STATE OF CALIFORNIA—CALIFORNIA STATE TRANSPORTATION AGENCY

DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
Transportation Laboratory
5900 Folsom Blvd.
Sacramento, California 95819-4612

METHOD OF TEST FOR DETERMINATION OF BINDER CONTENT AND CORRECTION FACTORS OF HOT MIX ASPHALT BY THE IGNITION METHOD

A. SCOPE

This test method describes the procedure to determine asphalt binder content and asphalt binder and aggregate correction factors for post-production gradations of hot mix asphalt (HMA) by the ignition method.

The type of aggregate in the HMA may affect the results of this test method. Different aggregates may lose weight, to varying degrees due to breakdown during the ignition process. Accordingly, correction factors are determined for each type of HMA. Correction factors must be developed for each furnace and mix design. This test method employs equipment requiring specific manufacturer operational procedures. This test method is divided into the following parts:

1. Determination of Ignition Furnace Asphalt Binder and Aggregate Correction Factors
2. Determination of Asphalt Binder Content by the Ignition Method

B. REFERENCES

AASHTO T 27	Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 30	Standard Method of Test for Mechanical Analysis of Extracted Aggregate
AASHTO T 308-25	Standard Method of Test for Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method
California Test 125	Method of Test for Sampling Highway Materials and Products Used in the Roadway Pavement Structure Sections
California Test 306	Method of Test for Reducing Samples of Asphalt Mixtures to Testing Size

C. APPARATUS

Supply apparatus as required by AASHTO T 308. Use the same ignition furnace for the correction factors that will be used for production testing.

For field laboratories that are not equipped with mixing apparatuses but are equipped with an ignition furnace, the mixture samples must be prepared elsewhere as specified herein and shipped to the field for determination of correction factors for the field laboratory furnace. These samples must be oven dried as described in this test method before they are placed into the ignition furnace.

For direct IR irradiation-type furnaces, the Default burn profile must be used for most materials. The operator selects burn-profile Option 1 or Option 2 to optimize the burn cycle. Option 1 is designed for aggregate that requires a large asphalt binder correction factor (greater than one percent)—typically very soft aggregate (such as dolomite). Option 2 is designed for samples that may not burn completely using the Default burn profile. The burn profile for testing asphalt mixture samples must be the same burn profile selected for correction samples.

D. DEFINITIONS

1. Asphalt Binder Correction Factor: The difference between the known asphalt binder content and the asphalt binder content measured by the ignition furnace. Certain virgin aggregate types or reclaimed asphalt pavement (RAP) materials may result in unusually high correction factors (greater than 1.0 percent). Such mixes must be corrected and tested at a lower temperature as described in Part 1 of this test method. Each ignition furnace will have its own unique asphalt binder correction factor for each mix determined in the location where testing will be performed.

2. Aggregate Gradation Correction Factors: The difference between the known aggregate gradation of the calculated blank and the aggregate gradation obtained through AASHTO T 30 after ignition testing. Due to potential virgin and RAP aggregate breakdown during the ignition process, an aggregate gradation correction factor for each mix will be determined for each ignition furnace in the location where testing will be performed.

3. Virgin Aggregate Gradation: The gradation of the combined virgin aggregate stockpiles/bins used to produce the asphalt mixture before the addition of asphalt binder and other additives. It is used as an input value to construct the JMF mixture and the calculated blank samples. The virgin aggregate gradation is not to be used for acceptance.

4. Calculated Gradation (Pre-Burn Gradation): The combined pre-burn gradation of virgin aggregate and RAP aggregate. This gradation represents the "before burn" blend to be used for determining aggregate correction factors.

5. Corrected Ignition Gradation (Post-Burn Gradation): The gradation of the mix after ignition testing and applying correction factors.

E. SAMPLING

For developing the correction factor, obtain samples of the aggregate, RAP, additives (if any), and the binder that will be used on the project in accordance with California Test 125.

If lime is included as a component of the mixture and it has not been previously added to the virgin aggregates, add the appropriate amount of lime per the mix design proportion to the virgin aggregates by making a lime slurry (lime and water mixture) and thoroughly mix with the virgin aggregates prior to the oven-dry process.

The size of the HMA sample must be governed by the nominal maximum aggregate size of the mixture and conform to the weight requirement shown in Table 1.

Table 1. Minimum Sample Size

Nominal Maximum Aggregate Size (inches)	Minimum Weight of Mixture Sample (g)
$1\frac{1}{2}$	4000
1	3000
$\frac{3}{4}$	2000
$\frac{1}{2}$	1500
$\frac{3}{8}$	1200
#4	1200

1. Sample sizes must not be more than 500 g greater than the minimum recommended values in Table 1.
2. Virgin aggregate and RAP used for correction specimens must be sampled from the stockpiles or hot bins designated for use in production. As-received virgin aggregate and RAP are used for specimen preparation.

PART 1. Asphalt Binder and Aggregate Correction Factors

1A. Correction Factors for Mixes without RAP

1. Oven-dry the virgin aggregate at a temperature of 110 ± 5°C (230 ± 9°F).

2. Separate "as received" virgin aggregate into individual particle size fractions through all specified sieves down to the No. 30, while retaining material passing No. 30 sieve in accordance with AASHTO T 27. Retain material on each sieve for specimen preparation. Determination of percent passing is not required at this step.

3. Prepare at least 6 "blank" (virgin aggregate only) specimens at the JMF post-production gradation target value as listed in the contractor's Hot Mix Asphalt Design Data. Determine the gradation of the "blank" in accordance with AASHTO T 30. Record as $\boldsymbol{G_{virgin}}$.

4. Using the remaining virgin aggregate blanks, prepare at least five correction specimens at the JMF design asphalt binder content and gradation. One of the five correction specimens must be designated as the "butter mix" and must be used in the mixing equipment prior to preparing any of the correction specimens. Two of the remaining four correction specimens must be used to determine correction factors. The additional two correction specimens may be used if required, see note under Step 7.

5. Place a freshly mixed specimen directly into the specimen basket assembly. Repeat with the remaining correction specimens as required. If any specimen is allowed to cool prior to placement in the specimen basket assembly, the specimen must be dried to constant mass at a temperature of 110 ± 5°C (230 ± 9°F). Do not preheat the specimen basket assembly.

6. Test the correction specimens in accordance with Part 2 of this test method. On the ignition furnace, set the binder correction factor at zero.

7. Once both of the correction specimens have been burned, determine the asphalt binder content for each specimen by calculation or from the printed ignition furnace tickets, if available.

   NOTE: If the difference between the asphalt binder contents of the two correction specimens exceeds 0.15%, repeat steps 2 through 7 with two more specimens. From the four results, discard the high and low. The binder correction

factor must be determined from the two original or remaining results, as appropriate.

8. Calculate the difference between the actual and measured asphalt binder contents for each correction specimen. The binder correction factor is the average of the differences expressed as percentage by mass of the HMA. Record as $\boldsymbol{CF_{binder}}$.

   NOTE: If the asphalt binder correction factor exceeds 1.0 percent, the test temperature must be lowered to 482 ± 5°C (900 ± 9°F) for a convection-type furnace. If there is no improvement in the correction factor, it is permissible to use the higher temperature. The temperature for determining the asphalt binder content of asphalt mixture specimens by this procedure must be the same temperature determined for the correction specimens.

9. Perform a gradation analysis on the residual aggregate from Step 6 in accordance with AASHTO T 30, if required. Record as $G_{ignition}$. The results will be utilized in developing the aggregate correction factors and must be calculated and reported to the nearest 0.1 percent.

10. From the gradation results, subtract the percent passing each sieve for each specimen from the percent passing each sieve of the "blank" specimen gradation results.

11. Determine the average difference for the two values. The aggregate gradation correction factors (equal to the resultant average differences) for all sieves must be applied to all acceptance gradation test results determined by AASHTO T 30, prior to final rounding and reporting.

1B. Correction Factors for Mixes with RAP

1. Oven-dry the virgin aggregate at a temperature of 110 ± 5°C (230 ± 9°F) and RAP at a temperature of 60°C (140°F) to a constant mass.

2. Separate "as received" virgin aggregate into individual particle size fractions through all specified sieves down to the No. 30 sieve, while retaining all material passing No. 30, in accordance with AASHTO T 27. Retain material on each sieve for specimen preparation. Determination of percent passing is not required at this step.

3. Reduce RAP to sample size in accordance with CT 306. Burn the RAP sample in accordance with Part 2 of this test method and record the final mass. Determine the gradation of the burned RAP sample in accordance with AASHTO T 30. Record as $\boldsymbol{G_{RAP(burned)}}$.

RAP percentage must be evaluated on an aggregate replacement basis. RAP contribution must be adjusted to reflect aggregate replacement rather than total mass.

This adjusted RAP aggregate percentage must be used for:

- Gradation calculations
- Blank construction
- Correction factor development

4. Determine a virgin aggregate gradation by subtracting the RAP aggregate contribution from the JMF PPG target values, $\boldsymbol{G_{target}}$. Using the separated as-received material, prepare a virgin aggregate blank based on the calculated gradation. Determine the gradation of the blank in accordance with AASHTO T 30. Record as $\boldsymbol{G_{virgin}}$.

5. Determine the combined gradation of $\boldsymbol{G_{virgin}}$ and $\boldsymbol{G_{RAP(burned)}}$ based on JMF $\boldsymbol{RAP_{agg}}$ percentage. This gradation will be the pre-burn target value for the purpose of calculating aggregate correction factors. Record as $\boldsymbol{G_{calculated}}$.

6. To determine RAP asphalt binder content, apply the RAP binder correction factor to the asphalt binder content measured by the ignition furnace. The result is reported as the calculated RAP binder content, $\boldsymbol{P_{b,RAP}}$. The RAP binder content is used to determine the virgin binder addition required to meet the design binder content, $\boldsymbol{P_{b,design}}$.

   Note: The RAP binder correction factor is the difference between the average solvent extracted and average ignition furnace binder content reported on the contractor's Hot Mix Asphalt Design Data.

7. Prepare at least five correction specimens at the JMF design asphalt binder content and post-production gradation target values. One of the five correction specimens must be designated as the "butter mix" and must be used in the mixing equipment prior to preparing any of the correction specimens. Two of the remaining four specimens, or correction specimens, must be used to determine correction factors. The additional two correction specimens may be used if required, see note under Step 10. Adjust the percentages of virgin aggregate and virgin RAP accordingly to account for binder present in the RAP specimen. Record as $\boldsymbol{Adjusted\ RAP_{agg}}$(%).

8. Place a freshly mixed specimen directly into the specimen basket assembly. Repeat with the remaining correction specimens as required. If any specimen is allowed to cool prior to placement in the specimen basket assembly, the specimen must be dried to constant mass at a temperature of 110 ± 5°C (230 ± 9°F). Do not preheat the specimen basket assembly.

9. Test the correction specimens in accordance with Part 2 of this test method. On the ignition furnace, set the binder correction factor at zero.

10. Once both of the correction specimens have been burned, determine the asphalt binder content for each specimen by calculation or from the printed ignition furnace tickets, if available.

    NOTE: If the difference between the asphalt binder contents of the two correction specimens exceeds 0.15%, repeat steps 2 through 10 with two more specimens. From the four results, discard the high and low. The binder correction factor must be determined from the two original or remaining results, as appropriate.

11. Calculate the difference between the actual and measured asphalt binder contents for each correction specimen. The binder correction factor is the average of the differences expressed as percentage by mass of the HMA. Record as $\boldsymbol{CF_{binder}}$.

    NOTE: If the asphalt binder correction factor exceeds 1.0 percent, the test temperature must be lowered to 482 ± 5°C (900 ± 9°F) for convection type furnace. If there is no improvement in the correction factor, it is permissible to use the higher temperature.

12. Perform a gradation analysis on the residual aggregate from Step 8 in accordance with AASHTO T 30. Record as $G_{ignition}$. The results will be used to develop the aggregate correction factor and must be reported to the nearest 0.1%.
13. From the gradation results, subtract the percent passing each sieve from the percent passing each sieve on the "calculated blank" gradation results.

14. Determine the average difference for the two values. The aggregate correction factors (equal to the resultant average differences) for all sieves must be applied to all acceptance gradation test results determined by AASHTO T 30, prior to final rounding and reporting.

PART 2. Asphalt Binder Content

2A. Test Procedure

1. Perform ignition furnace burn on the sample in accordance with AASHTO T 308 Method A.

F. CALCULATIONS

Aggregate Gradation Correction Factor for a Specified Sieve:

For Mixes without RAP-

$$CF_{aggregate} = G_{virgin} - G_{ignition}$$

NOTE: The final correction factor for a specified sieve that is reported is the average difference obtained from the correction specimens and the blank specimen.

For Mixes with RAP-

$$CF_{aggregate} = G_{calculated} - G_{ignition}$$

NOTE: The final correction factor for a specified sieve that is reported is the average difference obtained from the correction specimens and the combined virgin aggregate and RAP specimen.

Binder Content:

$$P_{b,measured} = \left[\frac{(M_{initial} - M_{final})}{M_{initial}} \times 100\right] - CF_{binder}$$

Binder Correction Factor:

$$CF_{binder} = P_{b,design} - P_{b,measured}$$

NOTE: The final correction factor that is reported is the average correction factor of the correction specimens.

Combined Gradation for a Specified Sieve:

$$G_{calculated} = \left(\frac{Virgin\ Agg.\%}{100} \times G_{virgin}\right) + \left(\frac{RAP\ Agg.\%}{100} \times G_{RAP(burned)}\right)$$

NOTE: The combined gradation represents the starting pre-burn calculated gradation used for the development of aggregate correction factors.

Design Binder Content:

$$P_{b,design} = P_{b,virgin} + (\frac{RAP\ \%}{100} \times P_{b,RAP})$$

RAP Adjustment:

$$Adjusted\ RAP(\%) = \frac{RAP_{agg\%}}{[1 - \frac{P_{b,RAP}}{100}]}$$

Virgin Aggregate Gradation for Mixes with RAP:

$$G_{virgin} = \frac{G_{target} - (\frac{RAP_{agg\%}}{100} \times G_{RAP})}{[1 - \frac{RAP_{agg\%}}{100}]}$$

G. REPORTING OF RESULTS

When required by the contract documents, submit test results electronically in accordance with the DIMEXML format and guidance documents found at the following link:

https://dime.dot.ca.gov/index.php?r=help/submittestresult

Report test results on the following forms, as applicable:

- CEM-3503, "Post-Production Gradation Correction Factor for Hot Mix Asphalt"
- CEM-3504, "Post-Production Gradation Correction Factor for Hot Mix Asphalt with Recycled Asphalt Pavement"
- CEM-3511, "Contractor Job Mix Formula Proposal"
- CEM-3512, "Contractor Hot Mix Asphalt Design Data"
- CEM-3513, "Caltrans Hot Mix Asphalt Verification"

H. PRECISION AND BIAS

Precision – Criteria for judging the acceptability of ignition burn results for asphalt binder content obtained by this test method are given in table below.

Single-Operator Precision – The figures in Column 2 of the table are the standard deviations that have been found to be appropriate for the conditions of test described in Column 1. Two results obtained in the same laboratory, by the same operator using the same equipment, in the shortest practical period of time, should not be considered suspect unless the difference in the two results exceeds the values given in the table, Column 3.

Multi-laboratory Precision – The figures in Column 2 are the standard deviations that have been found to be appropriate for the conditions of test described in Column 1. Two results submitted by two different operators testing the same material in different laboratories shall not be considered suspect unless the difference in the two results exceeds the values given in Column 3.

Table 2. Asphalt Binder Content Precision Estimates

Condition	Standard Deviation (1s)	Acceptable Range of Two Test Results (d2s)
Single-Operator Precision	0.069	0.196
Multi-laboratory Precision	0.117	0.330

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 binder 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.

Bias – Any biases inherent to the ignition furnace process used for this test method, when testing for asphalt binder content and aggregate gradation, are accounted for by the determination and application of appropriate correction factors.

I. HEALTH AND SAFETY

It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Prior to handling, testing or disposing of any materials, testers must be knowledgeable about safe laboratory practices, hazards and exposure, chemical procurement and storage, and personal protective apparel and equipment.

Refer to the Safety Manual for your Laboratory.

End of Text

(California Test 382 contains 10 pages)