

Summary:

This is a Performance Specification for Asphalt Pavement Compaction based on Continuous-Full-Coverage (CFC) density data collected with the PaveScan Rolling Density Meter (RDM) ground penetrating radar (GPR) system.

Main features of the new compaction performance specification will be as follows:

- Increase joint bonus to \$2.00/ft but raise the bar from 95.0% to 96.0% compaction for the full bonus
- Increase the specified minimum joint density from 91.0% to 92.0%
- Increase the joint bonus linearly from the minimum value of 92.0% to 96.0% in 0.1% increments
- Require sand seal application on all mat and joint sections below 92.0%, including Bridges
- For asphalt mat density pay factor calculate the Percentage of Conforming (PC) compaction values from the raw PaveScan RDM data for each lot. Use Minimum 93.0% of Maximum Specific Gravity (MSG) for the lower compaction limit. Use the raw data to calculate Percentage of Conforming (to five significant figures) compaction values $\geq 93.0\%$ of MSG directly. Mat Density Pay Factor = $0.55 + PC/200$.
Example: 400,000 compaction values for Lot 1 with 390,000 values $\geq 93\%$ of MSG.
 $PC = 100(390,000/400,000) = 97.500\%$.
Mat Density Pay Factor = $0.55 + PC/200 = 1.03750$

Justification:

For the first time Alaska DOT&PF has test equipment that rapidly maps asphalt paving compaction with full coverage readings done at a rate of one reading for every square foot of surface for the mat and linearly every six inches along longitudinal joints. This mapping also provides highly reliable detection and location recording of nearly 100% of poorly-compacted asphalt mat areas and joints. These are the areas where early pavement failures occur, reducing pavement life and increasing maintenance costs. Geo-located, Continuous-Full-Coverage density data, will be used on this project to compute compaction statistics for pay factors (e.g. percentage of conforming compaction values, average compaction, and standard deviation) and to accurately identify low-density regions in asphalt mats and longitudinal joints. PaveScan RDM data provides real-time location of areas below minimum acceptable compaction. Real-time communication of compaction deficiencies with the contractor promotes same shift adjustments to improve quality and increase pay factor. DOT&PF will require remediation of all low density areas by the contractor. Requiring remediation of low density pavement will increase pavement life, reduce maintenance costs, and incentivize better quality control by the contractor. We call this our “No Pothole Left Behind” specification.

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State Quality Assurance Engineer

**New PaveScan RDM Continuous-Full-Coverage HMA Compaction Specification:
Alaska Standard Specifications for Highway Construction:**

Replace Subsections 3.16, 3.17, 3.19 of Sections 401 and 408 with the following and add new subsection 3.21

401-3.16 COMPACTION. Thoroughly and uniformly compact the Hot-Mix-Asphalt (HMA) by rolling. In areas not accessible to large rollers, compact with mechanical tampers or trench rollers. Prevent indentation in the mat. Do not leave rollers or other equipment standing on HMA that has not sufficiently cooled.

The Lower Specification Limit for mat density is 93.0% of the Maximum Specific Gravity (MSG) as determined by Alaska Test Method (ATM) 409. The MSG to be used in the PaveScan RDM throughout the project will be determined during the RDM calibration process specified in section 401-3.21. Each type of HMA placed on the project requires a separate calibration.

PaveScan RDM density calibration shall be verified once per lot (5000 tons) of asphalt paving placed by comparison of PaveScan readings on the marked mat assurance core location to the subsequent measured density of the DOT&PF Quality Assurance mat core sample that is taken from that lot. Quality Assurance Core locations shall be marked with a six-inch-diameter template using either a lumber crayon or spray paint. The process of scanning the Quality Assurance Core location shall follow the appropriate steps of the PaveScan RDM calibration procedure, ATM 422. Determination of bulk specific gravity, maximum specific gravity and percent compaction of the drilled cores shall follow the appropriate steps of ATM 422. If compaction reading from PaveScan RDM is within $\pm 1.5\%$ of assurance core compaction calculated from laboratory testing then PaveScan RDM data shall be used to determine pay factors for that lot and any associated longitudinal joints.

If PaveScan RDM is outside $\pm 1.5\%$ of assurance core compaction calculated from laboratory testing for any lot then the contractor may request evaluation of that lot by randomly located drilled cores. Such cores shall be located by the Engineer at the rate of one per subplot of the disputed lot, with core compaction evaluated by following the appropriate steps of ATM 422. The contractor shall allow the Engineer to recalibrate the PaveScan RDM by taking readings on the subplot core locations prior to the contractor drilling and extracting the core samples. The core samples shall be given to the Engineer for evaluation by the Regional Laboratory. The contractor shall establish traffic control for this work. Traffic control for this work will be paid under the contingent sum item for traffic control.

401-3.17 JOINTS. Place and compact the HMA joints to provide a continuous bond, texture, and smoothness between adjacent sections of the HMA.

Minimize the number of joints. Do not construct longitudinal joints in the driving lanes unless approved by the Engineer in writing at the pre-paving meeting. Offset the longitudinal joints in one layer from the joint in the layer immediately below by at least 6 inches. Align the joints of the top layer at the centerline or lane lines.

Form transverse joints by saw-cutting back on the previous run to expose the full depth of the course or by using a removable bulkhead. Skew transverse joints 15 to 25 degrees.

For all joints below the top lift, uniformly coat joint surfaces with tack coat material meeting Section 402.

When Item 401(14) appears in the bid schedule, uniformly coat the joint face of all top lift joints with a joint adhesive. Otherwise use tack coat material meeting Section 402. Follow joint adhesive manufacturer's recommendations for temperatures and application method. Remove joint adhesive applied to the top of pavement surface.

If infrared joint heaters are used and passing joint densities are achieved throughout the first 1000 feet of longitudinal joint as measured by the PaveScan RDM system, then joint adhesive is not required.

The Lower Specification Limit for top lift longitudinal joint density is 92.0 percent of the MSG established for each mix design used on the project by the calibration process specified in section 401-3.21. Top lift longitudinal joints will be evaluated by Acceptance Sampling and Testing methods given in Subsection 401-4.02. Top lift longitudinal joints will be evaluated for Material Acceptance by Subsection 401-4.03.

Seal the surface of all longitudinal joints with less than 92.0 percent compaction, using a joint sealant meeting Subsection 702-2.06. Apply joint sealant according to the manufacturer's recommendations while the HMA is clean, free of moisture and prior to final traffic marking. Place the sealant at a maximum application rate of 0.15 gallons per square yard, and at least 12 inches wide centered on the longitudinal joint. After surface sealing, inlay by grinding pavement striping into the sealed HMA. Use grooving equipment that grinds a dry cut to groove the width, length, and thickness of the striping within the specified striping tolerances.

Joints formed by paving in echelon while the mat temperature is over 200 degrees F as measured by the Engineer, within three inches of the joint, do not require tack coat and joint adhesive, and will receive longitudinal joint density price adjustment incentive equivalent to the average density measured by the PaveScan RDM system throughout the mat area containing the echelon joint.

401-3.19 REPAIRING DEFECTIVE AREAS. Remove HMA that is contaminated with foreign material, is segregated (determined visually or by testing), flushing, or bleeding asphalt. Remove and dispose of defective HMA for the full thickness of the course. Cut the pavement so that edges are vertical and the sides are parallel to the direction of traffic. Coat edges with a tack coat according to Section 402. Place and compact fresh HMA so that compaction, grade and smoothness requirements are met. When low compaction of HMA is the only defect, the Contractor may submit a repair plan using repair options 1 and 2 (below) to the Engineer. Allowance of repair options 1 and 2, in lieu of removal and replacement, will be at the sole discretion of the Engineer.

1. Application of a Sand Seal per Special Provision SECTION 404, SEAL COAT.

- a. Apply Sand Seal to the mat of an entire lane station that contains low density (Bulk density less than 92.0% of MSG) areas that are small (less than 8 ft²), discontinuous, and total more than 2% of a lane station area [(2%)(12'x100') = 24 ft²].
 - b. Apply Sand Seal to the mat of an entire lane station that contains a large (equal to or greater than 8 ft²) contiguous low density area. If a large, low-density area straddles a station line, is less than 50' in length, and if it is the only low density area in both stations, then the 100' lane length of sand seal shall be centered on the defect.
 - c. Apply Joint Sealant to each station where the longitudinal joint within that station contains more than 5% joint density readings below 92.0%.
2. Heat with an infrared heater and re-compact.
- a. May use when low density areas are discrete, compact, and less than 24 ft² per lane station of 1200 ft².
 - b. Heat so that pavement surface temperature does not exceed 330⁰F and the temperature 1.5 inches below the surface is above 150⁰F.

401-3.21 CALIBRATION OF PAVESCAN RDM GPR SYSTEM.

Calibrate the PaveScan Rolling Density Meter (RDM) ground penetrating radar (GPR) system by **ATM 422 Calibration of PaveScan RDM Using Drilled Cores** (See Appendix 1)

USE THE FOLLOW SECTIONS WITH THE NOTED CHANGES AND ADDITIONS

401-4.01 METHOD OF MEASUREMENT (no changes)

401-4.02 ACCEPTANCE SAMPLING AND TESTING. The bid quantity of each type of HMA produced and placed will be divided into lots and the lots evaluated individually for acceptance.

A lot is normally 5,000 tons. The lot is divided into sublots of 500 tons, each randomly sampled and tested for asphalt binder content, and gradation according to this Subsection. The lot is evaluated for price adjustment according to Subsection 401-4.03.1. Seasonal startup or a new Job Mix Design (JMD) requires starting a new lot.

If less than 8 sublots have been placed at the time a lot is terminated, the material in the shortened lot will be included as part of the prior lot. The price adjustment computed for the prior lot will include the samples from the shortened lot. If there is no prior lot, and there are at least 3 sublots, the material in the shortened lot will be considered as a lot and the price adjustment will be based on the actual number of test results in the shortened lot. If there are less than 3 sublots, the HMA will be accepted for payment based on the Engineer's approval of the JMD, and placement and compaction of the HMA to the specified depth, finished surface requirements and tolerances. The Engineer reserves the right to perform any testing required in order to determine acceptance.

If 8 or 9 sublots have been placed at the time a lot is terminated, they will be considered as a lot and the price adjustment will be based on the actual number of test results in the shortened lot

If the bid quantity is between 1,500 to 4,999 tons, the quantity is considered one lot. The lot is divided into sublots of 500 tons, each randomly sampled and tested for asphalt binder content, and gradation according to this Subsection. The lot is evaluated for price adjustment according to Subsection 401-4.03.1.

For bid quantity less than 1,500 tons, HMA will be accepted for payment based on the Engineer's approval of the JMD, and placement and compaction of the HMA to the specified depth, finished surface requirements and tolerances. The Engineer reserves the right to perform any testing required in order to determine acceptance.

Sampling and testing include the following:

1. Asphalt Binder Content. HMA samples shall be taken randomly by the Contractor in the presence of the Engineer from behind the paver screed before initial compaction, or will be taken randomly by the Engineer from the windrow, according to ATM 402 or ATM 403, at the discretion of the Engineer. The location (behind the paver screed or windrow) will be determined at the pre-paving meeting. Random sampling locations will be determined by the Engineer.

Two separate samples will be taken, one for acceptance testing and one held in reserve for retesting if requested. Asphalt binder content will be determined according to ATM 405 or ATM 406, at the discretion of the Engineer.

2. Aggregate Gradation. Aggregates tested for gradation acceptance will have the full tolerances from Table 401-2 applied.
 - a. Drum Mix Plants. Samples will be taken from the combined aggregate cold feed conveyor via a diverter device, from the stopped conveyor belt or from the same location as samples for determination of asphalt binder content, at the discretion of the Engineer. Two separate samples will be taken, one for acceptance testing and one held in reserve for retesting if requested. The aggregate gradation for samples from the conveyor system will be determined according to ATM 304. For HMA samples, the gradation will be determined according to ATM 408 from the aggregate remaining after the ignition oven (ATM 406) has burned off the asphalt binder. Locate diverter devices for obtaining aggregate samples from drum mix plants on the conveyor system delivering combined aggregates into the drum. Divert aggregate from the full width of the conveyor system and maintain the diverter device to provide a representative sample of aggregate incorporated into the HMA.
 - b. Batch Plants. Samples will be taken from dry batched aggregates according to ATM 301 or from the same location as samples for determination of asphalt

binder content, at the discretion of the Engineer. Two separate samples will be taken, one for acceptance testing and one held in reserve for retesting if requested. The aggregate gradation for dry batch samples will be determined according to ATM 304. For HMA samples, the gradation will be determined according to ATM 408 from the aggregate remaining after the ignition oven (ATM 406) has burned off the asphalt binder.

3. Density. The Engineer will collect continuous full-coverage mat and longitudinal joint density data with the PaveScan Rolling Density Meter (RDM) ground penetrating radar (GPR) system.
 - a. Mat: Maintain traffic control after completion of compaction until; cooling of mat below 100⁰F, evaporation of all water from the mat, and completion of Continuous Full Coverage (CFC) scans have been performed with the PaveScan RDM system.
 - b. Longitudinal Joints: Maintain traffic control after completion of compaction until; cooling of joint below 100⁰F, evaporation of all water from the joint, and completion of CFC scanning has been performed with the PaveScan RDM system.
4. Retest. When test results have failed to meet specifications, retest of acceptance test results for asphalt binder content, and gradation may be requested provided the quality control requirements of Subsection 401-3.02 are met. Deliver this request in writing to the Engineer within 7 days of receipt of the final test of the lot. The original test results are discarded and the retest result is used in the price adjustment calculation regardless of whether the retest result gives a higher or lower pay factor. Only one retest per sample is allowed. When gradation and asphalt binder content are determined from the same sample, a request for a retest of either gradation or asphalt binder content results in a retest of both. Both gradation and asphalt binder content retest results are used in the price adjustment calculation.

Retest of localized mat or joint area identified for remediation of low compaction. The Engineer will mark the sample location for a drilled-core density retest within the PaveScan RDM located failure area contested by the contractor. For mat density retests, the contractor will drill and extract a six-inch-diameter core centered within the location marked by the Engineer. For joint density retests, the contractor will drill and extract a three-inch-diameter core centered on the joint and within the location marked by the Engineer. After coring the contractor shall immediately clean and dry the core-holes, tack the cut wall surfaces with hot (minimum 325⁰F) asphalt oil, fill the hole with hot mix asphalt (minimum 325⁰F) in lifts of loose thickness that will produce a compacted lift thicknesses of approximately 2” and compact each lift to minimum 92% of MSG with a 4” face diameter Marshal hammer for the 6” mat cores and with a 2” diameter Modified Proctor hammer for the 3” diameter joint cores using a minimum of 50 blows on each lift

of compacted asphalt mix placed in the patch. Finished surface of patched hole must be level with existing paving. Retesting of cores for density and compaction analysis will be performed by a department laboratory following the appropriate steps of ATM 422.

5. Asphalt Binder Grade. The lot size for asphalt binder is 200 tons. If a project has more than one lot and the remaining asphalt binder quantity is less than 150 tons, it is added to the previous lot and that total quantity will be evaluated as one lot. If the remaining asphalt binder quantity is 150 tons or greater, it is sampled, tested and evaluated as a separate lot.

If the bid quantity of asphalt binder is between 85 – 200 tons, the contract quantity is considered as one lot and sampled, tested, and evaluated according to this subsection. Quantities of asphalt binder less than 85 tons will be accepted based on manufacturer's certified test reports and certification of compliance.

Sample asphalt binder at the plant from the supply line in the presence of the Engineer according to ATM 401. The Engineer will take immediate possession of the samples. Take three samples from each lot, one for acceptance testing, one for Contractor requested retesting, and one held in reserve for referee testing if requested. Meet Subsection 702 requirements for asphalt binder quality.

6. Asphalt Binder Grade Retest. Retest of acceptance test results may be requested provided the quality control requirements of Subsection 401-3.02 are met. Deliver the request in writing to the Engineer within 7 days of receipt of notice of failing test. The original test results are discarded and the retest result is used for acceptance. Only one retest per sample is allowed.

If the contractor challenges the result of the retest, the referee sample held by the Engineer will be sent to a mutually agreed upon independent AASHTO accredited laboratory for testing. The original acceptance test result, the retest acceptance test result, and the referee sample test result will be evaluated according to ASTM D3244 to obtain an Assigned Test Value (ATV). The ATV value will be used to determine if the asphalt binder conforms to the contract. The Contractor shall pay for the referee sample test if the ATV confirms the asphalt binder does not meet contract requirements.

401-4.03 EVALUATION OF MATERIALS FOR ACCEPTANCE

The following methods are applied to each type of HMA when Price Adjustment Pay Items are included in the Bid Schedule. These methods describe how price adjustments are determined based on the quality of the HMA, longitudinal joint density and pavement smoothness.

The Engineer may reject material which appears to be defective based on visual inspection. If a test of rejected material is requested, a minimum of two samples are collected from the rejected material and tested. If all test results are within specification limits, payment for the material is made.

1. HMA Price Adjustment. Acceptance test results for HMA asphalt binder content, gradation and mat density are used in HMA price adjustment. These test results for a lot are analyzed collectively and statistically by the Quality Level Analysis (QLA) method as specified in Subsection 106-1.03.3 to determine the total estimated percentage of the lot that is within specification limits. The values for percent passing the #200 sieve, asphalt binder content and density test results are reported to the nearest 0.1 percent. All other sieves used in QLA are reported to the nearest whole number.

The HMA price adjustment is based on the lower of two pay factors. The first factor is a composite pay factor (CPF) for HMA that includes gradation and asphalt binder content. The second is the density pay factor (DPF).

A lot containing material with less than a 1.00 pay factor is accepted at an adjusted price, provided that pay factor is at least 0.80 and there are no isolated defects identified by the Engineer. A lot containing material that fails to obtain the minimum pay factor is considered unacceptable and rejected under Subsection 105-1.11.

HMA pay factors are computed as follows:

- a. All statistical Quality Level Analysis (QLA) is computed using the Engineer's Price Adjustment programs.
- b. The USL and LSL are equal to the Target Value (TV) plus and minus the allowable tolerances in Table 401-2, or as shown below. The TV is the specification value shown in the approved Job Mix Design.

**TABLE 401-2
HMA LOWER SPECIFICATION LIMIT (LSL) & UPPER SPECIFICATION LIMIT (USL)**

Measured Characteristics	LSL	USL
¾" or largest sieve size	99	100
½ inch sieve or first sieve retaining aggregate	TV-6	TV+6
3/8 inch sieve	TV-6	TV+6
No. 4 sieve	TV-6	TV+6
No. 8 sieve	TV-6	TV+6
No. 16 sieve	TV-5	TV+5
No. 30 sieve	TV-4	TV+4
No. 50 sieve	TV-4	TV+4
No. 100 sieve	TV-3	TV+3
No. 200 sieve	TV-2.0	TV+2.0
Asphalt Binder Content, %	TV-0.4	TV+0.4
Mat Density, %	93.0	NA

- c. The percent within limits (PWL), Quality Levels and characteristic pay factors (PFs) are determined by the Engineer for each Lot in accordance with Subsection 106-1.03.3. The Composite Pay Factor (CPF) for the lot is determined from gradation and asphalt binder content (ac) acceptance test results using the following example formula:

$$CPF = \frac{[f_{3/4 \text{ inch}} (PF_{3/4 \text{ inch}}) + f_{1/2 \text{ inch}} (PF_{1/2 \text{ inch}}) + \dots + f_{ac} (PF_{ac})]}{\sum f}$$

Table 401-3 gives the weight factor (f) for each test property considered.

TABLE 401-3 WEIGHT FACTORS

Property	Type I Factor "f"	Type II Factor "f"	Type III Factor "f"
1 inch sieve	4	-	-
¾ inch sieve	4	4	-
½ inch sieve	4	5	4
3/8 inch sieve	4	5	5
No. 4 sieve	4	4	5
No. 8 sieve	4	4	5
No. 16 sieve	4	4	5
No. 30 sieve	4	5	6
No. 50 sieve	4	5	6
No. 100 sieve	4	4	4
No. 200 sieve	20	20	20
Asphalt Content, %	40	40	40

- d. For asphalt mat density pay factor calculate the Percentage of Conforming (PC) compaction values from the raw PaveScan RDM data for each lot. Use Minimum 93.0% of Maximum Specific Gravity (MSG) for the lower compaction limit. Use the raw data to calculate Percentage of Conforming (to five significant figures)

compaction values $\geq 93.0\%$ of MSG directly. Mat Density Pay Factor = $0.55 + \text{PC}/200$.

No price adjustments will be made until repair of low density areas (e. and f. below) within the lot are completed and accepted by the Engineer.

- e. Sand seal will be required on low density (Bulk density less than 92.0% of MSG) mat areas for an entire lane station that contains low density areas that are small (less than 8 ft^2), discontinuous, and total more than 2% of a lane station area [$(2\%)(12' \times 100') = 24 \text{ ft}^2$].
 - f. Sand seal will be required on low density mat areas for an entire lane station that contains a large (equal to or greater than 8 ft^2) contiguous low density area. If a large, low-density area straddles a station line, is less than $50'$ in length, and if it is the only low density area in both stations, then the $100'$ lane length of sand seal shall be centered on the defect.
2. Longitudinal Joint Density Price Adjustment. A longitudinal joint density price adjustment will be based on the project average of all top lift joint density readings collected with the PaveScan RDM. Price adjustment will be determined as follows:
 - a. If project average top lift joint density is greater than 92.0% MSG, apply an incentive of $\$0.05$ per lineal foot for each 0.1% above 92.0% up to a maximum incentive of $\$2.00$ per lineal foot for achieving an average joint density of 96.0% or greater. No price adjustments will be made until repair of low density segments are completed and accepted by the Engineer.
 - b. If more than 5% of joint density readings are below 92.0% within any station ($100'$ segment) then that station will require repair with application of joint sealant as specified in subsection 401-3.19

The Longitudinal Joint Density Price Adjustment is the total price adjustment paid for under Item 401(9).

APPENDICIES

1. Calibration of the PaveScan Rolling Density Meter Ground Penetrating Radar System, (ATM 422 Calibration of PaveScan RDM using Drilled Cores)
2. Special Provision SECTION 404, SEAL COAT
3. Alaska DOT&PF Standard Specifications for Highways, Revised March 2017, Section 106-1.03.3

APPENDIX 1 ATM 422 Compaction Calibration of PaveScan RDM Using Drilled Cores

A. Compaction Calibration of PaveScan RDM using Drilled Cores

Procedure

General: A separate calibration shall be performed for each asphalt mix type specified for Compaction Acceptance by the PaveScan Rolling Density Meter (RDM) ground penetrating radar (GPR) system on a given project. Minimum acceptable correlation coefficient (R^2) shall be 0.90 for calibration of PaveScan RDM dielectric readings to drilled core bulk specific gravity values measured in accordance with Alaska Test Method 421 (ATM 421), Bulk Specific Gravity and Density of Compacted Asphalt Mixtures Using Automatic Vacuum Sealing Method, AASHTO T 331-13 (2017), (ASTM D6752-17).

1. Scan a minimum lane length of 1200 feet of pavement to get a representative sample of dielectric readings, then select Playback File. Next select Statistics and compare Min and Max dielectric values for the three antennas. If the difference between Max and Min dielectric values for the segment is less than approximately 1.0, then the segment length is too short and more lane length must be scanned to get adequate variation for a valid calibration. If the difference between Max and Min dielectric values for the segment is greater than approximately 1.0, then the segment length is adequate for a valid calibration. When a file length with the required dielectric variation has been obtained select Core Location under the playback menu for that section. Select 9 for the number of cores. Three (3) High, three (3) Low, and three (3) Mid dielectric locations will be selected from that file with each located by station and offset as well as GPS coordinates. Record the location and dielectric data for each of these 9 locations in your field book in station order from your current position.
2. Return to each location using the collect distance mode to measure your way back to each coring location. At each location use the active dielectric measurement to precisely find a location with a value similar to the target value from the Core Location algorithm. Number and mark core locations with a 6" diameter template using either a lumber crayon or spray paint.
3. Perform a time scan with middle antenna centered on core location for 15-20 seconds. Move the RDM ± 1.5 in. back and forth in the longitudinal direction and centered over the core location during the time scan.
4. Use Collect Core feature to perform a 4' distance scan parallel to traffic direction with middle antenna moving across the middle of the core, starting 2' before the core centerline and continuing 2' past the core centerline, until the program closes the file. (Collect Core feature is programmed to work off the digital measuring instrument that is connected to one of the cart wheels and shuts off automatically when travel across the core covers the programmed distance of about 4 feet.)

5. Allow contractor to take any non-destructive test (NDT) readings needed for calibration of contractor's quality control testing equipment at the same core location.
6. On completion of non-destructive data collection from the calibration section, proceed with obtaining core samples by ATM 413. Take care to center core barrel inside marked circle that indicates test location, record core number and mark number on the core clearly with a paint pen or other permanent marking system. Continue NDT data collection followed by obtaining cores in the remaining calibration sections until all calibration cores are collected.
7. Determine bulk specific gravity of cores by ATM 421, Bulk Specific Gravity by CoreLok Vacuum Sealing Method
8. On completion of bulk specific gravity test by ATM 421, and after sample has been carefully removed from vacuum sealing bag and final dry mass determined, determine maximum specific gravity by ATM 409, Theoretical Maximum Specific Gravity.
9. Calculate % compaction for each calibration core by dividing Bulk SpG by Theoretical MSG and then multiplying by 100.
10. Plot the average of the two core dielectric readings on the x-axis versus the % compaction on the y-axis. Calculate R^2 for the set of calibration points along with best fit exponential equation. Enter calibration data into PaveScan Computer.

B. Daily Calibration of Dielectric Reading Consistency among Antennas

Calibrate PaveScan RDM System per manufacturer's instructions at the start of each day or shift of paving to synchronize antenna readings.

APPENDIX 2 Special Provision SECTION 404, SEAL COAT

Special Provision

**SECTION 404
SEAL COAT**

404-1.01 DESCRIPTION. Add the following:

Construct a Sand Seal coat with cover coat.

Add the following subsection:

404-2.03 PROCESS QUALITY CONTROL. The engineer will inspect the construction equipment and cleaned asphalt surface before test strip construction, and prior to project production/application of the seal coat materials.

1. Submittals. Provide complete submittals (3 printed copies) to the Engineer for review and approval, at least 21 days before beginning construction of a test strip or project production/application of the seal coat materials. Submittals will be returned to the Contractor within 14 days from the date submitted, marked as approved by the Department, or requiring revisions. Amend and resubmit the documents for review until approved by the Engineer. Receive approval before beginning production.

Manufacturers, listed in the specifications and others, are required to submit for review and approval.

For the sand seal, submit the name, qualifications, and experience of the manufacturer's process control representative, who will be on site during the test strip and all project application, for approval. The onsite representative is required to be approved by the Engineer prior to their arrival on the project.

Submit product data, specifications, and certifications.

- a. Bituminous Materials.

Furnish at each delivery of bituminous material, the manufacturers documentation certifying the type, grade, and quality meet the specifications. Include the:

- 1) Shipment number.
- 2) Refinery.
- 3) Consignee.
- 4) Destination.
- 5) Contract number.
- 6) Date of shipment.

Submit two 1-quart samples of ready-to-apply bituminous material for each batch applied. Provide additional samples when requested by the Engineer.

b. Sand

Submit certification, include the:

- 1) Aggregate gradation
- 2) Aggregate Source

Provide samples when requested by the Engineer.

2. Equipment Maintenance. Equipment maintenance will be up-to-date prior to constructing a test strip and project seal coat production.

3. Equipment Calibration. Calibrate asphalt and sand seal coat material distributors, according to manufacturer's instructions. Provide, onsite, a qualified process control representative with authority, from the asphalt material and distributor manufacturer(s) to calibrate the equipment. Provide the Engineer with confirmation of the distributor(s) accuracy through demonstration and documentation before test strip construction, before seal coat production/application, and when directed by the Engineer before and during application of the seal coat materials. After distributor calibration is complete, any change in settings will require the distributor(s) to be recalibrated.

4. Production/Application of Materials. Before application of sand seal materials, verify the distributor(s) and vehicle is operating properly, including:

- a. The spray bar will maintain a constant height throughout the complete operation.
- b. The spray bar nozzles are set to the manufacturer recommended angle, are clean, in good working condition, and sized for the application rate.
- c. The spray bar shut-off is in good working condition, does not leak.
- d. The sand distributor provides a uniform distribution of sand with no patterns of non-uniform application due to the distribution method or vehicle speed.
- e. The sand hopper and distribution gates are in good working condition.
- f. The vehicle will maintain a uniform speed.

Fix all deficiencies before beginning material application.

5. Test Strip. Provide a test strip(s) for the following seal coat type(s) and when directed by the Engineer.

Seal Coat Type(s): Sand Seal.

Construct the test strip(s) prior to project application of the sand seal. Submit the proposed test strip location, date and time, to the Engineer for coordination, and approval. The Engineer's written approval is required before construction of the test strip begins.

Make the test strip a minimum of 1000 ft long by the typical project application width with calibrated equipment to be used for both the test strip and project production. Provide, onsite, the approved manufacturer's process control representative with authority, to modify mix materials, application rate, and application method of the asphalt and sand. At a minimum, the test strip results will include the optimum asphalt mix with cure time; and mix and sand application method and rate required for the project conditions to meet the specifications. If test results do not meet the specifications, the Engineer will direct an additional test strip(s) to be constructed. The Engineer may vary the test strip size depending on project conditions and results from a prior test strip(s).

Do not begin project production application until written approval of the test strip(s) results is received from the Engineer.

CONSTRUCTION REQUIREMENTS

404-3.01 WEATHER LIMITATIONS. Delete subsection in its entirety and replace with the following:

The Sand Seal shall be applied only when the existing surface has aged at least 2 weeks, has been dry 4 hours and the pavement surface temperature is a minimum of 50°F, or as approved by the Engineer. Develop an expected cure time from a test strip, as described in 404-3.04. Stop application if the weather conditions change such that the cure time varies from the test strip and becomes unacceptable as determined by the Engineer. Do not apply sand seal after September 15 unless approved by the Engineer. Applying the Sand Seal the following summer will not incur a penalty.

404-3.02 EQUIPMENT.

Delete No. 1 and replace with the following:

1. Distributor.

The distributor shall be so designed, equipped, maintained and operated that asphalt material at even heat may be applied uniformly on variable widths of surface up to half the roadway width plus 6 inches, at the specified rate with uniform pressure and within specified tolerances.

a. The distributor equipment shall include the following:

- 1) Computerized control of liquid asphalt spread rates to automatically deliver specified delivery rates and capable of changing rates when so directed.
- 2) Computer monitoring of spread rate, truck speed and distance traveled.
- 3) A thermometer for measuring temperatures of the tank's contents, readily visible from outside the truck cab.

- 4) Each nozzle in the spray bar shall be turned to make the constant angle with the longitudinal axis of the spray bar that is recommended by the manufacturer of the distributor. All nozzles in the spray bar shall be of the same manufacture, type and size. The spray bar height shall provide triple overlap of the asphalt emulsion being applied by the spray nozzles.
 - 5) The distributor truck shall be equipped with a 12-foot (3.6 m), minimum length, and spreader bar with individual nozzle control. The distributor shall be equipped to hand spray areas identified by the Engineer.
- b. Before the application of asphalt, the Contractor shall ensure that the distributor meets the following requirements:
- 1) The spray bar can be maintained at a constant height throughout the entire operation.
 - 2) Spray bar nozzles are clean and in good working condition and sized for the application rate.
 - 3) The spray bar has been provided with a positive shutoff to prevent dribbling.
 - 4) The distributor is capable of maintaining a uniform speed.
- c. Calibration and adjustment requirements will include:
- 1) The distributor will be inspected by the Engineer prior to the commencement of the operation. Any adjustments, maintenance and other requirements shall be performed prior to being used.
 - 2) The distributor shall be calibrated in accordance with the manufacturer's recommendations. The Engineer may require the Contractor to prove the accuracy of the distributor prior to commencing the asphalt application and any time thereafter if deemed necessary by the Engineer. Any change in settings on the distributor after calibrating will require that the distributor be recalibrated.
 - 3) Should any of the nozzles on the spray bar fail to provide a constant, uniform flow during the application of asphalt material, the distributor shall immediately cease application of the asphalt material. The distributor shall not be allowed to resume applying asphalt material until all of the nozzles are in good working order. Nozzle adjustments and/or repairs must be approved by the Engineer.
 - 4) The distributor truck shall be equipped with a 12-foot (3.6 m), minimum length, and spreader bar with individual nozzle control. The distributor shall be equipped to hand spray areas identified by the Engineer.

d. For sand seal applications:

- 1) A sander shall be mounted directly on the back of the asphalt distributor
- 2) The sander shall be equipped with a variable control system to ensure reasonably even distribution of the sand at varying application widths and speeds.
- 3) The sander controls shall be located in the cab of the distributor.
- 4) The sanding unit must have the ability to apply sand to the sealant without driving through the wet sealant.
- 5) The sander must have variable control mechanisms to regulate sand distribution, and should have a minimum hopper capacity of at least 3,000 pounds of sand.
- 6) Calibrate the sander prior to the start of the sand sealing.

404-3.03 PREPARATION OF SURFACE. Delete subsection in its entirety and replace with the following:

The asphalt surface to be treated shall be free of all dirt, sand, weeds, grass and excessive oil and/or grease. The surface shall be cleaned with a power broom or power blower supplemented by a hand sweeping or any other means required to remove deleterious matter to the satisfaction of the Engineer. Any crack sealing shall be completed, prior to the surface cleaning and preparation for sealing. Protect traffic markings and utility covers.

404-3.04 APPLYING ASPHALT MATERIAL. Replace the fifth paragraph with the following:

Provide, on site, the approved manufacturer's process control representative, that assisted with the test strip, for the entire application of sand seal on the project. Heat asphalt to manufacturer's recommended application temperature and apply at the approximate rate of 0.10 to 0.15 gallons per square yard as determined by the test strip and directed by the Engineer. Do not apply over and protect existing pavement markings and areas to receive new pavement markings.

Should any of the nozzles on the spray bar fail to provide a constant, uniform flow during the application of asphalt material, the distributor shall immediately cease application of sand seal. The distributor shall not be allowed to resume applying sand seal until all of the nozzles are in good working order.

Add the following Subsection:

404-3.06 APPLICATION OF SAND FOR SAND SEAL. Apply sand at the approximate rate of 0.65 to 0.8 pounds per square yard as determined by the test strip and approved by the Engineer. Sand shall be applied uniformly. Apply sand immediately after asphalt is applied. Do

not permit traffic on the sand seal until the surface has cured as determined by the test strip and approved by the Engineer.

Should any patterns of non-uniform application develop during the application of the sand material, the distributor shall immediately cease application. The distributor shall not be allowed to resume applying sand seal until the sand distributor deficiency is corrected.

Hand work may be required or approved for applications around obstructions. For hand applications, push-type hand sanders will be allowed. The Contractor shall organize this work so the asphalt application by hand and the sanding operation work as a cohesive unit with the hand sanding immediately following the hand asphalt application. Sanding shall be done in a manner so as to prevent appreciable amounts of sand from going onto any pavement prior to the sealant being applied. Any deviation from this method must be pre-approved by the Engineer.

404-4.01 METHOD OF MEASUREMENT. Add the following:

Sand Seal – by the square yard.

The quantity of sand seal to be paid for will be the number of square yards of material actually applied and accepted by the Engineer.

404-5.01 BASIS OF PAYMENT. Add the following:

Payment will be made at the contract unit price per square yard for Sand Seal. This price will be full compensation for furnishing all materials, for all preparation, delivery, and application of these materials, and for all labor, equipment, tools, and incidentals necessary to complete this item, including the furnishing and application of asphalt and sand and any other work necessary to complete this item. Removal of excess sand is considered a subsidiary obligation.

Payment will be made under:

<u>Pay Item No.</u>	<u>Pay Item</u>	<u>Pay Unit</u>
404(4)	Emulsified Asphalt Sand Seal	Square Yard

702-2.06 SAND SEAL EMULSIFIED ASPHALT. GSB 88 (manufactured by Asphalt Systems Inc.), Optipave (manufactured by SealMaster), or meet the following:

Emulsion concentrate, in the undiluted state, shall have the following properties:

Saybolt furol viscosity at 77 degrees Fahrenheit (25°C), ASTM D7496, (seconds)	20-100
Residue by distillation, ASTM D6997, or evaporation, ASTM D6934, (%)	57 min
Sieve test, ASTM D6933, (%)	0.2 max
pH, cationic,	2.0-6.5

Emulsion concentrate, diluted in the proportion of one part of concentrate to one part of hot water by volume and ready to apply, shall have the following properties:

Saybolt furol viscosity at 77 degrees Fahrenheit (25°C), ASTM D7496, (seconds).....	10-50
Residue by distillation, ASTM D6997, or evaporation, ASTM D6934, (%)	28-42
Sieve test, ASTM D6933, (%)	0.1 max
Pumping stability test,	pass
(Hot water temperature at or above 100 degrees Fahrenheit)	

The residue from distillation shall have the following properties:

Viscosity at 275 degrees Fahrenheit (135°C), ASTM D4402, (cts)	1750 max
Solubility in 1,1,1 Trichloroethylene, ASTM D2404, (%)	97.5 max
Penetration ASTM D5, (dmm)	50 max
Asphaltenes, ASTM D2007, (%)	15 min
Saturates, ASTM D2007, (%)	15 max
Polar Compounds, ASTM D2007, (%)	25 min
Aromatics, ASTM D2007, (%)	15 min

Pumping stability test is tested by pumping 1 pint, (475 ml) of sealer material diluted 1 part concentrate to 1 part water, at 77°F (25°C), through a ¼-inch gear pump operating 1750 rpm for 10 minutes with no significant separation or coagulation.

The bituminous base residue shall contain not less than 20 percent gilsonite, and shall not contain any tall oil pitch. Curing time, under recommended application conditions, shall not exceed 4 hours. The Contractor shall furnish and submit to the Engineer, manufacturer’s certification that the material is the type, grade, and quality specified for each load of bituminous material delivered. The certification shall show the shipment number, refinery, consignee, destination, contract number, and date of shipment. The Contractor shall submit to the Engineer, two 1-quart samples of ready-to-apply bituminous material for each batch applied and two 1-quart samples of concentrate for each load delivered. The Contractor shall submit any additional samples requested by the Engineer.

Joint Sealant

Conform to Subsection **702-2.06**

For top lift panels that have a longitudinal joint density less than 92.0% of the MSG, seal the surface of the longitudinal joints with joint sealant. Apply joint sealant according to the manufacturer’s recommendations while the HMA is clean, free of moisture and prior to final traffic marking. Place the sealant at a maximum application rate of 0.15 gallons per square yard, and at least 12 inches wide centered on the longitudinal joint. Apply sand as specified in **404-3.06**. After surface sealing, inlay by grinding pavement striping into the sealed HMA. Use grooving equipment that grinds a dry cut to groove the width, length, and thickness of the striping within the specified striping tolerances.

APPENDIX 3 106-1.03 TESTING AND ACCEPTANCE, Section 1.03.3

106-1.03 TESTING AND ACCEPTANCE. Materials are subject to inspection and testing by the Department at any time before, during, or after they are incorporated into the project. Use of untested materials is at the Contractor's risk. The Contractor shall remove and replace unacceptable material according to Subsection 105-1.11.

FOR MAT DENSITY via PaveScan RDM, Modify Subsection 3.f. and Add NEW SUBSECTION 3.g. as noted below:

3.

f. The density pay factor (DPF) is: $DPF = 0.55 + PC/200$

Where: PC varies from 50.000 to 100.000

When PC is less than 50.000, the pay factor (PF) = zero

g. For asphalt mat density pay factor calculate the Percentage of Conforming (PC) compaction values from the raw PaveScan RDM data for each lot. Use Minimum 93.0% of Maximum Specific Gravity (MSG) for the lower compaction limit. Use the raw data to calculate Percentage of Conforming (to five significant figures) compaction values \geq 93.0% of MSG directly. Mat Density Pay Factor = $0.55 + PC/200$.

Example: 400,000 compaction values for Lot 1 with 390,000 values \geq 93% of MSG.

$PC = 100(390,000/400,000) = 97.500\%$.

Mat Density Pay Factor = $0.55 + PC/200 = 1.03750$