5.9.57 DETERMINATION OF ASPHALT CONTENT AND GRADATION OF HOT MIX ASPHALT CONCRETE BY THE IGNITION METHOD (Kansas Test Method KT-57)

1. SCOPE

1.1. This test method covers the determination of asphalt content of hot mix paving mixtures by ignition of the asphalt cement at 932°F (500°C) in a furnace. The aggregate remaining after burning can be used for sieve analysis using KT-34.

1.2. The values in metric units are to be regarded as the standard.

2. REFERENCED DOCUMENTS

2.1. Part V, 5.9; Sampling and Test Methods Foreword

2.2. KT-1; Sampling and Splitting of Aggregates

2.3. KT-25; Sampling and Splitting Plant Mixed Asphalt Mixtures

2.4. KT-26; Sampling Asphalt Materials

2.5. KT-34; Sieve Analysis of Extracted Aggregate

2.6. AASHTO T 308; Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method

2.7. Ignition Oven Manufacturer’s instruction manual

3. SUMMARY OF TEST METHODS

3.1. The asphalt cement in the paving mixture is ignited using the furnace equipment applicable to the particular method. The asphalt content is calculated as the difference between the initial mass of the asphalt paving mixture and the mass of the residual aggregate, and the calibration factor. The asphalt content is expressed as mass percent.

4. SIGNIFICANCE AND USE

4.1. This method can be used for quantitative determinations of asphalt binder content and gradation in hot-mixed paving mixtures and pavement samples for quality control, specification acceptance and mixture evaluation studies. This method does not require the use of solvents. Aggregate obtained by this test method may be used for sieve analysis according to KT-34.

5. SAMPLING

5.1. Obtain samples of aggregate in accordance with KT-1.

5.2. Obtain samples of freshly produced hot-mix asphalt in accordance with KT-25. Quarter the larger sample in the following manner:

5.2.1. Spread a sheet of paper (Kraft or similar) on a hard, clean, smooth and level surface. Place the sample in a pile near the center of the paper and mix by alternately lifting each corner towards the
opposite corner thereby rolling the mixture to the opposite corner. This should be performed in a vigorous manner. Placing the sample on a piece of cardboard and mixing thoroughly with a trowel is an acceptable alternate.

5.2.2. Divide the pile into four equal quarters with a straightedge (trowel or similar metal blade) and completely remove two pre-selected diagonally opposite quarters.

5.2.3. Continues this quartering procedure until the original sample is reduced to the approximately desired size. On the final quartering step, if the sample is too larger before quartering, but will be too small after quartering, the sample pile is divided into equal opposite sectors but unequal adjacent sectors. This can be accomplished by varying the dividing angle at the center of the sample pile from the normal 90 degrees. Opposite sections can then be selected to obtain the desired sample size.

5.3. Obtain samples of asphalt cement in accordance of KT-26.

5.4. Preparation of Test Specimens:

5.4.1. Place the sample in a larger flat pan and warm to 230 ± 9°F (110 ± 5°C) for a minimum of 30 minutes or until the sample is dried to a constant mass.

5.4.2. The size of the test sample shall be governed by the nominal maximum aggregate size of the mixture and shall conform to the mass requirement shown in Table 1. When the mass of the test specimen exceeds the capacity of the equipment used, the test specimen may be divided into a suitable increments, tested and the results appropriately combined for calculation of the asphalt content (weighted average). Also, sample sizes should not be more than 400 g greater than the minimum recommended sample mass. Large samples of fine mixes tend to result in incomplete ignition of the asphalt.

<table>
<thead>
<tr>
<th>Nominal Max. Agg. Size, in (mm)</th>
<th>Min. Mass Specimen, g</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 in (9.5)</td>
<td>1200</td>
</tr>
<tr>
<td>1/2 in (12.5)</td>
<td>1500</td>
</tr>
<tr>
<td>3/4 in (19.0)</td>
<td>2000</td>
</tr>
<tr>
<td>1 in (25.0)</td>
<td>3000</td>
</tr>
<tr>
<td>1 1/2 in (37.5)</td>
<td>4000</td>
</tr>
<tr>
<td>RAP</td>
<td>2000</td>
</tr>
<tr>
<td>RAS</td>
<td>200</td>
</tr>
</tbody>
</table>

NOTE: Nominal maximum aggregate size is one size larger than the first sieve to retain more than 10%.

6. CALIBRATION

6.1. This method may be affected by the type of aggregate in the mixture. Accordingly, to optimize accuracy, a calibration factor will be established by testing a set of calibration samples for each mix type. This procedure must be performed before any acceptance testing is completed.

6.2. The calibration should be repeated each time there is a change in the mix ingredients or design.
6.3. According to the requirements of Section 5 of this test method, prepare two calibration samples at the design asphalt content. Prior to mixing, prepare a butter mix at the design asphalt content. The purpose of the butter mix is to condition the mixing bowl by providing a coating of asphalt and fines in the bowl. Mix and discard the butter mix prior to mixing any of the calibration specimens to ensure accurate asphalt content. Aggregate used for the calibration specimens shall be sampled from stockpiled material produced in the current construction season and designated to be used on the candidate project. In other words, this calibration process should not be completed until all necessary material has arrived on the project site. An additional “blank” specimen shall be batched and tested for aggregate gradation according to KT-34. The wash gradation shall fall within the mix design tolerances.

6.4. The freshly mixed specimens may be placed directly in the sample baskets. Allow the sample to cool to room temperature.

6.5. Test specimens in accordance with Sections 7 and 8 of this test method (Test Method A) or Sections 9 and 10 of this test method (Test Method B).

6.6. Perform a gradation analysis on the residual aggregate as indicated in Section 11 of this test method. Compare the gradation to the gradation of the unburned, “blank” specimen to evaluate the amount of aggregate breakdown. *This evaluation is for information only.*

6.7. Once all of the calibration specimens have been burned determine the measured asphalt contents for each sample by calculation.

6.8. If the difference between the measured asphalt contents of the two samples exceeds 0.15%, repeat the two tests and from the four tests, discard the high and low result. Determine the calibration factor \((C_f)\) from the two remaining results \((C_A \text{ and } C_B)\). Calculate the difference between the measured and actual asphalt contents for each sample. The calibration is the average of the differences expressed in percent by mass of the asphalt mixture for the Superpave designs and expressed in percent by mass of the remaining aggregate for Marshall Designs.

**Note:** Calibration factors \((C_f)\) cannot be less than zero. If a calibration factor is calculated to be less than zero record the calibration factor as zero.

7. APPARATUS (TEST METHOD A)

7.1. A forced air ignition furnace, capable of maintaining the temperature at 1072°F (578°C), with an internal balance thermally isolated from the furnace chamber accurate to 0.1 g. The balance shall be capable of weighing a 3500 g sample in addition to the sample baskets. A data collection system will be included so that the mass can be automatically determined and displayed during the test. The furnace shall have a built in computer program to calculate change in mass of the sample baskets and provide for the input of a correction factor for aggregate loss. The furnace shall provide a printed ticket with the initial specimen mass, specimen mass loss, temperature compensation, correction factor, corrected asphalt binder content (percent), test time, and test temperature. The furnace chamber dimensions shall be adequate to accommodate sample size of 3500 g. The furnace shall provide an audible alarm and indicator light when the sample mass loss does not exceed 0.01% of the total sample mass for three consecutive minutes. The furnace door shall be equipped so that the door cannot be opened during the ignition test. A method for reducing furnace emissions shall be provided. The furnace shall be vented into a hood or to the outside and when set up properly shall have no noticeable odors escaping into the laboratory. The furnace shall have a fan with capacity to pull air through the furnace to expedite the test and to reduce the escape of smoke into the laboratory.
NOTE: The furnace shall also allow the operator to change the ending mass loss percentage to 0.02%.

7.2. Sample basket(s) of appropriate size that allows the samples to be thinly spread and allows air to flow up through and around the sample particles. Sets with two or more baskets shall be nested. The sample shall be completely enclosed with screen mesh or perforated stainless steel plate or other suitable material.

NOTE: Screen mesh or other suitable material openings of approximately No. 8 (2.36 mm) and No. 30 (600 µm) has been found to perform well.

7.3. Catch pan of sufficient size to hold the sample basket(s) so that aggregate particles and melting asphalt binder falling through the screen mesh are caught.

7.4. Oven capable of maintaining 230 ± 9°F (110 ± 5°C).

7.5. The balance shall conform to the requirements of Part V, 5.9; Sampling and Test Methods Foreword, for the class of general purpose balance required for the principal sample mass of the sample being tested.

7.6. Safety equipment - safety glasses or face shield, high temperature gloves, long sleeve jacket, a heat resistant surface capable of withstanding 1202°F (650°C) and a protective cage capable of surrounding the sample baskets during the cooling period.

7.7. Miscellaneous equipment consisting of a pan larger than the sample basket(s) for transferring sample after ignition, spatulas, bowls and wire brushes.

8. TEST PROCEDURES (TEST METHOD A)

8.1. Preheat the ignition furnace to 932°F (500°C). Manually record the furnace temperature (set point) prior to the initiation of the test if the furnace does not record automatically.

8.2. Oven dry field HMA samples to a constant mass at a temperature of 230 ± 9°F (110 ± 5°C).

8.3. Enter the calibration factor for the specific mix to be tested in the ignition furnace as determined by Section 6 of this test method.

8.4. Weigh and record the mass of the sample basket(s) and catch pan (with guards in place).

8.5. Prepare the sample as described in Section 5 of this test method. Record the initial mass while at room temperature. Evenly distribute this sample in the sample basket(s) that have been placed in the catch pan, taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the specimen.

8.6. Weigh and record the total mass of the sample, basket(s), catch pan and basket guards. Calculate and record the initial mass of the specimen (total mass minus the mass of the specimen basket assembly).

8.7. Input the initial mass of the specimen in whole grams into the ignition furnace controller. Verify that the correct mass has been entered.

8.8. Open the chamber door and place the sample baskets in the furnace. Close the chamber door and verify that the sample mass [including the basket(s)] displayed on the furnace scale equals the total mass
recorded in Section 8.5 of this test method within ± 5 g. Differences greater than 5 g or failure of the furnace scale to stabilize may indicate that the sample basket(s) are contacting the furnace wall. Initiate the test by pressing the start/stop button. This will lock the sample chamber and start the combustion blower.

NOTE: The furnace temperature will drop below the set point when the door is opened, but will recover when the door is closed and ignition occurs. Sample ignition typically increases the temperature well above the set point, depending on sample size and asphalt content.

8.9. Allow the test to continue until the stable light and audible stable indicator indicate the test is complete (the change in mass does not exceed 0.01% for three consecutive minutes). Press the start/stop button. This will unlock the sample chamber and cause the printer to print out the test results.

8.10. Open the chamber door, remove the sample basket(s) and allow them to cool to room temperature (approximately 30 minutes).

8.11. Once the sample has cooled to room temperature, weigh and record the final mass. Calculate the uncorrected asphalt content, then apply correction factor to determine corrected asphalt content.

9. APPARATUS (TEST METHOD B)

9.1. A forced air ignition furnace, capable of maintaining the temperature at 1072°F (578°C). The furnace chamber dimensions shall be adequate to accommodate a sample size of 3500 g sample. The furnace door shall be equipped so that the door cannot be opened during the ignition test. A method for reducing furnace emissions shall be provided. The furnace shall be vented into a hood or to the outside and when set up properly shall have no noticeable odors escaping into the laboratory. The furnace shall have a fan with capacity to pull air through the furnace to expedite the test and to reduce the escape of smoke into the laboratory.

9.2. Sample basket(s) of appropriate size that allows the samples to be thinly spread and allows air to flow up through and around the sample particles. Sets with two or more baskets shall be nested. The sample shall be completely enclosed with screen mesh or perforated stainless steel plate or other suitable material.

NOTE: Screen mesh or other suitable material openings of approximately No. 8 (2.36 mm) and No. 30 (600 µm) has been found to perform well.

9.3. Catch pan of sufficient size to hold the sample basket(s) so that aggregate particles and melting asphalt binder falling through the screen mesh are caught.

9.4. Oven capable of maintaining 230 ± 9°F (110 ± 5°C).

9.5. The balance shall conform to the requirements of Part V, 5.9; Sampling and Test Methods Foreword, for the class of general purpose balance required for the principal sample mass of the sample being tested.

9.6. Safety equipment - safety glasses or face shield, high temperature gloves, long sleeve jacket, a heat resistant surface capable of withstanding 1202°F (650°C) and a protective cage capable of surrounding the sample baskets during the cooling period.
9.7. Miscellaneous equipment consisting of, a pan larger than the sample basket(s) for transferring sample after ignition, spatulas, bowls and wire brushes.

10. TEST PROCEDURES (TEST METHOD B)

10.1. Preheat the ignition furnace to 932°F (500°C).

10.2. Oven dry field HMA samples to a constant mass at a temperature of 230 ± 9°F (110 ± 5°C).

10.3. Record the calibration factor for the specific mix to be tested as determined in Section 6 of this test method.

10.4. Weigh and record the mass of the sample basket(s) and catch pan (with guards in place).

10.5. Prepare the sample as described in Section 5 of this test method. Place the sample basket(s) in the catch pan. Evenly distribute the sample in the basket(s), taking care to keep the material away from the edges.

10.6. Allow the sample to cool to room temperature. Weigh and record the total mass of the sample, basket(s), catch pan, basket guards. Calculate and record the initial mass of the specimen (total mass minus the mass of the specimen basket assembly).

10.7. Burn the HMA sample in the furnace for at least 40 minutes after the ignition oven has cycled through the initial burn off phase.

NOTE: The appropriate time for the initial burn of an HMA sample is dependent on sample size and aggregate material. For larger samples, the time could be significantly longer than 40 minutes.

10.8. Remove the sample from the furnace after ignition and allow to cool to approximately room temperature (at least 30 minutes).

10.9. Weigh and record the mass (W_A) of the sample after ignition to the nearest 0.1 g.

10.10. Repeat steps in Sections 10.7 through 10.9 of this manual until a visual inspection indicates complete burn-off has been accomplished. Adjust the 40 minute time so a single burn-off sequence is required. It may be necessary to cycle the sample through for an additional 10 minute program after the initial run. The material will appear free of asphalt (no small black asphalt particles intermixed in material) and the change is measured in mass (W_A) does not exceed 0.1% of the initial mass (W_S). Additional burn time may indicate a need for a new filter. Filters have found to last two to four burn-offs.

10.11. Record the last value obtained for (W_A) as the mass (W_A) of the sample after ignition.

10.12. Calculate the asphalt content of the sample using one of the following equations:
10.12.1. For a Superpave design (total mass mix):

\[
AC\% = \left[ \frac{W_S - W_A}{W_S} \times 100 \right] - C_F
\]

Where:
- \( AC\% \) = The measured (corrected) asphalt content percent by mass of the HMA sample.
- \( W_A \) = The total mass of aggregate remaining after ignition.
- \( W_S \) = The total mass of the HMA sample prior to ignition
- \( C_F \) = Calibration factor, percent of mass of HMA sample

Where:
- \( C_F = (C_A + C_B)/2 \)

\( C_A \) or \( C_B \) = measured asphalt content – actual content

Where:
- \( C_A \) or \( C_B \) = Individual sample correction factors, percent by mass of HMA sample as outlined in Section 6.8 of this test method.

10.12.2. For a Marshall mix design (dry aggregate method):

\[
AC\% = \left[ \frac{W_S - W_A}{W_A} \times 100 \right] - C_F
\]

Where: \( AC\% \) = The measured (corrected) asphalt content percent by dry aggregate mass of the HMA sample.

11. GRADATION

11.1. Allow the specimen to cool to room temperature in the sample baskets.

11.2. Empty the contents of the baskets into a flat pan. Use a small wire sieve brush to so that any residual fines are removed from the baskets.

11.3. Perform the gradation analysis according to KT-34

12. REPORT

12.1. Always report the test method (A or B), correct asphalt content, calibration factor, temperature compensation factor (if applicable), total percent loss, sample mass, test temperature and total time. Examples of a spreadsheet available for use with Method B are in Figure 1 and Figure 2.

13. PRECISION AND BIAS

13.1. The precision estimates in Table 2 are taken from AASHTO T-308.

NOTE: The precision estimates given in Table 2 are based on the analysis of test results from three pairs of AMRL proficiency samples. The data analyzed consisted of results from 353 to 461 laboratories for each of the three pairs of samples. The analysis included two binder grades: PG 52-34 and PG 64-22.
Average results for asphalt content ranged from 4.049 to 5.098 percent. The details of this analysis are in NCHRP Final Report, NCHRP Project No. 9-26, Phase 3.

**NOTE:** The precision estimates are based on 4 aggregate types, 4 replicates, and 12 laboratories participating with 0 laboratory results deleted as outlying observation. All 4 aggregates were tested in surface mixes and had relatively low absorption values.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Precision Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt Content</td>
<td>Standard Deviation 1s</td>
</tr>
<tr>
<td>Single Operator Precision Asphalt Content (%)</td>
<td>0.069</td>
</tr>
<tr>
<td>Multi Lab Precision Asphalt Content (%)</td>
<td>0.117</td>
</tr>
</tbody>
</table>

**13.2.** Any biases inherent to the ignition oven process used for Test Methods A and B, when testing for asphalt content and aggregate gradation, are accounted for by the determination and application of appropriate correction factors.

<table>
<thead>
<tr>
<th>Figure 1</th>
<th>Determination of Ignition Burn-Off Correction Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target AC %</strong></td>
<td><strong>5.55</strong></td>
</tr>
<tr>
<td>Trial #1</td>
<td>Trial #2</td>
</tr>
<tr>
<td>Mass of Sample &amp; Basket</td>
<td>7690.4</td>
</tr>
<tr>
<td>Mass of Basket</td>
<td>6179.1</td>
</tr>
<tr>
<td>Mass of Sample</td>
<td>1511.3</td>
</tr>
<tr>
<td>Mass of Aggregate &amp; Basket</td>
<td>7606.2</td>
</tr>
<tr>
<td>Mass of Basket</td>
<td>6179.1</td>
</tr>
<tr>
<td>Mass Loss</td>
<td>84.2</td>
</tr>
<tr>
<td>% AC by Mass of Mix (uncorrected)</td>
<td>5.57</td>
</tr>
<tr>
<td>Difference from Target %</td>
<td>0.02</td>
</tr>
<tr>
<td>Correction Factor (2 Trials)</td>
<td>0.03</td>
</tr>
</tbody>
</table>
### Figure 2

Spreadsheet for Calculating Corrected Asphalt Content

<table>
<thead>
<tr>
<th>Mix Type: SM-9.5A</th>
<th>Lab. No. 09-1511</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project #:</strong> 23-90 KA 1429-01</td>
<td><strong>Sample Date:</strong> 7/10/09</td>
</tr>
<tr>
<td><strong>Design No.:</strong> 3G09007A</td>
<td><strong>Report Date:</strong> 7/11/09</td>
</tr>
<tr>
<td><strong>Technician:</strong> J Doe</td>
<td></td>
</tr>
</tbody>
</table>

#### EXTRACTION

<table>
<thead>
<tr>
<th>SIEVE SIZE</th>
<th>GMS RET</th>
<th>% RET.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1” (25.0 mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/4” (19.0 mm)</td>
<td>7651.0</td>
<td></td>
</tr>
<tr>
<td>1/2” (12.5 mm)</td>
<td>6064.4</td>
<td></td>
</tr>
<tr>
<td>3/8” (9.5 mm)</td>
<td>1586.6</td>
<td>74.8 5</td>
</tr>
<tr>
<td>No.4 (4.75 mm)</td>
<td>7560.5</td>
<td>389.0 26</td>
</tr>
<tr>
<td>No.8 (2.36 mm)</td>
<td>1496.1</td>
<td>658.2 44</td>
</tr>
<tr>
<td>No.16 (1.18 mm)</td>
<td>90.5</td>
<td>957.4 64</td>
</tr>
<tr>
<td>No.30 (600 µm)</td>
<td>0.05</td>
<td>1166.9 78</td>
</tr>
<tr>
<td>No.50 (300 µm)</td>
<td>5.65</td>
<td>1331.4 89</td>
</tr>
<tr>
<td>No.100 (150 µm)</td>
<td></td>
<td>1406.2 94</td>
</tr>
<tr>
<td>No.200 (75 µm)</td>
<td></td>
<td>1451.1 97.0</td>
</tr>
<tr>
<td>Pan No. 200 (75µm)</td>
<td></td>
<td>1454.1</td>
</tr>
<tr>
<td>Total Time (min.)</td>
<td></td>
<td>89</td>
</tr>
</tbody>
</table>

#### Wt. of Agg. Before Washing

| Pan wt. within 0.2% of line 10. | 1455.3 |

Copies of the spreadsheet can be obtained from the Construction and Materials Field Engineer. Spreadsheets are currently in Excel format.