Colorado Procedure – Laboratory 5120

Standard Method of Test for

Determination of the Asphalt Binder Content of Bituminous Mixtures by the Ignition Method

1. SCOPE

1.1 This method of test determines the asphalt binder content of bituminous mixtures by heating the mixture until the asphalt binder fraction of the mix ignites and is burned away. The gradation of the remaining aggregate is then determined using CP 31. This procedure includes infrared heat source ignition furnaces. This procedure shall not be used for determining the asphalt binder content of cores or otherwise obtained samples from existing bituminous pavements.

1.2 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCED DOCUMENTS

2.1 Colorado Procedures:

CP 30 Sampling of Aggregates
CP 31 Sieve Analysis of Aggregates
CP 41 Sampling Bituminous Paving Mixtures
CP 55 Reducing Field Samples of Hot Mix Asphalt to Testing Size
CP 85 Binder and Asphalt Cement Content of Asphalt Mixtures by the Nuclear Method

3. SUMMARY OF TEST METHODS

3.1 A specimen of bituminous mixture is heated in a furnace at a high enough temperature to ignite the asphalt binder fraction, which burns away. The asphalt binder content is calculated by dividing the mass loss of the specimen after ignition by the mass of the bituminous mixture before ignition. A correction factor is determined for each bituminous mixture and then applied to the measured asphalt binder content of field produced bituminous mixtures.

4. SIGNIFICANCE AND USE

4.1 This method can be used for quantitative determinations of asphalt binder content and gradation in HMA mixtures and pavement samples for quality control, specification acceptance, and mixture evaluation studies. This method does not require the use of solvents. Residual aggregate obtained by this test method may be used for gradation analysis according to CP 31.

5. REDUCING PRODUCTION SAMPLES TO TEST SIZE

NOTE 1: The word *specimen* represents a test portion of bituminous mixture sample. When the specimen's mass exceeds the capacity of test equipment, it shall be divided into multiple units, tested, and the results averaged.

NOTE 2: The word *sample* represents a quantity of bituminous mixture gathered from a stockpile or roadway in accordance with CP 41.

5.1 If the bituminous mixture is not sufficiently soft to separate with a spatula or trowel, place it in a pan and warm it in an oven at the binder compaction temperature until it can be separated.

5.1.1 Sampling of HMA shall be done according to CP 41. One specimen conforming to the appropriate column of Table 1 shall be selected from each bituminous mixture production sample in accordance with CP 55. Extreme care must be taken to obtain

representative specimens.

5.2 The specimens shall conform to the mass requirements shown in the appropriate column of Table 1.

6. CALIBRATION

6.1 Virgin Aggregates

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

6.1.2 The calibration process should be repeated each time there is a change in the mix ingredients or design.

6.1.3 According to the requirements of Section 5 and using the Calculation in Subsection 9.1, prepare two calibration samples at the design asphalt content. Aggregate used for the calibration specimens shall be sampled from stockpiled material produced in the current construction season and designated for use on the candidate project. Any method may be used to combine the aggregates; however, an additional “blank” specimen shall be batched and tested for aggregate gradation according to CP 31. The washed gradation shall fall within the mix design tolerances.

NOTE 3: Mixing equipment, including bowls, wire whips, spoons, and spatulas should be buttered prior to calibration. If necessary, 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 an accurate asphalt content.

6.1.4 If they are going to be burned immediately, the freshly mixed specimens may be placed directly in the sample baskets. If allowed to cool, the samples shall be heated at the binder compaction temperature for 30 minutes. Do not preheat the sample baskets.

6.1.5 Test specimens in accordance with Sections 7, 8 and 9 (Test Method A) or Sections 10 and 11 (Test Method B).

6.1.6 Determine the measured asphalt contents for each sample by calculation.

6.1.7 Perform a gradation analysis on the residual aggregate as indicated in Section 12. Compare this gradation to the gradation of the unburned, “blank”, specimen to evaluate the amount of aggregate breakdown

6.1.8 If the difference between the measured asphalt contents of the two samples exceeds 0.15 percent, repeat the two tests and, from the four tests, discard the highest and lowest results. Determine the calibration factor from the two remaining results. Calculate the difference between the actual and measured asphalt contents for each sample. The calibration factor is the average of the differences expressed in percent by weight of the asphalt mixture.

6.2 Aggregates with Reclaimed Asphalt Pavement (RAP)

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

6.2.2 The calibration process should be repeated each time there is a change in the mix ingredients or design.

6.2.3 Determine the bitumen content of RAP using either Method A or B.

6.2.4 Sampling of RAP will be conducted using CP 30. The RAP shall not contain clay balls, organic matter, or other deleterious substances. Reduce to proper test sample size using CP 55. Two individual samples will be used to determine the average bitumen content using Methods A or B in this procedure.

Table 1: Size of Specimen

Nominal Maximum Aggregate Size (mm)	Sieve Size	Specimen Weight Range
4.75	No. 4	1200 - 1300
9.5	3/8 in.	1200 - 1300
12.5	½ in.	1500 - 1600
19.0	¾ in.	2000 - 2100
25.0	1 in.	3000 – 3100*
37.5	1 ½ in.	4000 – 4100*

* Specimens shall either be divided in half or thirds, each individual part will be tested, and then the results averaged.

6.2.5 Sample size will be determined by using Table 1.

6.2.6 According to the requirements of Section 5 and using the Calculation in Subsection 9.5, prepare two calibration samples at the design asphalt content. Aggregate used for the calibration specimens shall be sampled from stockpiled material produced in the current construction season and designated for use on the candidate project. Any method may be used to combine the aggregates; however, an additional "blank" specimen shall be batched and tested for aggregate gradation according to CP 31. The washed gradation shall fall within the mix design tolerances.

6.2.7 If they are going to be burned immediately, the freshly mixed specimens may be placed directly in the sample baskets. If allowed to cool, the samples shall be heated at the binder compaction temperature for 30 minutes. Do not preheat the sample baskets.

6.2.8 Test specimens in accordance with Sections 7, 8 and 9 (Test Method A) or Sections 10 and 11 (Test Method B).

6.2.9 Determine the measured asphalt contents for each sample by calculation.

6.2.10 Perform a gradation analysis on the residual aggregate as indicated in Section 12. Compare this gradation to the gradation of the unburned, "blank", specimen to evaluate the amount of aggregate breakdown.

6.2.11 If the difference between the measured asphalt contents of the two samples exceeds 0.15 percent, repeat the two tests and, from the four tests, discard the highest and lowest results. Determine the calibration factor from the two remaining results. Calculate the difference between the actual and measured asphalt contents for each sample. The calibration factor is the average of the differences expressed in percent by weight of the asphalt mixture.

TEST METHOD A

7. APPARATUS

7.1 *Ignition furnace* - A forced air ignition furnace that heats the samples by convection method or direct irradiation method that is capable of maintaining the manufacturer's

recommended temperature. There must be an internal balance thermally isolated from the furnace chamber that is readable to 0.1 g. The balance shall be capable of weighing a minimum 3000 gram 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 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 content (percent), test time, and test temperature. The furnace chamber dimensions shall be adequate to accommodate a sample size of at least 3000 grams. The furnace shall provide an audible alarm and indicator light 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 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 capability to pull air through the furnace to expedite the test and to reduce the escape of smoke into the laboratory.

NOTE 4: The furnace shall also allow the operator to change the ending mass loss percentage to 0.02 percent.

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, perforated stainless steel plate, or other suitable material.

NOTE 5: Screen mesh or other suitable material with maximum and minimum opening of 2.36 mm (No. 8) and 600 microns (No. 30) respectively 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 specified compaction temperature ± 5°C (± 9°F) throughout the oven chamber.

7.5 *Balance* - of sufficient capacity and conforming to the requirements of AASHTO M 231 Class G2 for weighing specimen in basket(s).

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

7.7 *Miscellaneous Equipment* - a pan larger than the sample basket(s) for transferring the sample after ignition, as well as spatulas, bowls, and wire brushes.

8. TEST PROCEDURE

8.1 All production specimens shall have a moisture correction determined in accordance with CP 43, Section 9 or shall be dried to a constant mass at 121°C ± 16°.

8.2 Preheat the ignition furnace to 538°C (1000°F) or per manufacturer's directions. Manually record the furnace temperature (set point) prior to the initiation of the test if the furnace does not record automatically.

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

8.4 Prepare the sample as described in Section 5. Evenly distribute the 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.

8.5 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).

8.6 Input the initial mass of the specimen in whole grams into the ignition furnace controller.

Verify that the correct mass has been entered.

8.7 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 Subsection 8.5 within ± 5 g. Differences greater than 5g 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 6 - The furnace temperature will drop below the set point when the door is opened, but will recover with the door closed and when ignition occurs. Sample ignition typically increases the temperature well above the set point, depending on sample size and asphalt content.

8.8 Allow the test to continue until the stable light and audible stable indicator indicates the test is complete (the change in mass does not exceed 0.01 percent for three consecutive minutes). Press the start/stop button. This will unlock the sample chamber.

NOTE 7: An ending mass loss percentage of 0.02 may be substituted when aggregate that exhibits an excessive amount of loss during ignition testing is used. The precision and bias statement was developed using 0.01 percent. Both precision and accuracy may be adversely affected by using 0.02.

8.9 Remove the specimen basket assembly after ignition and allow it to cool sufficiently until it can be safely handled. If the internal scale is being used to determine the percent binder, remove the ticket and report the percent binder. If the correction factor was not entered into the furnace, apply the correction factor before reporting the percent binder. If the external scale is being used to determine percent binder, weight the basket assembly containing the residual aggregate and record the weight. The amount of time elapsed between removal from the furnace and weighting on the external scale should be the same for correction factors and plant produced material, within 5 minutes.

8.10 Determine the uncorrected asphalt binder content for the external scale.

8.11 Determine the corrected asphalt binder content for the external scale.

8.12 See Section 12 to perform gradation on burn-off sample.

9. CALCULATIONS

9.1 **Laboratory Mixed Specimen**. The actual asphalt binder content of a laboratory mixed specimen is determined as follows:

$$W_b = \frac{P_b W_s}{100 - P_b}$$

Where:

W_b = Weight (mass) of asphalt binder in specimen, grams,
P_b = Actual percent of asphalt binder in specimen,
Ws = Weight (mass) of aggregate in specimen, gram.

9.2 The uncorrected asphalt binder content of a specimen is determined using an external scale as follows:

$$P_{b(uncorr)} = \frac{W_{m(initial)} - W_{m(final)}}{W_{m(initial)}} \times 100$$

Where:

$P_{b(uncorr)}$ = Uncorrected asphalt binder content, in percent, determined by the mass loss measured on an external scale,
$W_{m(initial)}$ = External scale weight (mass) of the bituminous mixture specimen before ignition, grams,
$W_{m(final)}$ = External scale weight (mass) of the bituminous mixture specimen after ignition, grams.

9.3 The asphalt binder correction factor (C_f), for asphalt binder content is the difference between the actual percent of asphalt binder content in the laboratory mix and the uncorrected percent of asphalt binder content of

the same mix after ignition. C_f is calculated as follows:

$$C_f = P_b - P_{b(uncorr)}$$

Where:

C_f = Asphalt binder correction factor in percent,
P_b and $P_{b(uncorr)}$ = as defined previously.

9.4 The corrected asphalt binder content for field-produced specimens is determined as follows:

$$P_{b(corr)} = P_{b(uncorr)} + C_f - P_w$$

Where:

$P_{b(corr)}$ = Percent asphalt binder content of field-produced specimens corrected for the aggregate and asphalt binder sources,
$P_{b(uncorr)}$ and C_f = as defined previously,
P_w = Percent moisture content determined in accordance with CP 85, Section 10.

9.5 **Laboratory-Mixed Specimen Using RAP.** Calculation for asphalt binder content of a laboratory-mixed specimen using RAP is determined as follows:

9.5.1 Mass of bitumen in RAP (W_{br})

$$W_{br} = W_{sr} \times P_{br}$$

Where:

W_{sr} = Mass of RAP in sample, grams,
P_{br} = Percent of asphalt cement in RAP.

Using the following modification to calculation in Subsection 9.1, determine the Total Mass of bitumen (W_b), grams required in the mix sample:

$$W_b = \frac{P_b (W_s - W_{br})}{100 - P_b}$$

Where:

P_b = Target % AC in mix sample,
W_s and W_{br} are as defined previously.

9.5.2 Determination of required bitumen masses.

Calculate the actual mass of bitumen (W_{ba}), grams required to add to the mix to achieve the target % AC.

$$W_{ba} = W_b - W_{br}$$

Where:
W_b and W_{br} = as defined previously.

9.5.3 Determine the Actual % AC (P_{ba}) in the mix sample as follows:

Actual Mass of Aggregate (W_{sa}), grams

$$W_{sa} = W_s - W_{br}$$

Where:

W_s = Total mass of aggregate, grams,
W_{br} = as defined previously.

Record the Actual Mass of Bitumen Added (W_{ba}), grams.

Total Mass of Mix (W_s), grams.

$$W_s = W_{sa} + W_{ba} + W_{br}$$

Actual % AC in Mix Sample (P_{ba}):

$$P_{ba} = 100 \times \left(\frac{W_{ba} + W_{br}}{W_s} \right)$$

TEST METHOD B

10. APPARATUS

10.1 *Ignition Furnace* - A forced air ignition furnace that heats the samples by convection method or direct irradiation method that is capable of maintaining the manufacturer's recommended temperature. The furnace chamber dimensions shall be adequate to accommodate a minimum sample size of 3500 grams. 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 capability to pull air through the furnace to expedite the test and to reduce the escape of smoke into the laboratory.

10.2 *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, perforated stainless steel plate, or other suitable material.

NOTE 8: Screen mesh or other suitable material with maximum and minimum opening of 2.36 mm (No. 8) and 600 microns (No. 30) respectively has been found to perform well.

10.3 *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.

10.4 *Oven* - capable of maintaining specified compaction temperature ± 5°C (± 9°F) throughout oven chamber.

10.5 *Balance* - of sufficient capacity and conforming to the requirements of AASHTO M 231 Class G2.

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

10.7 *Miscellaneous Equipment* - a pan larger than the sample basket(s) for transferring sample after ignition, spatulas, bowls, and wire brushes.

11. TEST PROCEDURES

11.1 All production specimens shall have a moisture correction determined in accordance with CP 85, Section 10 or shall be dried to a constant mass at 121°C ± 16°.

11.2 Preheat the ignition furnace to 538°C (1000°F) or per manufacturer's directions.

11.3 Record the calibration factor for the specific mix to be tested as determined in Section 6.

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

11.5 Prepare the sample as described in Section 5. Place the sample baskets in the catch pan. Evenly distribute the sample in the basket(s) taking care to keep the material away from the edges.

11.6 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).

11.7 Burn the HMA sample in the furnace for at least 45 minutes.

NOTE 9: The appropriate time for the initial burn of an HMA sample is dependent on the sample size. For large samples, the time could be significantly longer than 45 minutes. See manufacturer's manual for guidelines.

11.8 Remove the sample from the furnace after ignition, and allow it to cool sufficiently until it can be safely handled. The amount of time elapsed between removal from the furnace and weighing on the external scale should be the same for correction factors and plant produced material, within 5 minutes.

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

11.10 Place the sample back into the furnace.

11.11 After the furnace reaches the set temperature, burn the sample for at least 15 minutes.

11.12 Remove the sample basket assembly after ignition and allow it to cool sufficiently until it can be safely handled. The amount of time elapsed between removal from the furnace and weighing on the external scale should be the

same for correction factors and plant produced material, within 5 minutes.

11.13 Weigh and record the mass (W_A) of the sample after ignition.

11.14 Repeat these steps until the change in measured mass (W_A) of the sample after ignition does not exceed 0.01 percent of the initial sample mass (W_S).

NOTE 10: An ending mass loss percentage of 0.02 may be substituted when aggregate that exhibits an excessive amount of loss during ignition testing is used. Both precision and accuracy may be adversely affected by using 0.02 percent. After the time required to obtain the specified mass loss has been established for each mixture, repeated weights may not be necessary.

11.15 Record the last value obtained for W_A as the mass of the sample after ignition. Remove the specimen basket assembly after ignition and allow it to cool sufficiently until it can be safely handled. If the correction factor was not entered into the furnace, apply the correction factor before reporting the percent binder. If the external scale is being used to determine percent binder, weight the basket assembly containing the residual aggregate and record the weight. The amount of time elapsed between removal from the furnace and weighting on the external scale should be the same for correction factors and plant produced material, within 5 minutes. Follow steps as outlined in Subsections 8.10, 8.11, and 8.12.

11.16 Calculate the asphalt content of the sample according to Section 9.

12. GRADATION

12.1 Empty the residual aggregate from the baskets into a flat pan. Use a small wire brush to ensure that any residual fines are removed from the baskets. Weigh the residual aggregate on an external scale and record the weight.

12.2 Perform a gradation analysis in accordance with CP 31.

12.3 If aggregate degradation is suspected, or if the test results will be used for project acceptance, Subsections 12.3.1 to 12.3.6 may be used to verify whether aggregates have a tendency to degrade.

12.3.1 Obtain a sample of the final aggregate blend in question from a conveyor belt discharge or a stopped conveyor belt according to CP 30.

12.3.2 Using a sample splitter, split a sample weighing at least four times the sample size specified in Table 1 into four specimens having approximately equal mass. Set two specimens aside.

12.3.3 Mix two of the aggregate specimens with asphalt cement to yield specimens having an asphalt binder content within 0.5 percent of the mix in question.

12.3.4 Test the two mixed specimens as specified in Section 7.

12.3.5 Using CP 31, determine the gradation of the two specimens, which were mixed with asphalt binder and ignited. Determine the gradation of the two specimens, which were set-aside in Subsection 12.3.2.

12.3.6 Calculate the average percent passing each sieve size for the two sets of two specimens. Compare the average gradation at each sieve size for the two sets of specimens. If the gradation of the aggregate exposed to the heat applied in Subsection 12.3.4 is more than three percent finer than the untreated aggregate on any of the sieves, the aggregate is sensitive to heat degradation.

12.3.7 If an aggregate has been found to be sensitive to heat degradation as indicated in Subsection 12.3.6, apply a correction factor to the percent passing each screen to account for the degradation caused by ignition.

13. REPORT

13.1 There is no designated CDOT Form used for recording / reporting information for this CP-L.

13.1.1 The report shall include the following information:

13.1.2 Date of correction factor determination.

13.1.3 Identification of aggregate and mix type.

13.1.4 Test Method (A or B).

13.1.5 Correction factor.

13.1.6 Corrected asphalt content (nearest 0.01%).

13.1.7 Aggregate gradation, if performed.

14. PRECISION AND BIAS

14.1 The precision for this test method is as follows:

	Standard Deviation	
Type Index	Virgin Mixes, %	RAP Mixes, %
Single-laboratory	0.15	0.20
Multi-laboratory	0.30	0.40

14.2 A bias for this test method will be determined at a later date, and included in future revisions.