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DIVISION OF ENGINEERING SERVICES
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DETERMINATION OF ASPHALT BINDER CONTENT OF BITUMINOUS PAVING MIXTURES BY THE IGNITION METHOD

CAUTION: Prior to handling test materials, performing equipment setups, and/or conducting this method, testers are required to read "**SAFETY AND HEALTH**" in Section I of this method. It is the responsibility of the user of this method to consult and use departmental safety and health practices and determine the applicability of regulatory limitations before any testing is performed.

A. SCOPE

This test method provides a procedure to determine the asphalt binder content of bituminous paving mixtures by removing the asphalt binder via pyrolysis. Bituminous mixture samples are placed in a furnace and heated past the autoignition point of the asphalt binder (typically ranging from 470°C to 570°C). The asphalt binder is ignited and burned off leaving the aggregate intact.

The type of aggregate in the bituminous paving mixture may affect the results of this test method. Different aggregates may lose mass, to varying degrees due to the pyrolytic action. Accordingly, a correction factor is determined for each type of bituminous paving mixture. Correction factors are specific to the component materials and proportions thereof, and to the ignition furnace used in their development. Before a correction factor can be applied to a different ignition furnace than the one for which it was developed, it is necessary to verify the correction factor for the furnace in which it is intended to be used according to Section F of this procedure.

This test method employs appendices to modify the basic test method for equipment requiring specific manufacturer operational procedures.

B. APPARATUS

Ignition Furnace, having a temperature control capability of $\pm 5^{\circ}\text{C}$ between the range of 470°C and 580°C. The furnace shall accommodate sample sizes of at least 3000 g. The furnace shall have a blower/fan to move air within the ignition chamber in order to expedite the materials testing and to minimize any smoke or emissions that may be discharged into the laboratory during asphalt binder removal. The furnace must also incorporate a means (e.g., an afterburner and/or filter system) to minimize or eliminate emissions during asphalt binder removal.

The ignition furnace shall be either of the following types:

Type 1 – The Type 1 ignition furnace shall have an internal balance (accurate to 0.1 g) capable of measuring the combined masses of the catch pan, the sample basket(s), and the sample. The furnace shall have a data collection/processing system that permits the input of factory calibration data and a correction factor, determines and displays the mass loss during the test, detects the end point (i.e., when the mass loss during a 3 minute ignition interval does not exceed 0.01 % of the initial sample mass), and employs an audible alarm and visual display system and/or indicator lights. The furnace shall also provide a printout (or

ticket) with the elapsed time, temperature, initial sample mass, sample mass loss, correction factor, corrected asphalt content, and factory temperature compensation. Sample mass after ignition may be verified by weighing on an external scale.

Type 2 – The Type 2 ignition furnace has no internal balance or end point detection equipment. The duration of the ignition cycle must be established by manually measuring the sample's mass outside of the furnace to determine when a constant mass has been achieved.

Balance or scale, with a minimum capacity of 6000 g and capable of measuring the combined masses of the catch pan, the sample basket(s), and the sample to an accuracy of 0.1 g.

Temperature Probe, suitable for measuring sample temperatures within the sample basket(s) or within mixing bowls.

Sample Basket(s), of a size that allows the sample to be spread in relatively thin layers, and that allows air to flow through and around the sample's particles. The sample basket(s) shall be stackable and completely enclose the sample.

NOTE 1: Perforated steel sheets, 40 % of which consists of 3.175 ± 0.175 mm holes, or 6 mm expanded metal mesh, can be used.

Catch Pan, of sufficient size to hold the sample basket(s) and retain aggregate particles that fall through the sample basket(s) openings during the material testing.

Handling Apparatus, suitable for inserting and removing the catch pan and sample basket(s).

Assorted spatulas, pans, bowls and wire brushes.

Protective Gloves, well insulated and capable of withstanding 590°C.

Protective Cage, for isolating the catch pan and sample basket(s) during the cooling period.

Face Shield, to provide protection from heat, smoke/emissions, etc.

Oven, for drying at $110^{\circ}\text{C} \pm 5^{\circ}\text{C}$ and/or preheating ingredients at 110°C to 165°C prior to batching or testing.

Mixing Apparatus, Hobart Model A 200, or equal, and a mixing bowl (11 L \pm), or Caltrans mechanical mixing machine (California Test 304).

NOTE 2: Standard Hobart mixing paddles will have to be modified using flexible spring steel for bowl contact edges to prevent paddle breakage. Stainless steel paddles and wire whips are also acceptable and available. Whips should be inspected before use for loose or broken wires and to assure that bowl contact is achieved during mixing.

Sample splitters for aggregates, riffle type conforming to California Test 201.

Sample splitter for bituminous mixtures, mechanical or hand quartering types.

C. SAMPLING

1. For developing the correction factor, obtain samples of the aggregate, additives (if any), and the asphalt binder that will be used on the project in accordance with California Test 125. For testing, the size of the bituminous paving mixture sample shall be governed by the nominal maximum aggregate size of the mixture and shall conform to the mass requirement shown in Table 1.

NOTE 3: Nominal maximum aggregate size is one sieve size smaller than the maximum aggregate size. Maximum aggregate size is the smallest sieve size that requires 100 % passing.

Table 1

Nominal Maximum Aggregate Size, mm	Minimum Mass of Mixture Sample, g
4.75	1200
9.5	1200
12.5	1500
19.0	2000
25.0	3000
37.5	4000

2. Specimen sizes shall not be more than 400 g greater than the minimum recommended values in Table 1.
3. Prepare the aggregate per California Test 201 prior to batching for this test method.

D. CORRECTION FACTOR

1. Record the mix design (including additives and the type of asphalt binder) to be used for the project. All specimens prepared for the determination of a correction factor shall be tested using the mix design gradation that includes the same aggregates, additives and asphalt binder that will be used on the project. Prepare all loose mixture specimens in accordance with California Test 304, Part 1A, "Preparation of Design Sets," except eliminate curing.

NOTE 4: For field laboratories that are not equipped with mixing apparatus but are equipped with an ignition furnace, the mixture samples will have to be prepared elsewhere as specified herein, and shipped to the field for determination of the correction factor for the field laboratory furnace. These samples shall be

oven dried as outlined in Section E, Step 2, before they are placed into the ignition furnace.

2. Split and batch enough aggregate for four mixture specimens (keep in mind that up to 10 specimens may be required per mix design). Randomly select one of the batched aggregate specimens and perform washed sieve gradation analysis according to California Test 202. Verify that the results for each sieve size are within the project gradation tolerances for the mixture design. If they are not, then discard all four samples and use the sieve results to adjust the gradation as needed according to California Tests 304 and 105. Repeat this step as needed to produce specimen gradations that comply with the mixture design tolerances before proceeding to the next step.
3. Set the ignition furnace temperature at 538°C (the set point). If it is adjustable, the afterburner temperature should be set according to the furnace manufacturer's recommendations for the type of bituminous mixture being tested.

NOTE 5: If experience with particular materials indicates correction factors > 0.5 % are likely to result from using the 538°C set point, then the alternate 482°C set point may be used to develop the correction factor.

4. Start with clean equipment for each mix design to be tested. Prior to mixing the specimens, prepare an initial (or "butter") mix to condition the mixing equipment. The "butter" mix shall be the same as the mix design to be tested. The use of the "butter" mix minimizes any bias contributed by residual mix retained in the mixing bowl. Remove this mix from the bowl by scraping, leaving a coating of mix residue. Discard the material that is removed.

5. Prepare two mix specimens at the design asphalt binder content. Measure and record the mass of dry aggregate used in each sample as M_{agg} . Measure and record the mass of the asphalt binder used in each sample as M_{ab} . Record the known asphalt binder content for each sample, in percent of dry aggregate, as AC_{known} .
6. Measure the mass of the sample basket(s) and catch pan. Record this mass as M_e .
7. Evenly distribute one specimen in the sample basket(s), in as relatively thin a layer(s) as possible. Whenever possible, take care to keep the material away from the edges of the basket(s), noting that 25 mm is the recommended spacing. Not all sample baskets are large enough to accommodate the recommended spacing, and the material may be placed against the sides of the basket(s) as necessary. Whenever multiple stacked baskets are used, also take care to distribute the specimen as evenly as possible amongst the sample baskets.
8. Place the other of the two mixture specimens in a $110 \pm 5^\circ\text{C}$ oven until ready to test per Section D, Step 21. Do not preheat the sample basket(s).

NOTE 6: It is the intent of this test method to test each pair of samples back to back or at least during the same day.

9. Measure the total mass of the sample, sample basket(s), and catch pan. Record this initial mass as M_1 . If a Type 2 furnace will be used, also record the temperature of the bituminous mixture when M_1 is measured because it will be used for all testing that incorporates the correction factor determined by this procedure. Place the mixture specimen in the ignition furnace within 15 minutes after mixing or removal from $110 \pm 5^\circ\text{C}$ oven (see Steps 5 and 8).

10. Calculate and record the initial sample mass as follows:

$$M_s = M_1 - M_e$$

Where:

- M_s = initial sample mass prior to ignition,
 M_1 = total mass of the sample, sample basket(s), and catch pan prior to ignition, as determined in Section D, Step 9, and
 M_e = total mass of the sample basket(s) and catch pan as determined in Section D, Step 6.

NOTE 7: Verify that the furnace chamber temperature is stabilized at the set point entered in Section D, Step 3 prior to proceeding and between all subsequent tests. The furnace chamber temperature will increase during the ignition phase of the test.

For Type 1 furnaces, follow Steps 11 through 13, and then skip to Step 21. For Type 2 furnaces, skip to Step 14.

11. After placing the sample, sample basket(s), and catch pan in the furnace, close the door and verify that the mass of the sample, sample basket(s), and catch pan indicated by the internal balance is within ± 5 g of the total mass (M_1) recorded in Section D, Step 9. Differences of more than 5 g or failure of the balance to stabilize may indicate that the sample basket(s) and catch pan are in contact with the furnace wall. If necessary, reposition the sample basket(s) and catch pan in the furnace.

NOTE 8: For some furnaces, the initial sample mass (M_s) recorded in Section D, Step 10 must be entered by the technician based on an external measurement.

NOTE 9: Input a correction factor of zero into the ignition furnace computer.

12. Perform the sample "burn" in the ignition oven. When the change in mass of the sample over a 3-minute interval does not exceed 0.01 % of the initial sample mass (M_s), remove the sample, sample basket(s), and catch pan from the oven. Place them in the protective cage, and allow them to cool.
13. Report the mass (M_2) of the sample, sample basket(s), and catch pan after the ignition process. Also, record the total ignition time to obtain M_2 . This mass and time will be obtained upon completion of the ignition process from the printout or display, along with a printout showing the elapsed time, temperature, initial specimen mass, specimen mass loss, asphalt content with zero correction factor, and factory temperature compensation.

For Type 2 furnaces, follow Steps 14 through 20.

14. Perform the sample "burn" in the furnace for 40 minutes. Monitor and record temperature with time, taking note of the time when the temperature drops back down to the set point (538°C). If the temperature has not returned to the set point at the end of the initial 40 minutes, continue heating for 5-minute increments until the temperature drops to the set point. Monitor and record the 5-minute increments versus temperature. This incremental time record is required in other parts of this test method.
15. Remove the sample, sample basket(s), and catch pan from the furnace. Place them in the protective cage, and allow them to cool to the same temperature at which M_1 was measured in Section D, Step 9, $\pm 3^\circ\text{C}$.

NOTE 10: The temperature used for Step 15 shall be used for all testing that incorporates the correction factor determined by this procedure.

16. Measure and record the mass (M) of the sample, sample basket(s), and catch pan after ignition. Then, place them back into the furnace and let the furnace return to the set point temperature, then heat the sample for another 10 minutes.
17. Remove the sample, sample basket(s), and catch pan from the furnace. Place them in the protective cage, and allow them to cool to the same temperature at which M_1 was measured in Section D, Step 9, $\pm 3^\circ\text{C}$. Again, measure and record the mass (M) of the sample, sample basket(s), and catch pan at that same temperature, $\pm 3^\circ\text{C}$.
18. Repeat steps 16 and 17 until the change in mass (M) over a 10-minute interval does not exceed 0.01 % of the initial sample mass (M_s) as determined in Section D, Step 10.
19. Record the last value obtained as the mass (M_2) of the sample, sample basket(s), and catch pan after ignition. Measure M_2 at the same temperature as $M_1 \pm 3^\circ\text{C}$. Also, record the total ignition time (as found in Step 14, and Steps 16 through 18) required to obtain M_2 and the incremental time (as found in Step 14) to return to the set point temperature (538°C).

20. Calculate the asphalt binder content as follows:

$$A = \frac{M_1 - M_2}{M_2 - M_e} \times 100$$

Where:

A_1 = asphalt binder content of first mixture specimen expressed in percent by mass of dry aggregate,

- A_2 = asphalt binder content of second mixture specimen,
- M_1 = total mass of the sample, sample basket(s), and catch pan prior to ignition, as determined in Section D, Step 9,
- M_2 = total mass of the sample, sample basket(s), and catch pan after ignition, as determined in Section D, Step 19, and
- M_e = total mass of the sample basket(s) and catch pan as determined in Section D, Step 6.
- AC_{known} = known percent asphalt Binder added to each Laboratory prepared specimen (by dry mass of aggregate).

21. Repeat Steps 6 through 20 for the second specimen prepared at the known asphalt binder content.
22. If the difference between the measured asphalt binder contents of the two samples, $A_{(1)}$ and $A_{(2)}$, exceeds 0.15 %, repeat the Steps 5 through 20 for two additional specimens and, from the four test results, discard the high and low results. Determine the correction factor from the two remaining results.
23. Calculate the correction factor as follows:

$$CF = \frac{[A_{(1)} - AC_{\text{known } (1)}] + [A_{(2)} - AC_{\text{known } (2)}]}{2}$$

Where:

CF = the correction factor, is the average of the differences between the measured and actual asphalt binder contents for each sample expressed in percent by mass of dry aggregate, and

24. If a correction factor exceeds 0.5 %, lower the test temperature to 482°C and repeat the test procedure. Use the correction factor obtained at the 482°C set point even if it exceeds 0.5 %.

The temperature set point used to test field samples of bituminous paving mixtures per Section E, "Test Procedure," must be the same temperature set point used to establish the correction factor in Section D, Steps 3 and 9.

25. Use the correction factor determined from Step 23 or, if applicable, Step 24 to adjust the measured asphalt binder content obtained in Section E, "Test Procedure." The correction factor determined by this test method shall be used only with the same furnace and mix design gradation that includes the same aggregates, additives and asphalt binder used to establish the factor. If the mix design, component materials and/or the equipment are changed, or if the ignition furnace is moved to a different location, then a new correction factor shall be determined.

E. TEST PROCEDURE

1. In accordance with California Test 125, obtain and split a field sample of bituminous paving mixture from the project. The field sample size shall be sufficient to meet the minimum requirements of Table 1, Section C, and to provide approximately 2000 g for California Test 370.
2. Oven dry the sample to a constant mass at $110 \pm 5^\circ\text{C}$ until there is less than a 0.1 % difference in the mass measured for a 60 minute interval of drying time (refer to California Test 226) or determine the moisture content of the bituminous mixture according to California Test 370 so

that the measured mass loss can be corrected for moisture.

3. Set the ignition furnace temperature set point at the appropriate temperature set point as established during the determination of the correction factor, 538°C or 482°C. If it is adjustable, the afterburner temperature should be set according to the furnace manufacturer's recommendations for the type of bituminous mixture being tested.
4. Determine the mass of the sample basket(s) and catch pan. Record this mass as M_e .
5. Evenly distribute the field sample in the sample basket(s), and in as relatively thin a layer(s) as possible. When possible, take care to keep the material away from the edges of the basket(s), noting that 25 mm is the recommended spacing. If the sample baskets are not large enough to accommodate this recommended spacing the material may be placed against the sides of the basket(s). Whenever multiple stacked baskets are used, also take care to distribute the sample as evenly as possible amongst the sample baskets.
6. Measure the mass of the sample, sample basket(s), and catch pan. Record this initial mass as $M_{initial}$. If a Type 2 furnace will be used, this mass shall be measured when the sample cools down to the temperature at which M_1 was measured as recorded in Section D, Step 9.
7. Calculate and record the initial sample mass as follows:

$$M_s = M_{initial} - M_e$$

Where:

M_s = initial sample mass prior to ignition,

$M_{initial}$ = total mass of the sample, sample

basket(s), and catch pan prior to ignition, as determined in Section E, Step 6, and

M_e = total mass of the sample basket(s) and catch pan as determined in Section E, Step 4.

NOTE 11: Verify that the furnace chamber temperature is stabilized at the set point entered in Section E, Step 3 prior to proceeding and between all subsequent tests. The furnace chamber temperature will increase during the ignition phase of the test.

For Type 1 furnaces, follow Steps 8 through 10. For Type 2 furnaces, skip to Steps 11 through 18.

8. After placing the sample, sample basket(s), and catch pan in the furnace, close the door and verify that the mass of the sample, sample basket(s), and catch pan indicated by the internal balance is within ± 5 g of the initial mass recorded in Section E, Step 6. Differences of more than 5 g, or failure of the balance to stabilize, may indicate that the sample basket(s) and catch pan are in contact with the furnace wall. If necessary, reposition the sample basket(s) and catch pan in the furnace.

NOTE 12: For some furnaces, this initial sample mass (M_s) must be entered by the technician based on the external measurement (Section E, Step 7).

NOTE 13: Input into the ignition furnace computer the correction factor developed for this mix design in Section D, Step 23 or, if applicable, Step 24.

9. Perform the sample "burn" in the ignition oven until the change in mass of the sample over a 3-minute interval does not exceed 0.01 % of the initial sample mass (M_s) prior to ignition.

10. Report the mass (M_2) of the sample, sample basket(s), and catch pan after ignition and the total ignition time to obtain M_2 . This mass and time will be obtained upon completion of the ignition process from the printout or display along with a printout showing the elapsed time, temperature, initial specimen mass, specimen mass loss, corrected asphalt content, the correction factor input, and factory temperature compensation.

For Type 2 furnaces, follow Steps 11 through 18.

11. Perform the sample "burn" in the furnace for the longest of the two total ignition times as recorded in Section D, Step 19.

12. Remove the sample, sample basket(s), and catch pan from the furnace, place them in the protective cage and allow them to cool to the temperature recorded in Section D, Step 9, $\pm 3^\circ\text{C}$.

13. Measure and record the mass (M) of the sample, sample basket(s), and catch pan after ignition.

14. Place the sample, sample basket(s), and catch pan back into the furnace and let the furnace return to the temperature set point. Heat the sample for an additional 10 minutes.

15. Remove the sample, sample basket(s), and catch pan from the furnace, place them in the protective cage and allow them to cool to the temperature recorded in Section D, Step 9, $\pm 3^\circ\text{C}$. Measure and record the mass (M) of the sample, sample basket(s), and catch pan.

16. Repeat Steps 14 and 15 until the change in mass (M) of the sample, sample basket(s), and catch pan during a 10-minute period does not exceed 0.01% of the initial sample mass prior to ignition (M_s).

17. Record the last value obtained as the mass (M_2) of the sample, sample basket(s), and catch pan after ignition. Measure M_2 at the same temperature as $M_{\text{initial}} \pm 3^\circ\text{C}$. Record the total ignition time.

18. Determine the corrected asphalt binder content as follows:

$$AC = \left[\frac{M_1 - M_2}{M_2 - M_e} \times 100 \right] - CF$$

Where:

AC = corrected asphalt binder content, percent by mass of dry aggregate,

M_{initial} = total initial mass of the sample, sample basket(s), and catch pan as determined by Section E, Step 6,

M_1 = total mass of the sample (adjusted for moisture content), sample basket(s), and catch pan prior to ignition, calculated as follows:

$M_1 = M_{\text{initial}}$ for oven dried samples,

Or:

$$M_1 = \frac{M_{\text{initial}} - M_e}{1 + (H_2O/100)} + M_e$$

M_2 = total mass of the sample, sample basket(s), and catch pan after ignition as determined in Section E, Step 17,

M_e = total mass of the sample basket(s) and catch pan per Section E, Step 4,

CF = correction factor per Section D, Step 23 or, if applicable, Step 24, and

H₂O = moisture, percent of mix, per Section E, Step 2.

F. VERIFYING TRANSFER OF CORRECTION FACTOR TO ANOTHER IGNITION FURNACE

Before a correction factor determined in one ignition furnace according to Section D can be transferred or applied to a different ignition furnace for acceptance purposes, it is necessary to verify that the correction factor is appropriate for use in that other furnace according to the following procedure.

1. Prepare two mixture specimens for ignition furnace testing at the design asphalt binder content according to the requirements of Section D herein. NOTE 4 may be applied as needed.
2. Test the first specimen in the acceptance ignition furnace according to Section E and apply the previously determined correction factor to calculate the asphalt binder content. Compare the calculated value to the known asphalt binder content.
3. Repeat Step 2 using the second mixture specimen.
4. Average the results from Steps 2 and 3. If the resulting average asphalt binder content differs by less than or equal to $\pm 0.15\%$ from the actual binder content, the previously determined correction factor may be applied to the acceptance furnace. Record any difference from the known asphalt binder content for reference. However if the difference of the average from Steps 2 and 3 is greater than $\pm 0.15\%$ from the actual binder content, a new correction factor must be determined for the acceptance ignition furnace. The data from Steps 2 and 3 may be used to calculate the new factor as long as the requirements of Section D are met. Otherwise a new correction factor must be developed according

to the requirements and procedures of Section D.

G. REPORT

1. The report (see worksheets) should include the following:
 - a. Date,
 - b. Identification of aggregate, additives (if any), asphalt binder, and mix type,
 - c. Sample location, project identification, and Resident Engineer,
 - d. Test number,
 - e. Furnace Type (1 or 2), make, model, and serial number,
 - f. Correction Factor determination data,
 - g. Ignition time and incremental time,
 - h. Mass of sample before and after ignition,
 - i. Moisture content of bituminous mixture (when required), and
 - j. Corrected percent asphalt binder content.

H. PRECISION AND BIAS

Data to establish the following precision statements were obtained from a round robin study on carefully batched samples of dense graded asphalt concrete. This was reported by the National Center for Asphalt Technology in 1995.

Analyses of the data within laboratory and between laboratory precision provided the following:

	<u>Standard Deviation (S)</u>	<u>Acceptable Range of Two Results (D2S)</u>
Within laboratory	0.04	0.11
Between laboratories	0.06	0.17

The data consisted of measurements using a Type 1 oven and individual batched samples prepared for the round robin testing. There were 4 aggregate types, 4 replicates and 12 laboratories involved.

Developing a calibration factor for each aggregate addresses a known bias. Criteria for other biases such as sampling have not been established.

I. SAFETY AND HEALTH

Do not open the furnace door during ignition. Also, open the door slowly and carefully due to the possibility of flash re-ignition if the sample combustion is incomplete. The temperature of the furnace and door interior, and the sample, sample basket(s) and catch pan during and after removal from the furnace is extremely high. Caution must be exercised at all times, as failure to do so could result in severe burns or fire. The sample, sample basket(s) and catch pan must not be placed near any materials which are subject to ignition at the high temperatures used in this procedure, and must always be placed inside the protective cage to prevent accidental contact during the cooling period.

Prior to handling, testing or disposing of any waste materials, testers are required to read: Part A (Section 5.0), Part B (Sections: 5.0, 6.0 and 10.0) and Part C (Section 1.0) of Caltrans Laboratory Safety Manual. Users of this method do so at their own risk.

REFERENCES

California Tests 125, 201, 202, 226, 304, and 370

End of Text

(California Test 382 contains
16 pages and Appendices)

CORRECTION FACTOR WORKSHEET (SECTION D)

Sample I.D. _____ Project I.D. _____ Resident Engineer _____
 Location of Sample _____
 Furnace Make and Model _____ Serial No. _____
 Furnace Type (1 or 2) _____ Furnace Temperature Set Point (circle one) 538°C 482°C
 Testing Laboratory _____ Mobile Lab Unit I.D. _____
 _____ Technician Name _____
 _____ Date of Test _____
 Aggregate Source _____ Type of Asphalt Cement _____
 Additive(s) Type(s) and Source(s) _____

Type of AC Mix and Design Specifications (use the table below):

Type __: __ mm Maximum, _____ (Design Asphalt Binder Content = __%)

Sieve Size	Project Mix Design X or Target Values* Percent Passing	Project Tolerance Limits	Sample Gradation (Section D, Step 2)	
			Mass (grams)	Percent Passing
25 mm				
19 mm				
12.5 mm				
9.5 mm				
6.35 mm				
4.75 mm				
2.36 mm				
1.18 mm				
600 µm				
300 µm				
150 µm				
75 µm				

*X or Target Values from project mix design (Section D, Step 1)

Correction Factor Determination Data

- (1) _____ (2) _____ = M_{agg} , mass of the dry aggregate. (Section D, Step 5)
- (1) _____ (2) _____ = M_{ab} , mass of the asphalt cement. (Section D, Step 5)
- (1) _____ (2) _____ = AC_{known} , known asphalt binder content. (Section D, Step 5)
- (1) _____ (2) _____ = M_e , mass of sample basket(s), and catch pan. (Section D, Step 6)
- (1) _____ (2) _____ = M_1 , initial mass of sample, sample basket(s), + catch pan (Section D, Step 9)
- (1) _____ (2) _____ = M_s , initial mass of sample (Section D, Step 10).
- (1) _____ (2) _____ = Temperature °C (°F) at which M_1 was measured (Section D, Step 9)
- (1) _____ (2) _____ = M_2 , final mass of sample, sample basket(s), + catch pan after ignition process. (Section D, Step 13, or Step 19 at same temperature as M_1 , ± 3°C.)
- (1) _____ (2) _____ = Total ignition time (Section D, Step 13 or 19).
- (1) _____ (2) _____ = Incremental time, if applicable; use "N/A" if not applicable.
- (1) _____ (2) _____ = A, measured percent asphalt binder content.

_____ = Difference between $A_{(1)}$ and $A_{(2)}$ (Section D, Step 22).

_____ = CF, the Correction Factor (Section D, Step 23 or, if applicable, Step 24).

$$A = \left[\frac{M_1 - M_2}{M_2 - M_e} \times 100 \right] \qquad CF = \frac{[A_{(1)} - AC_{known (1)}] + [A_{(2)} - AC_{known (2)}]}{2}$$

TEST PROCEDURE WORKSHEET (SECTION E)

Sample I.D. _____ Project I.D. _____ Resident Engineer _____
 Location of Sample _____
 Furnace Make and Model _____ Serial No. _____
 Furnace Type (1 or 2) _____ Furnace Temperature Set Point (circle one) 538°C 482°C

NOTE: If a Type 2 furnace will be used, then initial and final mass must be measured at the temperature recorded in Section D, Step 9 during correction factor development, with a tolerance of ± 3°C.

Testing Laboratory _____ Mobile Lab Unit I.D. _____
 _____ Date of Test _____
 _____ Technician Name _____
 Aggregate Source _____ Type of Asphalt Cement _____
 Additive(s) Type(s) and Source(s) _____

Type of AC Mix and Design Asphalt Binder Content:

Type __: __ mm Maximum, _____ (Design Asphalt Binder Content = ____%)

- _____ = M_e , mass of sample basket(s), and catch pan. (Section E, Step 4)
- _____ = $M_{initial}$, initial mass of sample, sample basket(s), and catch pan (Section E, Step 6)
- _____ = M_s , initial mass of sample (Section E, Step 7).
- _____ = Temperature °C at which $M_{initial}$ was measured (Section E, Step 6 & Section D, Step 9).
- _____ = M_2 , final mass of sample, sample basket(s), and catch pan after the ignition process. (Section E, Step 10, or Step 17 at same temperature as Section D, Step 9)
- _____ = Total ignition time (Section E, Step 10 and Step 17).
- _____ = Moisture Content of sample, from California Test 226 or 370 test results (if applicable).
- _____ = M_1 , mass of sample (adjusted for moisture content), sample basket(s), and catch pan. (Section E, Step 18)
- _____ = CF, the Correction Factor (Section D, Step 23 or, if applicable, Step 24).
- _____ = AC, corrected measured percent asphalt binder content.

[Note: Sample Gradations may be run after the completion of the ignition process.]

$$AC = \left[\frac{M_1 - M_2}{M_2 - M_e} \times 100 \right] - CF \qquad M_1 = \frac{M_{initial} - M_e}{1 + \left(\frac{H_2O}{100} \right)} + M_e$$

APPENDIX A

Determination of Asphalt Binder Content of Bituminous Paving Mixtures by the Ignition Method Using the Microwave Asphalt X-Celerator (MAX)

A. SCOPE

This appendix specifies modifications that must be made to the basic California Test 382 when determining the asphalt binder content of bituminous mixtures by the ignition method using the Microwave Asphalt X-celerator (MAX).

B. APPARATUS

Use the apparatus described in the basic test method except that the ignition furnace shall be the MAX. All references to Type 2 furnaces (and procedures for Type 2 furnaces) shall be disregarded.

NOTE 1: MAX operates like traditional (convection) ignition furnaces. The difference is MAX uses microwave energy to heat the furnace in lieu of electric energy.

NOTE 2: MAX software routines default to wet mass (total mass of mix) calculations. As a special modification for MAX units sold only in California, check to see that "dry aggregate calculation" is activated (turned ON) under the MAX setup Menu/Program Variables. The dry mass calculation will stay activated as long as the software chip is not replaced or the option is not deactivated. The California Test 382 methodology uses the dry mass calculation and not the wet mass calculation.

C. SAMPLING

Sample as prescribed in the basic test method.

D. CORRECTION FACTOR

The correction factor determined by this test method shall be used only with the furnace and with the mix design gradation that includes the same aggregates, additives and asphalt binder used to establish the correction factor. If the mix design, component materials and/or the

equipment are changed, then a new correction factor

shall be determined (see Section D of the basic test method).

Disregard all references to Type 2 furnace procedures. Determine the correction factor as described in the basic test method except as follows (numbers below correspond with the numbers in Section D, "Correction Factor," in the basic test method):

1. Set the furnace control temperature set point at 538°C and the preheat temperature at 650°C. The preheat temperature is there to compensate for the heat lost when the door is opened and the sample is placed into the furnace. The MAX manufacturer recommends setting the afterburner temperature at 750°C.
2. Eliminate the 25 mm spacing recommendation for the sample baskets used with the MAX oven.

NOTE 3: If the procedure to determine the correction factor (with the MAX oven) requires lowering the furnace temperature set point, lower the furnace control temperature set point to 482°C and the preheat temperature to 600°C and repeat the procedure. The furnace control temperature set point and the preheat temperature used to test field samples of bituminous mixtures per Section E, "Test Procedure," must be the same temperatures used to obtain the correction factor.

E. TEST PROCEDURE

Disregard all references to Type 2 furnace procedures. Perform the test procedure as described in the basic test method except as follows (numbers below corresponds

with the numbers in Section E, "Test Procedure," in the basic test method):

1. Set the furnace control temperature and the preheat temperature at the appropriate temperatures as established during correction factor determination. The afterburner temperature should be set to 750°C.
2. Eliminate the 25 mm spacing recommendation for the sample baskets used with the MAX oven.

F. VERIFYING TRANSFER OF CORRECTION FACTOR TO ANOTHER IGNITION FURNACE

Observe the provisions in the basic test method.

G. REPORT

Report as prescribed in the basic test method.

H. PRECISION AND BIAS

The data for producing a precision statement have not been established for this extension of the basic test method.

I. SAFETY AND HEALTH

Observe the safety and health provisions listed in the basic test method.

APPENDIX B

Determination of Asphalt Binder Content of Bituminous Paving Mixtures by the Ignition Method Using the New Technology Oven (NTO)

A. SCOPE

This appendix specifies modifications that must be made to the basic California Test 382 when determining the asphalt binder content of bituminous mixtures by the ignition method using the New Technology Oven (NTO).

B. APPARATUS

Use the apparatus described in the basic test method except that the ignition furnace shall be the NTO, temperature control specifications shall be replaced with "NTO burn profiles," emission control equipment specifications for afterburners and filters shall not be required, and all references to Type 2 furnaces (and procedures for Type 2 furnaces) shall be disregarded.

NOTE 1: The NTO does not operate like convection-type ignition furnaces. The difference is that the NTO uses an irradiation method to directly heat the sample. Unlike convection-type ignition furnaces in which the chamber air is heated and thus the sample, in the NTO infrared energy is used to excite the molecules in the bituminous mixture.

NOTE 2: Because the NTO does not rely on the chamber temperature to heat the sample, it is not necessary to check or verify the chamber temperature. The displaced chamber temperature is simply a reference.

NOTE 3: The NTO manufacturer's preset software selections for sample burn profiles can be used for the testing purposes. However, proper burn profiles should be established for bituminous mixtures from various aggregate sources. Burn profile consultation with the oven's manufacturer is recommended. This test also uses the dry mass calculation and not the wet mass calculation to determine the asphalt binder content of the samples tested in the ignition oven. The oven's software routines must be

set to use the dry mass of aggregate calculation.

C. SAMPLING

Sample as prescribed in the basic test method.

D. CORRECTION FACTOR

Disregard all references to Type 2 furnace procedures. Determine the correction factor as described in the basic test method except as follows (numbers below correspond with the numbers in Section D, "Correction Factor," in the basic test method):

1. Change furnace temperature control requirements to burn profile control requirements. Eliminate the afterburner temperature control requirements.
2. Eliminate the 25 mm requirement for sample baskets with perforated sides and bottoms.
3. If the difference between $A_{(1)}$ and $A_{(2)}$ exceeds 0.15, repeat the two tests, and then discard the high and low numbers from the four test results. Average the remaining two results, and then compute the correction factor. If the correction factor exceeds 0.5, lower the burn profile energy level and repeat the procedure. Use the correction factor from the last burn profile energy level tested. The burn profile used to test bituminous mix samples per Section E must be the same burn profile used to establish the correction factor.

E. TEST PROCEDURE

Disregard all references to Type 2 furnace procedures. Perform the test procedure as described in the basic test method except as follows (numbers below correspond with

the number in Section E, "Test Procedure," in the basic test method):

1. Change furnace temperature control requirements to burn profile control requirements. Eliminate the after-burner temperature requirements.
2. Eliminate the 25 mm requirement for sample baskets with perforated sides and bottoms.

F. VERIFYING TRANSFER OF CORRECTION FACTOR TO ANOTHER IGNITION FURNACE

Observe the provisions in the basic test method.

G. REPORT

Report as prescribed in the basic test method.

H. PRECISION AND BIAS

The data for producing a precision statement have not been established for this extension of the basic test method.

I. SAFETY AND HEALTH

Observe the safety and health provisions listed in the basic test method.