Kentucky Method 64-437-08
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DETERMINATION OF ASPHALT BINDER CONTENT OF ASPHALT MIXTURES USING THE NUCLEAR ASPHALT CONTENT GAUGE

1. SCOPE:

1.1. This method describes the requirements for the determination of the asphalt binder content (AC) of asphalt mixtures using the nuclear asphalt content gauge (NACG).

1.2. This method is derived from AASHTO T 287, *Asphalt Cement Content of Asphalt Concrete Mixtures by the Nuclear Method*.

1.3. If unfamiliar with the operation of NACGs, review the operator's manual carefully.

1.4. Due to the possession and use of radioactive sources, maintain a specific license issued by the United States Nuclear Regulatory Commission (Commission), equivalent-agreement, state-licensing agency. Obtain the appropriate licenses according to the provisions of the Kentucky Cabinet for Human Resources Administrative Radiation Regulations (Regulations).

1.5. When transporting a NACG, ensure the correct documents according to the Commission and the Regulations are readily accessible to the driver.

1.6. Ensure NACG operators wear an approved form of a radiation-dosimetry film badge with a neutron chip capable of monitoring the occupational radiation exposure. When not in use, do not store the badge with the NACG.

1.7. To maintain compliance with a Radioactive Materials License, properly store the instrument containing the radioactive material. In general, store the NACG no closer than 15 feet from the nearest full-time work station.

2. SIGNIFICANCE AND USE: This method is one of a group of approved means of determining the AC of asphalt mixtures. Other means include Kentucky Method (KM) 64-405, *Extraction of Binder From Asphalt Paving Mixtures*; KM 64-436, *Asphalt Binder Content Determination of Asphalt Mixtures by Plant Recordation*; KM 64-438, *Asphalt Binder Content Determination of Asphalt Mixtures Based on the Maximum Specific Gravity (MSG)*, or AASHTO T 308, *Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method*. Use KM 64-437 for acceptance, process-control, or informational testing.

3. OPERATIONAL NOTES:

3.1. Since a NACG measures the total amount of hydrogen in the sample, this procedure is sensitive to changes in moisture content. Both asphalt binder and water contain hydrogen. So, unless the test sample is completely free of moisture, determine the moisture content according to KM 64-434, *Determination of Moisture Content in Asphalt Mixtures (Rapid Field Test)*, and make a correction to compensate for the moisture.

3.2. Keep any other source of neutron radiation at least 30 ft. away from the NACG. Do not place the equipment where large amounts of hydrogen-containing material (for example, asphalt binder, water, or plastic materials) may be moved during the calibration or testing procedures.

4. EQUIPMENT:

4.1. Gauge: Provide a NACG conforming to AASHTO T 287. Furnish a printer for recording all values.

4.2. Straightedge: Provide a stiff, steel straightedge, approximately 18 in. in length.

4.3. Compaction plate: Provide a piece of plywood, 3/4 in. or thicker, or a metal plate, 3/8 in. or thicker, having an area slightly larger than the top of the sample pans. Ensure the plywood is smooth and solid.

4.4. Provide a balance, capable of weighing to 15 kg, accurate to 1.0 g.

4.5. Provide an oven, capable of heating to $300 \pm 5\ ^{o}F$.

4.6. Provide assorted spoons, mixing bowls, thermometers, and a trowel.

4.7. Provide the NACG manufacturer's instructional manual.

5. SAMPLING:

5.1. Obtain samples of aggregates according to AASHTO T2, *Sampling of Aggregates*.

5.2. For acceptance testing, select the actual batch or increment of material for determining the AC on a random basis according to KM 64-113, *Sampling Materials by Random Number Sampling*.

5.3. Obtain samples of asphalt mixtures according to KM 64-425, *Sampling Asphalt Mixtures*.

6. CALIBRATION:

6.1. This procedure is sensitive to the type of aggregate, percentage and source of asphalt binder, and aggregate gradation. Therefore, develop a calibration curve for each mix. Obtain a dry aggregate reading often enough to ensure that changes in aggregate are detected (see Subsection 9.2 of this method). If a significant change (± 1.0%) in this count occurs, perform a new calibration.

NOTE 1: When using the NACG as the primary means of AC determination (as specified in the quality control plan), calibrate the mixture. Provide the calibration information to Kentucky Transportation Cabinet (Cabinet) personnel as specified in Subsection 10.2 of this method.

6.2. Obtain aggregate samples, and blend the aggregates in the proper proportions. Obtain enough aggregate for a minimum of three samples, approximately 65 lb_m.

6.3. Place the dried, heated aggregate in a tared sample pan in three equal layers. For the first layer, fill the pan to approximately one-third of the depth. Use a spatula to distribute the aggregate to avoid segregation. Raise the pan 1 in., and drop it to a solid surface. Repeat the drop three more times. For the second layer, fill the pan to approximately two-thirds of the depth. Use a spatula to distribute the aggregate evenly. Raise the pan 1 in., and drop it to a solid surface. Repeat the drop three more times. For the third layer, completely fill the pan until the aggregate is slightly above the top rim of the pan. Place the straightedge firmly across the rim and, using a sawing motion, strike off the surface of the sample so that it is flush with the rim. Fill gaps between the straightedge and the sample with fine aggregate such that the surface is level. Raise and drop the pan four times as specified for the first two layers. Otherwise, do not compact the sample. Measure and record the weight of the sample. Obtain a sample count according to the manufacturer's instructions. Use the sample weight and count to determine if any changes in the aggregates occur during construction and establish the approximate mixture sample weights for future testing.

6.4. Prepare the mixture according to KM 64-411, *Preparing Ingredient Materials for, and Performing, a Laboratory Mix Design of an Asphalt Mixture*. Ensure the calibration curve consists of a minimum of three points. Mix one at the target AC, one at 1% above, and one at 1% below.

6.5. Begin the calibration using the target AC. Place the mixture sample in a tared sample pan in three equal layers. Heat all bowls, sample pans, and tools used in the mixture-calibration process to prevent temperature loss. Fill the sample pan to approximately one-third of the pan depth. Level the mixture with a trowel or spatula. Raise the pan 1 in., and drop it to a solid surface. Repeat the drop three more times. For the second layer, fill the pan to approximately two-thirds of the depth. Use a spatula to distribute the mixture evenly. Raise the pan 1 in., and drop it to a solid surface. Repeat the

drop three more times. For the third layer, completely fill the pan until the weight of the mixture in the pan equals the dry aggregate weight determined in Subsection 6.3 of this method. If the pan is not full, fill the pan to the point that the mixture is mounded slightly above the top rim of the pan. Measure and record the weight of the mixture in the pan. Use this weight (± 10 g) for all calibrations and test samples using this mixture calibration. Level the top of the mixture using a trowel or spatula. Raise and drop the pan four times as specified for the first two layers. Place the pan of mixture on a level floor, and place the compaction plate on top of the pan. Stand on the plate to consolidate the sample. Compact all samples at a minimum temperature of 240 °F to ensure that the mix will compact properly. In order to obtain uniform compaction for each calibration sample, ensure the compaction temperature of each sample is within ± 10 °F of one another.

NOTE 2: Use a target compaction temperature of 265 °F.

6.6. Place the sample of mixture in the NACG, and proceed per the manufacturer's instructions for operation of the equipment and the sequence of operation. Count all calibration samples on the 16-min. calibration count.

6.7. Repeat Subsections 6.5 and 6.6 of this method for the remaining calibration samples. Use the same weight as obtained in Subsection 6.5 of this method for all calibration samples.

NOTE 3: Retain the midpoint/target AC pan after the NACG calibration as a check sample for NACG accuracy. Seal the pan in a plastic bag to prevent the accumulation of moisture.

6.8. Prepare a calibration curve by plotting the calibration sample reading versus AC on linear graph paper, choosing a convenient scale factor for the counts and AC. Connect the points with a straight line. Ensure the calibration has a correlation factor greater than or equal to 0.995 (1.000 is a perfect correlation). Calculate the correlation factor using the following formula:

$$Correlation\ Factor = \sqrt{1 - \frac{\sum_i (Y_i - \hat{Y}_i)^2}{\sum_i (Y_i - \bar{Y})^2}},$$

where:

Y_i = actual AC values for each sample (%);

$\hat{Y}_i$ = calculated AC values from the curve;

$\bar{Y}$ = mean of the actual AC values (%); and

i = number of calibration samples.

6.9. Perform the calibration procedure for each asphalt mixture. Although the aggregate combination remains constant, when introducing any solid additive or modifier into the mixture, perform a separate calibration. However, when using 0.5% or less liquid anti-stripping additive, do not perform a separate calibration.

NOTE 4: Use this calibration procedure with recycled-asphalt pavement (RAP) incorporated into the mixture, provided the RAP is of uniform gradation, AC, and asphalt binder grade. When using RAP, mix it in the calibration samples at the same rate used in the overall mixture.

7. PREPARATION OF TEST SAMPLE:

7.1. Place the test sample in the sample pan by the same method used in the preparation of the mixture-calibration samples. Also, ensure the test sample is the same weight (± 10 g) as the calibration samples. Use the same compaction temperature ± 10 ^{o}F.

7.2. Determine the moisture content of the mixture according to KM 64-434. Subtract the percentage of moisture from the NACG reading for each test sample. Alternatively, dry the test sample to a constant mass in an oven at 230 ± 9 ^{o}F, thereby eliminating the need for a moisture-content determination. Exercise caution when drying test samples in an oven. Do not dry the test sample in an oven for longer than two hours prior to testing it in the NACG. If a constant weight cannot be achieved within the two-hour time period, determine the moisture content of the mixture by KM 64-434.

8. PROCEDURE:

8.1. Obtain a sample of the plant-produced mixture according to KM 64-425. Prepare the test samples for AC determination as described in Subsection 6.5 of this method.

8.2. Place the test sample in the NACG, and proceed as described in the manufacturer's instructions to obtain the sample counts. Count all test samples on four- or 16-min. counts. Determine the NACG reading, and adjust the value by subtracting the moisture content obtained as described in Subsection 7.2 of this method.

9. STANDARDIZATION:

9.1. All nuclear devices are subject to long-term aging of the radioactive source, detectors, and other electronic systems; this aging may change the relationship between the count rate and AC. Therefore, develop new calibration curves periodically, at a minimum of once yearly. Changes in the surroundings of the NACG may also produce changes in the count rate. In order to minimize these effects, perform background counts daily, and keep the NACG away from potential influences that may affect the count as described in Subsection 3.2 of this method.

NOTE 5: When using the equipment either continuously or intermittently during the day, leave the power on to prevent having to repeat background counts. This practice will provide more stable and consistent readings.

9.2. Dry-aggregate standard count.

9.2.1. Turn on the equipment, and allow for the stabilization of the equipment according to the manufacturer's recommendations.

9.2.2. Prepare the dry aggregate sample as described in Subsections 6.2 and 6.3 of this method. Ensure the sample weight is the same as measured in the calibration procedure in Subsection 6.3 of this method.

9.2.3. Place the dry aggregate sample in the NACG, and proceed as per the manufacturer's instructions for operation of the equipment and the sequence of operation. Compare the dry aggregate count against the "calibration of the dry aggregate" reading to determine if any changes in the aggregate have occurred. Changes in the aggregate may affect both the aggregate and mixture sample counts. Perform a new calibration if a change in the dry aggregate count of $\pm$ 1.0% occurs.

10. CALCULATIONS AND REPORT:

10.1. Retain a record of each calibration sample for each mixture on file. Include the date of the calibration testing, NACG model and serial number, mixture type and calibration identification number, aggregate sources and sizes, percent of each aggregate, gradation of the mixture, asphalt binder type and source, AC, and total sample weight. Also include the background count, dry aggregate count, and calibration constants for each mixture sample.

10.2. Supply the calibration record for each mixture to the Cabinet.

10.3. For acceptance testing, supply the printed record of each test with the appropriate *Asphalt Mixtures Acceptance Workbook* (AMAW). Supply a continuous tape or connected series of tickets documenting all of the tests for a given day's production. When using the NACG to obtain test results from other mixtures (commercial sales, other mixtures, projects, etc.), include the record of all such testing. Clearly note and mark those records that are not applicable to the mixture in question. Include the calibration data for the mixture and the data for each acceptance test in each sublot's acceptance information. Specifically, provide the following data:

NACG model and serial number
Date and the time tested
Producer identification (SiteManager number)

Project identification (project code number)

Sample identification (consecutive numbering of the tests during production)

Sample weight
Background count
Identification number of the current mixture's calibration
Count time (duration of the testing)
AC results and the sample counts
Mixture identification (SiteManager material code)
Calibration constants (three samples)

10.4. Determine the AC of each test sample as displayed by the NACG. As specified in Subsection 7.2 of this method, subtract the moisture content of the mixture from the NACG reading.

10.5. Calculate the actual AC by the following formula:

$AC(\%) = W_1 - W_2$,
where:

W_1 = NACG reading; and

W_2 = percent of moisture in the mixture.

10.6. Report the AC results to the nearest 0.1 percent on the AMAW.

APPROVED _____
DIRECTOR
DIVISION OF MATERIALS

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