) + 2.0\right)}{5}$$

Where $R1_A$, $R1_B$, $R1_C$, R2, R3, R4, $R5_A$, $R5_B$, and $R5_C$ represent nuclear density

Designation: D2950/D2950M – 22

Standard Test Method for Density of Asphalt Mixtures in Place by Nuclear Methods[1]

This standard is issued under the fixed designation D2950/D2950M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method describes a test procedure for determining the density of asphalt mixtures by the attenuation of gamma radiation, where the source and detector(s) remain on the surface (backscatter method) or the source or detector is placed at a known depth up to 300 mm [12 in.] while the detector or source remains on the surface (direct transmission method).

1.2 The density, in mass per unit volume of the material under test, is determined by comparing the detected rate of gamma emissions with previously established calibration data.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.4 All observed and calculated values shall conform to the guide for significant digits and rounding established in Practice D6026.

1.5 For limitations, see Section 5 on Interferences.

1.6 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard. It is the recommendation of Committee D04 that the following note be added to the end of the Significance and Use section of all applicable standards. Applicable standards are those in which measurement or calibration are made, sample are procured, or products are selected. The subcommittee shall determine the appropriateness of adding the note throughout the consensus process.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific warning statements, see Section 7.

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
D8 Terminology Relating to Materials for Roads and Pavements
D1188/D1188M Test Method for Bulk Specific Gravity and Density of Compacted Asphalt Mixtures Using Coated Samples
D2041/D2041M Test Method for Theoretical Maximum Specific Gravity and Density of Asphalt Mixtures
D2726/D2726M Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Asphalt Mixtures
D3665 Practice for Random Sampling of Construction Materials
D3666 Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
D6026 Practice for Using Significant Digits and Data Records in Geotechnical Data
D6752/D6752M Test Method for Bulk Specific Gravity and Density of Compacted Asphalt Mixtures Using Automatic Vacuum Sealing Method
D6926 Practice for Preparation of Asphalt Mixture Specimens Using Marshall Apparatus
D7013/D7013M Guide for Calibration Facility Setup for Nuclear Surface Gauges
D7759/D7759M Guide for Nuclear Surface Moisture and Density Gauge Calibration

[1] This test method is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.21 on Specific Gravity and Density of Asphalt Mixtures.

Current edition approved Dec. 15, 2022. Published January 2023. Originally approved in 1971. Last previous edition approved in 2014 as D2950/D2950M – 14. DOI: 10.1520/D2950_D2950M-22.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3. Terminology

3.1 *Definitions*—See Terminology D8 for general definitions.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *detector, n*—a device to detect and measure radiation.

3.2.2 *gamma (radiation) source, n*—a sealed source of radioactive material that emits gamma radiation as it decays.

3.2.3 *nuclear gauge, n*—a device containing one or more radioactive sources used to measure certain properties of asphalt mixtures.

3.2.4 *test count, n*—the measured output of a detector for a specific type of radiation for a given test.

4. Significance and Use

4.1 The test method described is useful as a rapid, nondestructive technique for determining the in-place density of compacted asphalt mixtures.

4.2 With proper calibration and confirmation testing, the test method is suitable for quality control and acceptance testing of compacted asphalt mixtures.

4.3 The test method can be used to establish the proper rolling effort and pattern to achieve the required density.

4.4 The nondestructive nature of the test allows repetitive measurements to be made at a single test location between roller passes and to monitor changes in density.

4.5 The density results obtained by this test method are relative. Correlation with other test methods such as D1188/D1188M, D2726/D2726M, or D6752/D6752M is required to convert the results obtained using this method to actual density. It is recommended that at least seven core densities and seven nuclear densities be used to establish a conversion factor. A new factor must be established at any time a change is made in the paving mixture or in the construction process.

NOTE 1—The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of Specification D3666 are generally considered capable of competent and objective testing, sampling, inspection, etc. Users of this standard are cautioned that compliance with Specification D3666 alone does not completely ensure reliable results. Reliable results depend on many factors; following the suggestions of Specification D3666 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.

5. Interferences

5.1 The chemical composition of the material being tested may significantly affect the measurement, and adjustments may be necessary. Certain elements with atomic numbers greater than 20 may cause erroneously high test values.

5.2 The test method exhibits spatial bias in that the instrument is most sensitive to the density of the material in closest proximity to the nuclear source.

5.2.1 When measuring the density of an overlay, it may be necessary to employ a correction factor if the underlying material varies in thickness, mineral composition, or degree of consolidation at different points within the project. (See Annex A1.)

5.2.2 The surface roughness of the material being tested may cause lower than actual density determination.

5.3 Oversize aggregate particles in the source-detector path may cause higher than actual density determination.

5.4 The sample volume being tested is approximately 0.0028 m^3 [0.0989 ft^3] for the backscatter method and 0.0056 m^3 [0.198 ft^3] for the direct transmission method. The actual sample volume varies with the apparatus and the density of the material.

NOTE 2—The volume of field-compacted material represented by a test can be effectively increased by repeating the test at adjacent locations and averaging the results.

5.5 If samples of the measured material are to be taken for purposes of correlation with other test methods such as D1188/D1188M, D2726/D2726M, or D6752/D6752M, the volume measured can be approximated by a 200 mm [8 in.] diameter cylinder located directly under the center line of the radioactive source and detector(s). The height of the cylinder to be excavated will be the depth setting of the source rod when using the direct transmission method or approximately 75 mm [3 in.] when using the backscatter method (Note 3).

NOTE 3—If the layer of an asphalt mixture to be measured is less than the depth of measurement of the instrument, corrections must be made to the measurements to obtain accurate results due to the influence of the density of the underlying material. (See Annex A1 for the method used.)

6. Apparatus

6.1 *Nuclear Device*—An electronic counting instrument, capable of being seated on the surface of the material under test, and which contains:

6.1.1 *Gamma Source*—A sealed high-energy gamma source such as cesium or radium, and

6.1.2 *Gamma Detector*—Any type of gamma detector such as a Geiger-Mueller tube(s).

6.2 *Reference Standard*—A block of dense material used for checking instrument operation and to establish conditions for a reproducible reference-count rate.

6.3 *Scraper Plate*—A metal plate, straightedge, or other suitable leveling tool which may be used to level the test site to the required smoothness using fine sand or similar material.

6.4 *Drive Pin*—A steel rod of slightly larger diameter than the rod in the direct transmission instrument, to prepare a perpendicular hole in the material under test for inserting the rod. A drill may also be used.

7. Hazards

7.1 This equipment utilizes radioactive materials which may be hazardous to the health of the users unless proper precautions are taken. Users of this equipment must become familiar with applicable safety procedures and government regulations.

7.2 Effective user instructions together with routine safety procedures, such as source leak tests, recording and evaluation of film badge data, etc. are a recommended part of the operational guidelines for the use of this instrument.

7.3 A regulatory agency radioactive materials license may be required to possess this equipment.

8. Calibration

8.1 Calibrate the instrument in accordance to Guides D7759/D7759M and D7013/D7013M.

8.2 *Calibration Adjustments*—The calibration response shall be checked by the user prior to performing tests on materials that are distinctly different from the material types used in establishing the calibration curve. The calibration response shall also be checked on newly acquired or repaired apparatus. Take a sufficient number of measurements and compare them to other accepted methods (such as Test Method D1188/D1188M, D2726/D2726M, or D6752/D6752M) to establish a correlation.

9. Standardization and Reference Check

9.1 Nuclear test devices are subject to long-term aging of the radioactive source, detectors, and electronic systems, which may change the relationship between count rate and material density. To offset this aging, the apparatus may be standardized as the ratio of the measured count rate to a count rate made on a reference standard. The reference count rate should be of the same order of magnitude as the measured count rate over the useful density range of the apparatus.

9.2 Standardization of equipment should be performed at the start of each day's work, and a permanent record of this data retained.

9.2.1 Perform the standardization with the apparatus located at least 10 m [33 ft] away from other sources of radioactivity and clear of large masses or other items which may affect the reference count rate.

NOTE 4—The user is advised that the value given in 9.2.1 is intended as a minimum distance for nuclear sources typical in surface moisture/density gauges. The user should consider requiring a greater distance if other nuclear sources of greater activity are present.

9.2.2 Turn on the apparatus prior to standardization and allow it to stabilize. Follow the manufacturer's recommendations in order to provide the most stable and consistent results.

9.2.3 Using the reference standard, take at least four repetitive readings at the normal measurement period and determine the mean. If available on the apparatus, one measurement period of four or more times the normal period is acceptable. This constitutes one standardization check.

9.2.4 If the value obtained in 9.2.3 is within the following stated limits, the apparatus is considered to be in satisfactory operating condition and the value may be used to determine the count ratios for the day of use. If the value is outside these limits, allow additional time for the apparatus to stabilize, make sure the area is clear of sources of interference, and then conduct another standardization check. If the second standardization check is within the limits, the apparatus may be used, but if it also fails the test, the apparatus shall be adjusted or repaired as recommended by the manufacturer. The limits are as follows:

$$|N_s - N_o| \le 2.0\sqrt{N_o/F} \quad (1)$$

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 5—The count per measurement periods shall be the total number of gammas detected during the timed period. The displayed value must be corrected for any prescaling which is built into the instrument. The prescale value (F) is a divisor which reduces the actual value for the purpose of display. The manufacturer will supply this value if other than 1.0.

9.3 Use the value of N_s to determine the count ratios for the current day's use of the instrument. If for any reason the measured density becomes suspect during the day's use, perform another standardization check.

NOTE 6—See Annex A2 for more information on evaluating gauge standardization.

10. Procedure

10.1 In order to provide more stable and consistent results: (*1*) turn the instrument on prior to use to allow it to stabilize, and (*2*) leave the power on during the day's testing.

10.2 Standardize the apparatus.

10.3 Select a test location in accordance with the project specifications, or, if not otherwise specified, in accordance with Practice D3665. If the instrument will be closer than 1 m [3 ft] to any vertical mass that may influence the result, follow the instrument manufacturer's correction procedure.

10.4 Maximum contact between the base of the instrument and the surface of the material under test is critical. The maximum void shall not exceed 6 mm [¼ in.]. Use native fines or fine sand to fill the voids and level with the guide/scraper plate.

10.5 For the direct transmission method, use the guide/scraper plate and drive the drive pin to a depth of at least 25 mm [1 in.] deeper than the desired measurement depth.

NOTE 7—Extreme care must be taken when driving the drive pin into a compacted asphalt mixture, as it may cause a disturbance of the material which could cause errors in the measurement. Drilling may be more suitable.

10.6 Place the source in the proper position. For the direct transmission method measurements, move the instrument so that the rod is firmly against the side of the hole in the gamma measurement path.

10.7 Take a count for the normal measurement period. If the backscatter method using the air gap technique is used, take an additional measurement in the air-gap position as recommended by the manufacturer. (See Note 3.)

10.8 Determine the ratio of the reading to the standard count or the air-gap count. From this ratio and the calibration and adjustment data, determine the in-place density. (See Note 8 and Note 9.)

NOTE 8—Some instruments have built-in provisions to compute the ratio, bulk (or wet) density, and allow an adjustment bias.

NOTE 9—If the depth of an asphalt mixture layer under test is less than the depth of measurement of the instrument, the value obtained in 10.8 must be adjusted. (See Annex A1.)

NOTE 10—Do not leave the gauge on a hot surface for more than 1 min after completion of a measurement. Prolonged high temperatures may adversely affect the instrument's electronics. The gauge should be allowed to cool between measurements.

11. Calculation of Results

11.1 Using the calibration chart, calibration tables, or equation and coefficients, or instrument direct readout feature with appropriate calibration adjustments, determine the in-place density. This is the bulk (or wet) density.

11.1.1 An adjustment bias can be calculated by comparing the results from a number of instrument measurements to the results obtained using Test Method D1188/D1188M, D2726/D2726M, or D6752/D6752M.

11.2 Compare the results obtained to samples compacted by Test Method D6926 or with the results of test methods such as D2041/D2041M to determine acceptability (percentage of compaction).

12. Report

12.1 Report the following information:

12.1.1 Make, model, and serial number of the test apparatus,

12.1.2 Date and source of calibration data,

12.1.3 Date of test,

12.1.4 Standard count for the day of the test,

12.1.5 Test site description including project identification number, location, and mixture type(s),

12.1.6 Thickness of layer tested and any adjustment bias,

12.1.7 Method of measurement (backscatter or direct transmission), depth, count rate, calculated density of each measurement and any adjustment data, and

12.1.8 Percentage of compaction, if required.

13. Precision and Bias[3]

13.1 *Precision:*

13.1.1 Precision is based on a field experiment in 2008 that used six gauges from five manufacturers. Materials included Superpave 9.5, 12.5, 19.0, and 37.5 HMA used on a construction project sponsored by the New York DOT. Density varied from 127.8 to 149.1 lb/ft^3 [2047.16 to 2388.35 kg/m^3] with mean of 138.07 lb/ft^3 [2211.68 kg/m^3] and standard deviation 3.9 lb/ft^3 [62.47 kg/m^3]. Each test with a single gauge was conducted by the same operator, therefore, single-operator precision for this statement is also considered to be single-gauge precision if conducted by the same operator.

13.1.2 *Single-Operator Precision*—The single-operator standard deviation has been found to be 1.57 lb/ft^3 [25.15 kg/m^3].[4] Therefore, results of two properly conducted tests by the same operator on the same material should not differ by more than 4.4 lb/ft^3 [70.48 kg/m^3].[4]

13.1.3 *Multilaboratory Precision*—The multilaboratory standard deviation has been found to be 1.75 lb/ft^3 [20.03 kg/m^3].[4] Therefore, results of two properly conducted tests from two different laboratories on the same material should not differ by more than 4.9 lb/ft^3 [78.49 kg/m^3].[4]

13.2 *Bias:*

13.2.1 No information can be presented on the bias of the procedure in Standard Test Method for Density of Asphalt Mixtures in Place by Nuclear Methods for measuring density as no material having an accepted reference value is available.

NOTE 11—With regards to the bias statement above, any user may elect to conduct a comparison of these gauges related to the laboratory measured value from core samples. Gauge measurements should be taken directly on the location of the pavement where cores will be cut.

14. Keywords

14.1 asphalt mixture density; density; in-place density; nuclear test method

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D04-1032. Contact ASTM Customer Service at service@astm.org.

[4] These numbers represent, respectively, the (1s) and (d2s) limits as described in Practice C670.

ANNEXES

(Mandatory Information)

A1. DETERMINATION OF DEPTH OF MEASUREMENT

A1.1 The depth of measurement is characteristic of a particular instrument design and may be defined as that depth, measured from the surface, at which a significant change in density will not result in change in the measurement.

A1.1.1 Determine the depth by measuring the apparent density of top layers of uniform density but varying thicknesses placed over a base layer having a highly different density. Vary the thickness of the top layer until a constant density as determined by the instrument is reached (Note A1.2).

NOTE A1.1—For lift thicknesses of 51 mm [2 in.] or less, the backscatter mode is suggested; for lift thicknesses greater than 51 mm [2 in.] the direct transmission mode is suggested. Thin lift gauges can be used for lift thicknesses up to 102 mm [4 in.].

NOTE A1.2—Materials such as magnesium and aluminum in sheet form have proven to be satisfactory for the top layer. Blocks of magnesium and aluminum used as calibration standards are useful as the base material.

A1.1.2 Plot the results on graph paper and determine the depth at which the apparent measured density is equal to the calculated density. This determination should be made for both a lower density material and a higher density material as the top layer. The depth of measurement is the average of the two results.

A2. EVALUATING GAUGE STANDARDIZATION

A2.1 The Poisson distribution of nuclear decay events, the half-life of the isotope used for the measurements, and other electronic and mechanical sources of variance all contribute to the variability and change in gauge standardization counts over time.

A2.2 The purpose of the daily standardization count is twofold: to compensate for the temporal effects on the gauge count rate, and to aid in identifying unacceptable levels of change in gauge response.

A2.3 In-place density properties of the asphalt under test are determined by first dividing the measurement count by the standardization count. The resulting ratio is then used as the dependent variable in the calibration equation to determine the in-place density of the asphalt.

A2.4 Because the ratio described in A2.3 is used to evaluate the aforementioned properties of the asphalt, any sources of multiplicative changes to the nuclear counting properties of the gauge, such as source strength decay over time, are canceled and have little to no effect on gauge measurements.

A2.5 Other phenomena can have additive or subtractive effects on the count rate, however, which can bias the counts and can result in inaccurate measurements by the gauge.

A2.6 Daily standardization counts are initially evaluated as follows:

A2.6.1 The density count taken on a given day is compared to the respective average of the four preceding standardization counts.

A2.6.2 If the density standardization count falls within ±1 % of the average density counts, then the density standardization count is acceptable.

A2.6.3 If the standardization count fails to meet these limits, it is typically because an excessive amount of time has passed between consecutive standardization counts and natural source decay prevents meeting this criteria. Evaluate the density standardization count in the following manner:

A2.7 If the standardization count is outside the limits set by Eq A2.1 and Eq A2.2, repeat the standardization check. If the second standardization check satisfies Eq A2.1, the gauge is considered to be in satisfactory operating condition.

$$0.98(N_{dc})e^{\frac{-t(\ln(2))}{T_{d(1/2)}}} < N_{d0} < 1.02(N_{dc})e^{\frac{-t(\ln(2))}{T_{d(1/2)}}} \quad (A2.1)$$

where:

$T_{d(1/2)}$ = half-life of the isotope that is used for the density determination in the gauge. For example, for ^{137}Cs, the radioactive isotope most commonly used for density determination in these gauges, $T_{d(1/2)}$, is 11 023 days,
N_{dc} = density system standardization count acquired at the time of the last calibration or verification,
N_{d0} = current density system standardization count,
t = time that has elapsed between the current standardization test and the date of the last calibration or verification. The units selected for t, $T_{d(1/2)}$, and $T_{m(1/2)}$ should be consistent, that is, if $T_{d(1/2)}$ is expressed in days, then t should also be expressed in days,
$ln(2)$ = the natural logarithm of 2, which has a value of approximately 0.69315, and
e = the inverse of the natural logarithm function, which has a value of approximately 2.71828.

A2.7.1 The limits for Eq A2.1 are based on the exponential decay equation for isotopes of a known half-life. They provide a ±2 % range around the theoretical standardization count at the time of the reading based on the standardization count at the time of calibration. This range is based on the expanded uncertainty of the gauge count response for a properly functioning gauge.

A2.7.2 Calibration reports for these gauges typically come with a table that indicates the ±2 % range of density standardization counts for a period of approximately one year after the time of calibration.

A2.7.3 *Example*—A nuclear gauge containing a ^{137}Cs source for density determination (half-life = 11 023 days) is calibrated on March 1 of a specific year. At the time of calibration, the density standard count was 2800 counts per minute (prescaled). According to Eq A2.1, what is the allowed range of standard counts for November 1 of the same year?

A2.7.3.1 For this example, a total of 245 days have elapsed between the date of calibration or verification (March 1) and the date of the gauge standardization (November 1). Therefore:

t = 245 days,
$T_{d(1/2)}$ = 11 023 days,
$T_{m(1/2)}$ = 157 788 days,
N_{dc} = 2800 counts, and
N_{mc} = 720 counts.

A2.7.3.2 According to Eq A2.1, therefore, the lower limit for the density standard count taken on November 1, denoted by N_{d0}, is:

$$0.98(N_{dc})e\frac{-t(\ln(2))}{T_{d(1/2)}} = 0.98(2800)e\frac{-245(\ln(2))}{11\ 023} = 2744e^{-0.01541} = 2702 \text{ counts} \quad (A2.2)$$

A2.7.3.3 Likewise, the upper limit for the density standard count taken on November 1, denoted by N_{d0}, is:

$$1.02(N_{dc})e\frac{-t(\ln(2))}{T_{d(1/2)}} = 1.02(2800)e\frac{-245(\ln(2))}{11\ 023} = 2856e^{-0.01541} = 2812 \text{ counts} \quad (A2.3)$$

A2.7.3.4 Therefore, the density standardization count acquired on November 1 should lie somewhere between 2702 and 2812 counts, or $2702 \leq N_{d0} \leq 2812$.

A2.8 If the standardization count fails to meet the limits described in A2.6.2, and additionally the standardization count fails to meet the limits described in A2.7, the functionality of the gauge or the accuracy of the calibration, or both, may be compromised. Under these circumstances, the gauge should be removed from service until the source of the discrepancy can be identified and corrected. Repairs or modifications to the gauge will require verification of the existing calibration of the gauge, or a calibration of the gauge, as described in Guide D7759/D7759M.

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Random density test locations will be determined at the frequency specified in the Standard Specification Articles 1030.07 and 1030.08. Cores shall be collected by the Contractor at these locations and secured by the Department for testing. The test locations will be determined as follows:

A) Prior to paving, the test locations will be determined by the Engineer using the "Random Numbers" table as specified herein or the Department's Quality Management Program (QMP) Package software. The values are to be considered confidential and are not to be disclosed to anyone outside of the Department until finish rolling is complete. Disclosing the information prior to finish rolling would be in direct violation of federal regulations. Once random test locations are determined by the Engineer, it may be necessary to alter these locations due to quantity adjustments, sequencing changes, or other alterations made by the Department or Contractor. The Engineer will document any changes to the random test locations and provide documentation to the Contractor upon completion of the project.

Each test location will be randomly located both longitudinally and transversely within each density interval by using two random numbers. The first random number is used to determine the longitudinal distance to the nearest 1 ft (300 mm) into the density testing interval. The second random number is used to determine the transverse offset to the nearest 0.1 ft (30 mm) from the left edge of the **paving lane**. The direction of the **paving lane** will be the same as the direction of traffic.

Longitudinal Location: Determine the random longitudinal location by multiplying the length of the prescribed density interval by the random number selected from the Random Numbers table.

Transverse Offset to Center of Core: Determine the random transverse offset as follows:

1. PFP. The effective lane width of the paving lane will be used in calculating the transverse offset. The effective lane width is determined by first subtracting 1.0 ft (300 mm) for each unconfined edge from the entire paved lane width (i.e. If a 12.0 ft (3.7 m) wide paved lane has two unconfined edges, the effective lane width would be 10.0 ft (3.0 m).) The effective lane width is reduced by 1.0 ft (300 mm) for each confined longitudinal joint with longitudinal joint sealant (LJS) (i.e. If a 12.0 ft (3.7 m) wide paved lane has one unconfined edge without LJS and one confined edge with LJS, the effective lane width would be 10.0 ft (3.0 m).) The effective lane width is reduced by 4.0 in. (100 mm) for each confined edge without LJS. The effective lane width is further reduced 4.0 in. (100 mm) for the diameter of the core barrel.

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Effective lane width of PFP pavement = pavement lane width – 1.0 ft (300 mm) for each unconfined/LJS edge – 4.0 in. (100 mm) for each confined non LJS edge – 4.0 in. (100 mm) for core barrel

The transverse offset is determined by first multiplying the effective lane width by the selected random number. If the left edge is unconfined or located immediately above LJS, 1.0 ft (300 mm) will be added to the calculated transverse offset measurement. If the left edge is confined but without LJS, 4.0 in. (100 mm) will be added to the calculated transverse offset measurement. An additional 2 in. (50 mm) will be added to the calculated transverse offset measurement to account for the distance from the edge of the core barrel to the center of core. The transverse offset is measured from the left physical edge of the paved lane to locate the center of the core on the pavement.

Transverse Offset to Center of Core = effective lane width x random number + 1.0 ft (300 mm) if left edge is unconfined/LJS edge + 4.0 in. (100 mm) if left edge is confined non LJS edge + 2.0 in. (50 mm) for core barrel

Areas outside the mainline pavement that are paved concurrently with the mainline pavement (i.e. 3 ft (1 m) wide shoulders, driveways, etc.) are not considered part of the paved mainline mat. See the PFP example calculation herein.

Additionally, the longitudinal joint density test locations of a paved lane with one or both unconfined edges without LJS will be determined by multiplying each sublot length for each unconfined, non-LJS edge by a random number. The transverse locations of the longitudinal joint density coring will be centered at a distance of 4.0 in. (150 mm) plus 2.0 in. (50 mm) (to account for the distance from the edge of the core barrel to the center of core) from each unconfined, non-LJS edge. See the PFP example calculation herein.

2. QCP. The effective lane width of the paving lane will be used in calculating the transverse offset. The effective lane width is determined by first subtracting 1.0 ft (300 mm) for each longitudinal joint with LJS from the entire lane width. The effective lane width is then reduced 4.0 in. (100 mm) for each joint that does not have LJS. The effective lane width is further reduced by 4.0 in. (100 mm) for the diameter of the core barrel.

Effective lane width of QCP pavement = pavement lane width – 1.0 ft (300 mm) for each edge with LJS – 4.0 in. (100 mm) for each edge without LJS – 4.0 in. (100 mm) for core barrel

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The transverse offset is determined by first multiplying the effective lane width by the selected random number. If the left edge is located immediately above LJS, 1.0 ft (300 mm) will be added to the calculated transverse offset measurement. If the left edge is confined but without LJS, 4.0 in. (100 mm) will be added to the calculated transverse offset measurement. An additional 2 in. (50 mm) will be added to the calculated transverse offset measurement to account for the distance from the edge of the core barrel to the center of core. The transverse offset is measured from the left physical edge of the paved lane to locate the center of the core on the pavement.

Transverse Offset to Center of Core = effective lane width x random number + 1.0 ft (300 mm) if left edge has LJS + 4.0 in. (100 mm) if left edge does not have LJS + 2.0 in. (50 mm) for core barrel

Cores taken within 1.0 ft (300 mm) of an unconfined edge without LJS will have 2.0% density added for pay adjustment calculation purposes. See the QCP example calculation herein.

B) This process will be repeated for all density intervals on a given project.

C) Moving Test Locations.

There are two scenarios in which random test locations may be moved longitudinally using the same random transverse offset. The first scenario is to avoid only the obstacles listed under Case 1 below. The second scenario is to avoid pavement defects in the surface being overlaid as described in Case 2 below.

1) Case 1. In the event the random test location will not allow the necessary compactive effort to be applied, the Engineer will adjust the longitudinal location of the test location in order to avoid the obstacle. Using the same random transverse offset, the test location will be moved longitudinally, ± 15 ft (4.6 m) to avoid the following obstacles only:

    a) Structures or Bridge Decks
    b) Detection loop or other pavement sensors
    c) Manholes or other utility appurtenances

2) Case 2. In the event there are pavement defects in the surface being overlaid, the Contractor may place temporary markings on the shoulder prior to paving to represent longitudinal locations where a defect is present. These pavement defect locations will be approved by the Engineer. If a random test location lands at the same longitudinal location as a temporary mark, the test location will be moved 5 ft (1.5 m) past the temporary mark in the direction toward the paver at the same transverse offset. In the case of an asphalt scab (i.e. thin layer of less than 0.5 in. (13 mm) of asphalt pavement remaining after milling) the temporary markings shall show the extent or length of the defect. The test location will then be moved to a longitudinal distance 5 ft (1.5 m) past the end of the defect toward the paver.

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D) Example Calculations.

PFP Example.

This **PFP** example illustrates the determination of the random test locations within the first mile of a lot.

Given: The HMA pavement consists of a 13.0 ft wide mat 1.5 in. thick with the left edge confined without LJS and the right edge unconfined without LJS.

This will require a density testing interval of 0.2 miles. The random numbers for the longitudinal direction are: 0.917, 0.289, 0.654, 0.347, and 0.777. The random numbers for the transverse direction are: 0.890, 0.317, 0.428, 0.998, and 0.003.

The individual longitudinal density test interval distances can be converted to the cumulative random distance using the following equation:

$$CD_n = [D \times (n-1)] + R_n$$

Where:

n = the density interval number
CD = cumulative distance
D = density testing interval length (typically 1056 ft (0.2 mile))
R = random distance within the given density testing interval

The longitudinal test locations are determined by multiplying the longitudinal random numbers by 1056 ft (0.2 mile). The transverse core locations are determined by multiplying the transverse random number by the effective width of the paved mat.

Determine the effective lane width by subtracting 1.0 ft for each unconfined edge and 4.0 in. (0.33 ft) for each confined edge without LJS from the 13.0 ft paved lane width. In this case the right edge is unconfined, so subtract 1.0 ft (1.0 ft), and the left edge is confined without LJS so subtract 4.0 in. (0.33 ft). Then subtract 4.0 in. (0.33 ft) for the width of the core barrel.

Effective Lane Width = 13.0 ft - 1.0 ft - 0.33 ft – 0.33 ft = 11.34 ft

The calculated transverse offset distances are determined by multiplying the effective lane width of 11.34 ft by the random numbers and adding 4.0 in. (0.33 ft) for the left confined edge plus 2.0 in. (0.17 ft) for the core barrel (0.33 ft + 0.17 ft = 0.5 ft). The random locations for the first mile measured from the beginning of the lot and the left (confined) edge of the paved mat to the center of the core barrel are as follows (See Figure 1):

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Core #	Longitudinal Location	Cumulative Distance	Center of Core Transverse Location[1/]
1	1056 x 0.917 = 968 ft	1056 x (1-1) + 968 = 968 ft	(11.34 x 0.890) + 0.5 = 10.6 ft
2	1056 x 0.289 = 305 ft	1056 x (2-1) + 305 = 1361 ft	(11.34 x 0.317) + 0.5 = 4.1 ft
3	1056 x 0.654 = 691 ft	1056 x (3-1) + 691 = 2803 ft	(11.34 x 0.428) + 0.5 = 5.4 ft
4	1056 x 0.347 = 366 ft	1056 x (4-1) + 366 = 3534 ft	(11.34 x 0.998) + 0.5 = 11.8 ft
5	1056 x 0.777 = 821 ft	1056 x (5-1) + 821 = 5045 ft	(11.34 x 0.003) + 0.5 = 0.5 ft

1/ Transverse location of the center of the core measured from the left physical edge of the paved lane.

Additionally, there will be two longitudinal joint density sublots in the unconfined right edge within the mile section, each sublot 0.5 mile (2640 ft). The random numbers to determine the locations for coring are: 0.822 and 0.317.

Sublot #	Core #	Longitudinal Location	Cumulative Distance	Center of Core Transverse Location[1/]
1	1	2640 x 0.822 = 2170 ft	2640 x (1-1) + 2170 = 2170 ft	6.0 in.
2	2	2640 x 0.317 = 837 ft	2640 x (2-1) + 837 = 3477 ft	6.0 in.

1/ Transverse location of the center of the core measured from the right physical edge of the paved lane.

QCP Example.

This **QCP** example illustrates the determination of the core locations within the first mile of a project.

Given: The pavement consists of a 13.0 ft wide mat 1.5 in. thick with the left edge confined with LJS and the right edge unconfined without LJS.

This will require a density testing interval of 0.2 miles. The random numbers for the longitudinal direction are: 0.904, 0.231, 0.517, 0.253, and 0.040. The random numbers for the transverse direction are: 0.007, 0.059, 0.996, 0.515, and 0.101.

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The individual density test interval distances can be converted to the cumulative random distance using the following equation:

$$CD_n = [D \times (n-1)] + R_n$$

Where:

n = the density interval number
CD = cumulative distance
D = density testing interval length (typically 1056 ft (0.2 mile))
R = Random distance within the given density testing interval

The longitudinal core locations are determined by multiplying the longitudinal random numbers by 1056 ft (0.2 mile).

The transverse core locations are determined by multiplying the transverse random numbers by the effective lane width. The effective lane width is the width of the paved lane minus 1.0 ft for the left edge confined with LJS, 4.0 in (0.33 ft) for the right edge without LJS, and 4.0 in. (0.33 ft) for the core barrel.

Effective Lane Width = 13.0 ft - 1.0 ft - 0.33 ft – 0.33 ft = 11.34 ft

The calculated transverse offset distances are determined by multiplying the effective lane width by the random numbers and adding 1.0 ft for the left confined edge with LJS plus 2.0 in. (0.17 ft) for the core barrel (1.0 ft + 0.17 ft = 1.17 ft). The random locations for the first mile measured from the beginning of the lot and the left (confined) edge of the paved mat to the center of the core barrel are as follows:

Core #	Longitudinal Location	Cumulative Distance	Center of Core Transverse Location[1/]
1	1056 x 0.904 = 955 ft	1056 x (1-1) + 955 = 955 ft	(11.34 x 0.007) + 1.17 = 1.2 ft
2	1056 x 0.231 = 244 ft	1056 x (2-1) + 244 = 1300 ft	(11.34 x 0.059) + 1.17 = 1.8 ft
3	1056 x 0.517 = 546 ft	1056 x (3-1) + 546 = 2658 ft	(11.34 x 0.996) + 1.17 = 12.5 ft
4	1056 x 0.253 = 267 ft	1056 x (4-1) + 267 = 3435 ft	(11.34 x 0.515) + 1.17 = 7.0 ft
5	1056 x 0.040 = 42 ft	1056 x (5-1) + 42 = 4266 ft	(11.34 x 0.101) + 1.17 = 2.3 ft

1/ Transverse location of the center of the core measured from the left physical edge of the paved lane.

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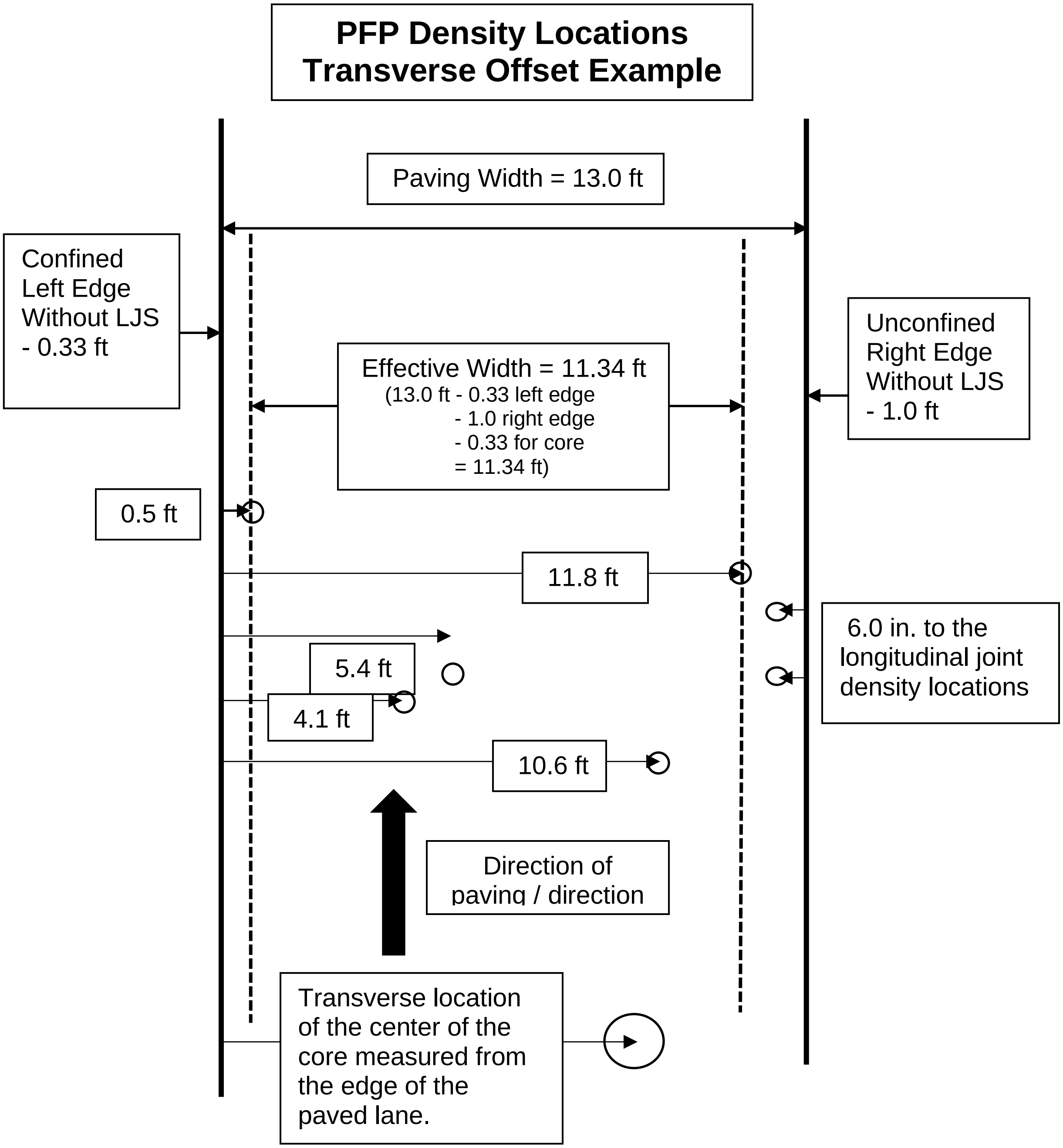

Figure 1.

Illinois Department of Transportation

Hot-Mix Asphalt PFP and QCP Procedure for Determining Random Density Locations
Appendix E.3

Effective Date: April 1, 2009
Revised Date: December 1, 2021

RANDOM NUMBERS

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

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