

State of Nevada
Department of Transportation
Materials Division

**METHOD OF TEST FOR DETERMINING BITUMEN RATIO IN HOT MIX ASPHALT
BY THE IGNITION METHOD**

SCOPE

This test method covers the determination of bitumen ratio on hot mix asphalt (HMA) paving mixtures and pavement samples by ignition of the asphalt cement in an ignition furnace at 482°C or 538°C (900°F or 1000°F).

APPARATUS

1. Furnace (Figure 1), forced air ignition furnace capable of maintaining temperatures to $538 \pm 5.5^{\circ}\text{C}$ ($1000 \pm 10^{\circ}\text{F}$), with an internal balance thermally isolated from the furnace chamber accurate to 0.1 g. The balance shall be capable of weighing a 3,000 g sample in addition to the sample baskets. A data collection system will be included so that the weight can be automatically determined and displayed during the test. The furnace shall have a built-in computer program to calculate the change in mass of the sample baskets and provide for the input of a calibration factor to account for aggregate loss or incomplete asphalt combustion. The furnace shall provide a printed ticket with the initial sample mass, sample mass loss, temperature compensation, calibration factor, corrected asphalt content (%), corrected bitumen ratio (%), test time and test temperature. The furnace chamber dimensions shall be adequate to accommodate a sample size of 3,000 g. The furnace shall provide an audible alarm and visible indicator when the sample mass loss does not exceed 0.01 percent 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. If the furnace uses filters, they must be self-cleaning ceramic filters. The furnace shall be vented into a hood or to the outside and shall have no noticeable odors escaping into the laboratory. The furnace shall have a fan with the capability to pull air through the furnace to expedite the test and to reduce the escape of smoke into the laboratory.
2. Balance, with a capacity of 12,000 g and sensitive to 0.1 g.
3. Sample baskets (Figure 2), two or more nested sample baskets will be used that allow the samples to be thinly spread and allow air to flow up through and around the sample particles. The sample shall be completely enclosed with screen mesh or perforated steel plate with maximum and minimum openings of No. 6 (3.35 mm) and No. 30 (600 μm).
4. Catch pan (Figure 2), sufficient size to hold the sample baskets so that aggregate particles falling through the screen mesh are caught. Wire guards will be provided to attach the sample baskets firmly to the catch pan.
5. Retriever (Figure 2), capable of safely moving the sample baskets in and out of the heated furnace.

6. Oven, capable of maintaining a temperature of $110^{\circ} \pm 5^{\circ}\text{C}$ ($230^{\circ} \pm 9^{\circ}\text{F}$).
7. Safety equipment (Figure 2), face shield or safety glasses to provide eye protection when loading and unloading sample baskets out of the furnace. Gloves capable of withstanding temperatures up to 538°C (1000°F). A protective cage to surround the sample baskets during cooling.
8. Miscellaneous equipment, pans for holding samples. Spatulas and brushes for removing asphalt mixtures and aggregate from baskets and pans.

FURNACE CLEANING

1. The furnace shall be cleaned before a calibration factor (C.F) is obtained and weekly thereafter, by the field lab tester, to ensure proper operation. Follow the instructions below for proper cleaning. Cleaning shall be performed with the furnace at room temperature.
 - a. After the power to the furnace has been disconnected, disassemble the top vent tube from the blower motor. Using a Shop-Vac, clean out the vent tube and the blower motor of all soot build up.
 - b. Remove the top two covers of the furnace, using a Shop-Vac clean the area under the top two covers. Oil the blower motor with Anderol 465 lubricant.
 - c. Open the chamber door. Using a Shop-Vac clean the area around chamber door. Inspect the door insulation for black streaks of soot. (Usually running from the outside corners of the insulation towards the center.) If black streaks are present, it is a sign the door is loose and the chamber is sucking in air. Contact the local IA lab for repair.
 - d. Remove the hearth plate and Shop-Vac furnace walls. While the hearth plate is removed, verify ceramic support tube placement. The four ceramic support tubes located in the bottom of the furnace chamber, shall be positioned and seated on the appropriate pins on the balance plate, the tubes shall be centered and shall not touch the sides of the ports. Once the position of ceramic support tubes has been verified place the hearth plate on top of the tubes.
 - e. In the 1087 and 1275 series furnace there is an orifice in the back of the chamber. This orifice is the opening that extends upward into the top plenum. It acts like a chimney to prevent smoke buildup in the chamber. Ensure this orifice is free of any soot buildup. A pipe cleaner or stiff wire brush can be used to clean out the orifice.
 - f. When all cleaning is complete, oil the blower motor with Anderol 465 lubricant. Put the furnace back together and place heat tape back around the vent tube and blower connection.
 - g. Perform the lift test on the furnace after the weekly cleaning has been completed. Record the lift test on the weekly calibration check on NDOT form 040-053. Refer to the Operation Manual for the lift test procedure and lift ranges.

CALIBRATION

1. A calibration factor (C.F.) is required to account for the loss of aggregate during the ignition process or for the incomplete combustion of the asphalt in a sample. The C.F. may be affected by the type, source and gradation of aggregate used, by the type, quantity, and brand of asphalt used, and by the addition of mineral filler. Therefore, to optimize accuracy, a C.F. shall be established for every aggregate type and source and for every type and brand of asphalt used. Any change in the aforementioned will require that a new C.F. be established.

In addition to the reasons listed above, a new C.F. will be required under the following conditions:

- a. Change in the recommended bitumen ratio of $\pm 0.4\%$ or greater.
- b. Change in any one of the aggregate bin percentages of $\pm 4.0\%$ or greater
- c. Change in the amount of mineral filler or a change in the method of adding mineral filler.
- d. If the Resident Engineer has a reason to suspect a material change that may affect the C.F..

The C.F. is also dependent upon the testing temperature. Testing will be performed at either 538°C or 482°C (1000°F or 900°F). A test temperature is selected that will provide adequate ignition of the asphalt, while minimizing aggregate loss.

2. After the hotplant has been calibrated, obtain the combined and marinated aggregate (coldfeed samples) at the hotplant per Test Method Nev. T200. Prepare four coldfeed samples for the C.F. per Test Method Nev. T203. All C.F. calculations shall be completed on NDOT form 040–053 or 040–053A.
3. Using the most current job mix formula (JMF), calculate the amount of mineral filler based on actual bin percentages, per section 401 of the Standard Specifications for Road and Bridge Construction.

Example:

7%	– 1 in. aggregate	(coarse)
21%	– 3/4 in. aggregate	(coarse)
25%	– 1/2 in. aggregate	(coarse)
20%	– crushed fines	(fine)
27%	– washed sand	(fine)

53% coarse aggregate	x 0.01	=	0.53% mineral filler
47% fine aggregate	x 0.02	=	0.94% mineral filler

(Example: 2500 g of blended aggregate including 1.47% mineral filler)

$$\text{Formula: } \frac{\text{Dry Aggregate} + \text{Mineral Filler}}{1 + [(\% \text{ Mineral Filler}) \div 100]} = \text{Dry Aggregate without Mineral Filler}$$
$$\frac{2500\text{g aggregate}}{1.0147 \text{ mineral filler}} = 2463.8 \text{ g of aggregate without Mineral Filler}$$

4. Preheat the ignition furnace to 538°C (1000°F).
5. Dry the coldfeed sample to a constant mass, per Test Method Nev. T112. Heat up the asphalt in the oven so that it is in a liquid state (easy to stir and pour).
6. Place the coldfeed sample into a heated (230° ± 9°F), tared and buttered bowl and record the weight. Place the buttered bowl with material into the oven and calculate how much asphalt and/or RAP will need to be added. Refer to the Standard Operation Procedures Manual sections, 040–053 or 040–053A.
7. Once asphalt and/or RAP calculations are completed remove the buttered bowl with the material from the oven with gloves and form a “crater” in the middle of the material. Place the buttered bowl with material on the tared balance. Use a buffer to protect the balance from the heat.
8. Once the “crater” is made in the center of the material and the balance has been tared, stir the preheated asphalt with a stir rod to ensure uniformity before pouring. Carefully pour the calculated amount of hot asphalt into the “crater”. Stop when the balance reads the exact amount of asphalt calculated for the calibration, if the required amount of asphalt is exceeded, it is permissible to carefully dab out the extra asphalt with a paper towel. When calibrating for a RAP material, add the calculated amount of RAP material to the buttered bowl, material and asphalt.
9. Place the buttered bowl containing the material, asphalt and rap (if required) on a burner to keep warm while stirring into a homogenous mixture.
10. Once two calibration samples are mixed, test the samples in accordance with the “PROCEDURE” section, steps 4 through 10, using a correction factor of zero.
 - a. After placing material in the basket and recording the weight. The final weight shall be within 10 grams of the “Total Weight” as calculated on NDOT form 040–053 or 040–053A.
11. If the difference between the “Bit. Ratio” of the two samples is less than 0.15%, these results may be used to calculate the C.F.. If the difference between the “Bit. Ratio” for the two samples exceeds 0.15, repeat the calibration procedure with the two additional samples, repeating steps 5 through 10 of the “CALIBRATION” section. From the four samples discard the high and the low results and determine the C.F. from the remaining two results. The difference between these two remaining results must be within 0.15%.
12. Calculate the difference between the “Bit. Ratio” and “Bit. Ratio Total” to obtain the C.F. for each sample. To obtain the C.F. for this material take the average of the two correction factors to the nearest 0.01.

It is possible that some asphalt/aggregate combinations will produce a “Bit. Ratio” less than the mix design bitumen ratio. This will produce a negative C.F., rather than correcting for aggregate loss, a negative C.F. corrects for the asphalt that is not completely ignited during the test procedure.

13. If the C.F. exceeds 1.00%, lower the test temperature to 482°C (900°F) and repeat the calibration procedure. Use the C.F. obtained at 482°C (900°F) even if it exceeds 1.00%. If excessive aggregate breakage occurs at 538°C (1000°F), the test temperature shall be lowered to 482°C (900°F) and the calibration procedure repeated even if the C.F. does not exceed 1.00%.
14. The C.F. is to be recorded and used to determine the corrected bitumen ratio of HMA paving mixtures as per the “PROCEDURE” section. The temperature for testing HMA samples in the “PROCEDURE” section shall be the same temperature selected for testing calibration samples. The C.F. will be verified by testing a single sample at least once a week by the procedure outlined in this section. If the difference between the “Bit. Ratio” and “Bit. Ratio Total” differs from the C.F. by more than 0.20, a new C.F. will be established as per this section. Record the C.F. including weekly checks on NDOT form 040–053 or NDOT form 040–053A if utilizing RAP.
15. The C.F. to be used for HMA paving mixtures shall be the average between the two C.F. samples tested at the same temperature to the nearest 0.01.

SAMPLE PREPARATION

1. Obtain a representative sample of the paving mixture per Test Method Nev. T200.
2. If the mixture is not sufficiently soft to separate during splitting, place it in an oven at 135°C (275°F) until it can be easily handled.

Obtain a representative split of the heated sample per Test Method Nev. T203. The size of the test sample shall conform to the minimum mass requirements per Test Method Nev. T206 after the ignition process.

If the sample size exceeds the capacity of the furnace, the sample may be split into two representative portions and the results combined after testing. Sample sizes shall not be more than 500 g greater than the minimum recommended sample mass.

3. Oven dry the sample or use a representative split of the material and obtain the moisture content (MC) per Test Method Nev. T306.

PROCEDURE

1. Preheat the ignition furnace to the proper temperature for the sample to be tested as determined in the “CALIBRATION” section.
2. Weigh the mass of the sample basket assembly (sample baskets, catch pan and guards) and write on NDOT form 040–050.

3. Divide the representative split of material into two approximately equal portions, evenly distribute each sample portion into the sample baskets and spread into thin layers. If the sample basket size allows, keep the mix approximately 25 mm (1 in.) away from the sides of the sample baskets to reduce aggregate loss. Weigh the sample, sample baskets, catch pan, and guards. Calculate the dry mass (MI) of the sample (total sample mass – mass of the sample basket assembly) to the nearest 0.1 g, and record on NDOT form 040–050.
4. Enter the dry mass (MI) of the sample and the C.F., obtained in the “CALIBRATION” section, into the furnace.

To enter the C.F. into the furnace, on the front control panel of the furnace, press the button on the keypad labeled “calibration factor”, immediately enter the C.F. using the number keypad and press enter, wait a moment and press the “calibration factor” button again to ensure the C.F. number entered is correct.

To enter the dry mass (MI) of the sample into the furnace, on the front control panel of the furnace and press the button on the keypad labeled “weight”, immediately enter the dry mass (MI) using the number keypad and press enter, wait a moment and press the “weight” button again to ensure that the dry mass (MI) weight entered is correct.

Take care to input the correct sign (positive or negative) when entering the C.F., press the “calibration factor” button twice to enter a negative value. Press the “calibration factor” button twice to return to a positive value.

5. Before placing the sample in the furnace, zero out the balance by pressing the “(0)” button located on the keypad of the furnace.
6. Open the furnace door and gently set the sample basket assembly on the hearth plate. Do not slide the sample basket assembly on the hearth plate or against the thermocouple. Ensure that the sample basket does not contact any of the interior walls of the furnace. Verify that the total sample mass (including the sample basket assembly) displayed on the furnace balance equals the total mass recorded within ± 5 g. Differences greater than 5 g or failure of the furnace balance to stabilize may indicate that the sample basket assembly is contacting a furnace wall. Initiate the test, by pressing the “start” button on the furnace keypad. This will lock the furnace door and start the combustion blower.

The furnace temperature will drop below the set point (538° or 482°C) when the door is opened, but will recover with the door is closed and when ignition occurs.

7. Burn the sample in the furnace at the specified temperature until the mass loss does not exceed 0.01 percent of the dry mass for three consecutive one minute intervals. The visible indicator and audible stable alarm will indicate that the test is complete. At this point press the “stop” button on the furnace, the test will stop and print out the results.

If there is a power failure and the furnace turns off during ignition, turn the furnace back on and make sure the sample completed combustion. DO NOT open the door until combustion is complete. If a manual calculation of the bitumen ratio is needed, make a note on NDOT form 040–050 as to why a

manual calculation was performed.

8. Remove the sample basket assembly from the furnace and allow it to cool. The sample basket assembly shall be placed on a heat resistant surface and covered with the protective cage during cooling.
9. B.R. (printed tape) will be automatically computed by the furnace and reported on a printed tape. If the M.C. has been determined, subtract the M.C. from the B.R. (printed tape) and report as the B.R..
12. If for any reason the furnace cannot be used to automatically calculate a corrected B.R., calculations can be performed manually. Weigh the total mass of the cooled sample after ignition (sample, sample baskets, catch pan, and guards). Calculate the B.R. by the following formula:

$$\text{B.R. from Manual Calculation} = \left[\left(\frac{\text{MI} - \text{MF}}{\text{MF}} \right) \times 100 \right] - \text{CF}$$

Where:

MI = Dry mass of HMA sample prior to ignition.

MF = Mass after ignition.

CF = Calibration Factor obtained in accordance with the "CALIBRATION" section.

Determine the mass of the aggregate after ignition within 30 minutes of cooling.

13. The aggregate remaining after ignition should be used for the sieve analysis if required per the specifications, per Test Method Nev. T206.

REPORT

1. B.R. shall be reported to the nearest 0.01% on NDOT form 040-050 and to the nearest 0.1% on NDOT form 040-011.



Figure 1
Furnace

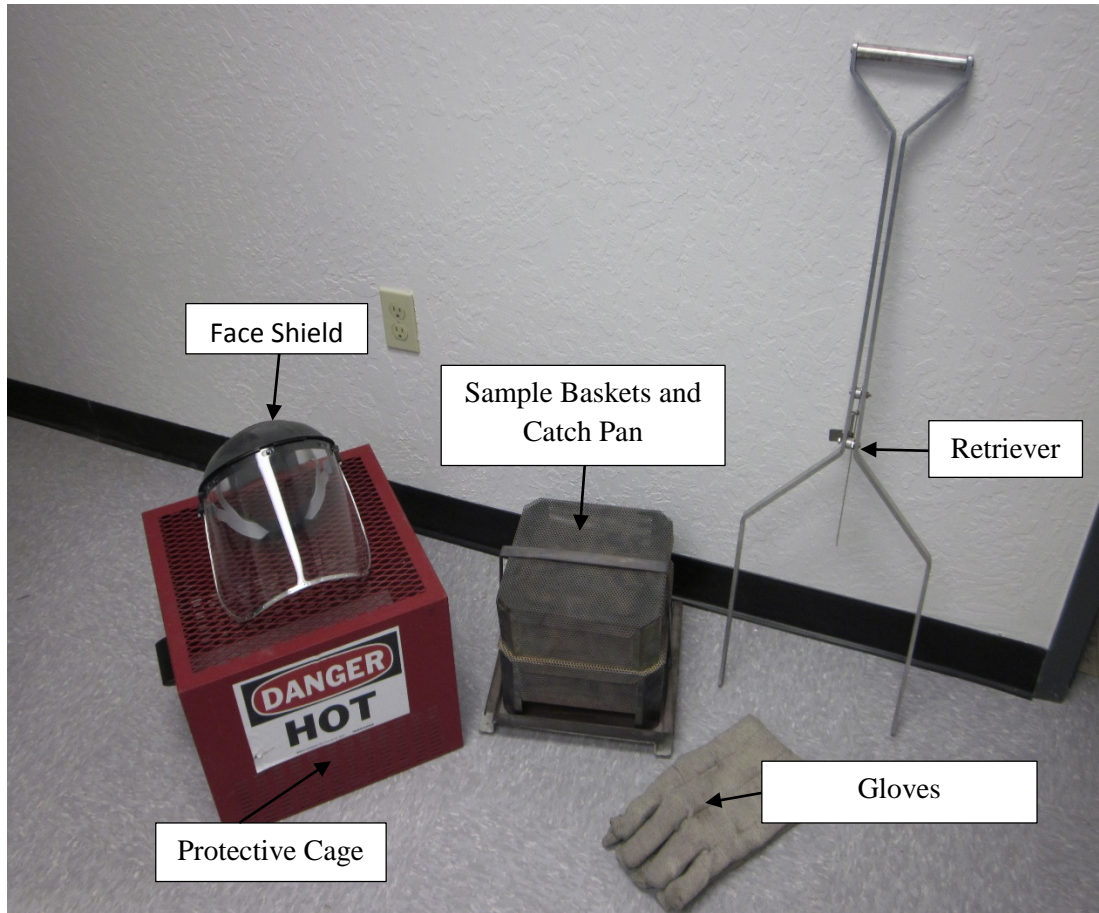


Figure 2