

# APPENDIX C

## TESTS AND PROCEDURES

### SAND EQUIVALENT TEST

The sand equivalent test, described in AASHTO T 176, is a method of determining the relative proportion of detrimental fine dust or clay-like materials in the portion of aggregate passing the 4.75 mm (No. 4) sieve. The sand equivalent test is conducted as follows:

1. A sample of material is placed in a transparent, graduated cylinder containing a prepared solution of calcium chloride, glycerine and formaldehyde in water.
2. The sample and solution are shaken in a prescribed manner.
3. An identical solution is passed through an irrigator tube which, under pressure, is used to wash the clayey material upward and out of the sample as the cylinder is gradually filled.
4. After a 20 minute settling period, the top of the clay suspension is read.
5. A metal weighted foot is lowered into the cylinder and allowed to come to rest on top of the clean sand.
6. The level of the bottom of the foot is read.
7. The sand equivalent value is the ratio, multiplied by 100, of the reading at the top of the sand, divided by the reading at the top of the clay.

For all sands, the minimum sand equivalent is 30.

### MAGNESIUM SULFATE SOUNDNESS TEST

Equipment and test procedures are detailed in AASHTO T 104. A brief description of the test follows:

1. Container of sized fractions of an aggregate are immersed in a saturated solution of magnesium sulfate. The sample containers are constructed to allow free access to and drainage of the solution from the sample without loss of aggregate.
2. Samples are oven-dried after immersion.
3. After the required number of immersion and drying cycles, the percent weight loss of the sized fractions is determined by sieving.
4. Weighted average percent losses for each size fraction, based upon the graduation of the original sample, are determined. The total of these values is the percent loss test value.

### SILICA CONTENT OF SAND

Sands that are used for deslicking mixes must not only be free of clay and dirt, but must also have a high silica content. The chemistry Laboratory will determine the percent of silica (SiO<sub>2</sub>) in sands.

for checking boil time.

**Virginia Test Method - 13  
Anti -Stripping Additive**

**November 1, 2000**

**1. Scope**

- 1.1 This method of test covers a procedure for determining the effectiveness of an anti-stripping additive when used as an asphalt anti stripping compound in asphalt mixtures.
- 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 whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

**2. Apparatus**

- 2.1 A balance, accurate to 0.10 gram.
- 2.2 Pans and spatula for mixing the aggregate and asphalt anti stripping additive.
- 2.3 Beakers, approximately 600 ml, for boiling asphalt mixtures.
- 2.4 A gas burner for heating water in beakers.
- 2.5 Stopwatch for checking boil time.

**3. Material**

- 3.1 A standard aggregate is used. The aggregate is obtained from Lone Jack Limestone Co., Glasgow, Virginia. It is a 50:50 blend of #8 (2.36 mm) and #10 (0.425 mm) Quartzite. The blend shall be separated by dry sieving and proportioned to meet the following gradation for each test batch.

Sieve Size (in.)	(mm)	% Passing
½"	12.5 mm	100.0
3/8"	9.5 mm	90.0
No. 4	4.75 mm	62.0
No. 8	2.36 mm	42.0
No. 30	0.600 mm	18.0
No. 50	0.300 mm	12.0
No. 100	0.150 mm	8.0
No. 200	0.075 mm	4.0

- 3.2 The asphalt is AC 20 (PG 64-22) and meets Virginia specifications.

#### **4. Procedure**

- 4.1 500 g of asphalt cement, treated with the anti stripping additive at the manufacturer's recommended percentage shall be placed in a clean container and heated at  $275^{\circ}\text{F} \pm 5^{\circ}\text{F}$  ( $135 \pm 3^{\circ}\text{C}$ ). The container shall be sealed securely and placed in an oven which will hold this temperature for 96 hours.
- 4.2 Remove the sample from the oven and stir thoroughly.
- 4.3 Mix 6 percent of the treated asphalt with the proportioned test batch to produce a total mix of 400 g. The total mix shall be 24 g treated asphalt, and 376 g of proportioned aggregate (one test batch). Heat on hot plate and stir until coated.
- 4.4 After complete coating, allow mixture to cool to  $230^{\circ}\text{F} \pm 10^{\circ}\text{F}$  ( $110 \pm 5^{\circ}\text{C}$ ), place approximately 200 g on a paper towel before boiling. Place the remainder (approximately 200 g) of the mixture in boiling water and continue boiling for 10 minutes  $\pm$  30 seconds. Then remove from heat source.
- 4.5 Drain the water from the mixture and place the mixture on a paper towel. Allow to cool to room temperature.
- 4.6 The next morning compare the boiled and un-boiled portions on the paper towels. If the boiled portion shows more signs of stripping than the un-boiled portion, the test fails.

#### **5. General Requirements**

- 5.1 The anti stripping additive shall contain no ingredient harmful to the asphalt material and shall not alter appreciably the specified characteristics of the asphalt material when added in the recommended proportions. It shall be capable of thorough dispersion in the asphalt material at the temperature of use and shall be capable of remaining in the asphalt material in storage indefinitely at temperature normally encountered without detrimentally affecting the asphalt material, or losing its effectiveness as an asphalt anti stripping compound and without any discernible settlement or stratification.

#### **6. Report**

- 6.1 Report as passing or failing the Boiling Test on Form TL 50.

## FIELD TESTING

### I. Scope

- a. The following procedure is to be used for determining the effectiveness of an anti stripping additive in combination with the materials used for production at the asphalt concrete plant.

### II. Apparatus

- a. 12.5mm (1/2 inch) sieve.
- b. A balance, accurate to one gram (0.04 oz).
- c. Beakers, approximately 600 ml (20 oz) for boiling asphalt mixtures.
- d. A gas burner for heating water in beakers.
- e. Stopwatch for checking boil time.

### III. Procedure

- a. For control testing of plant mixed material, use approximately 400 g of the mixture passing the 12.5mm (1/2 inch) sieve.
- b. The test will be performed at the District or Central Laboratory and shall be run within 30 hours after obtaining the sample. The sample shall be heated to a temperature of 230°F ±10°F (110 ±5°C). (The sample shall not remain at this temperature more than 30 minutes). When necessary for the test to be run at the plant, it shall be conducted as soon as the sample cools to 230°F ± 10°F (110 ±5°C).

NOTE: Remove plus 12.5mm (1/2 inch) material from mixture prior to attaining specified temperature.

- c. Place approximately 200 g on a paper towel before boiling.
- d. Place the remainder (approximately 200 g) of the mixture in boiling water and continue boiling for 10 minutes ±30 seconds. Then remove from heat source.
- e. Drain the water from the mixture and place the sample on a paper towel. Allow to cool at room temperature.
- f. The next morning compare the boiled and un-boiled portions on the paper towels. If the boiled portion shows more signs of stripping than the un-boiled portion, the test fails. The producer shall be notified immediately and a second sample is taken and tested as stated herein.
- g. If the second sample fails, production shall be halted until corrective action is taken to the satisfaction of the Engineer.
- h. On resumption of production, samples will be taken immediately and tested as stated above.

### IV. Report

- a. Report as passing or failing the Boiling Test on Form TL 50.

## Virginia Test Method – 22

### Field Determination of Percent Density of Compacted Asphalt Concrete Mixtures - (Asphalt Lab)

October 1, 2008

#### 1. Scope

This method covers the procedure for determining the percent density of compacted Asphalt Concrete mixtures in the field.

#### 2. Apparatus

- 2.1 Rotary saw or coring machine as specified in VDOT specifications or special provisions.

#### 3. Test Specimens

- 3.1 Two 4 x 4 in. (100 x 100 mm) sawed specimens shall be taken per site or two 4 in. (100 mm) diameter core specimens.
- 3.2 Care shall be taken to avoid distortion, bending or cracking of specimens during and after removal from the pavement.
- 3.3 To aid in cooling specimens, CO<sup>2</sup>, or dry ice is recommended for use prior to sawing and removing from the pavement.
- 3.4 If necessary, specimen may be separated from other pavement layers by sawing or other satisfactory means.

#### 4. Procedure

- 4.1 Measure thickness of test specimen.
- 4.2 Determine the bulk specific gravity of the specimen in accordance with VTM 6.
- 4.3 The initial theoretical maximum specific gravity of asphalt concrete mixture may be the job-mix value determined at the job-mix asphalt content until the production value has been determined on the material being placed in accordance with AASHTO T-209.

NOTE: The initial theoretical maximum specific gravity value shall be verified by the District or Central Office Laboratory.

- 4.4 For dense graded asphalt concrete mixes (i.e. SUPERPAVE™ mixes), the theoretical maximum specific gravity used as the denominator for the percent density calculation shall be determined by a moving average of five values based on the contractor's test results.

For stone matrix asphalt concrete mixes, the theoretical maximum specific gravity

used as the denominator for the percent density calculation shall be determined by using the simple average of the contractor's daily production test results. Only the theoretical maximum specific gravity results for that day's production shall be used.

- 4.5 Until five values are obtained from the contractor's testing, the theoretical maximum specific gravity used shall be a simple average.

**5. Calculation**

- 5.1 Calculate the percent density of each Site as follows:

$$\text{Percent Density} = \frac{\text{Average Bulk Specific Gravity}}{\text{Theoretical Maximum Specific Gravity}} \times 100$$

Where the Average Bulk Specific Gravity is either the average of the two specimens per site or the average bulk specific gravity of the total sites being evaluated, reported to 3 decimal places

**6. Report**

- 6.1 Report depth to nearest 0.1 in. (3 mm).  
6.2 Report percent density of each test specimen to nearest 0.1 percent.

**7. Precision**

- 7.1 If the difference in the bulk specific gravity between two specimens from the same test site varies by more than 0.045, discard and obtain two more specimens from a new test site.
- 7.2 If the difference in theoretical maximum specific gravity between the VDOT monitor sample and the contractor sample varies by more than 0.019 per AASHTO T-209, then the results (VDOT and contractor) shall not be used in the calculation of percent density unless testing error is identified. If testing error is identified, then VDOT will determine which maximum theoretical specific gravity result to use in the percent density calculation.

## Virginia Test Method - 36

### Quantitative Extraction of Bitumen From Asphalt Paving Mixtures By the Reflux Method

November 1, 2000

AASHTO T 164, Method B, shall be followed, except as modified below:

#### I. Scope

- 1.1 The aggregate remaining shall be used for sieve analysis according to AASHTO T 30.
- 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 whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

#### 5. Apparatus

- 5.1 Oven may be omitted.
- 5.2 Pan minimum dimensions of 12 in. (300 mm) long, 8 in. (200 mm) wide, and 1 in. (25 mm) deep.
- 5.3 The balance shall be capable of weighing at least 2000g to an accuracy of 1.0 g.
- 5.4 The hot plate shall be thermostatically controlled.
- 5.6 Ignition Dish may be omitted.
- 5.7 Desiccators may be omitted.

#### 6. Reagent

- 6.1 and 6.2 may be omitted.
- 6.3 Use 1000 ml of solvent (800 ml of 1,1,1, Trichloroethane, inhibited, and 200 ml of 95% ethyl alcohol (denatured)).
- 6.4 may be omitted.

#### 8. Sampling

- 8.1 The test sample shall be the end result of quartering a larger sample taken in accordance with VTM 48. (AASHTO T 248 may be used as a guide to quartering.)
- 8.2.2 The size of the test sample shall be governed by the nominal maximum aggregate size in the mixture. In no case shall the test sample weigh less than the minimum weight of sample shown below:

## Size of Sample

Nominal Maximum Aggregate Size    Minimum Weight (Mass) of Sample

No. 4 (4.75 mm)	400 g
3/8 in. (9.5 mm)	500 g
1/2 in. (12.5 mm)	1000 g
3/4 in. (19.0 mm)	1200 g
1 in. (25.0 mm)	1400 g
1 1/2 in. (37.5 mm)	1800 g

### 9. Moisture Content

9.1 The moisture determination (VTM 49) will be made as deemed necessary. When the sample for moisture determination is to be used for the determination of Asphalt Content, care should be taken to completely wash all the mixture from the pan into the Reflux apparatus using the solvent for that test. The dry weight of the mixture shall be used in the calculation of Asphalt Content.

### 13. Apparatus

13.1.1.1 Glass Jar, cylindrical, plain, 8 3/4 in. (222.25 mm) OD, 18 in. (457 mm) high, made of heat resistant glass.

13.1.1.4 The filter paper to be used shall be Whatman No. 2, Eaton Dikeman, Grade 613, or equivalent, 38.5 cm in diameter. This type of filter paper eliminates the ash correction.

### 15. Procedure

15.2.1 Fold each sheet of filter paper on its diameter and fold once again. Open to form a hollow cone with one ply on one side and three plies on the other, and a single one ply seam.

15.2.2 May be omitted.

15.2.3 Place the test portion in the frame(s). If two frames are used, distribute the test portion approximately equally between the two.

15.2.4 Pour the 1000 ml of solvent into the glass jar and place the loaded cone(s) and frame(s) in the jar. The solvent level must be below the tip of the lower cone.

15.2.6 Remove the frame assembly from the cylinder. Allow to dry in air as close as practical to an exhaust fan or in a vented hood. Then remove the filter paper(s) containing the sample and place in a pan. Dry to constant mass and then burn the filter paper. Record the mass of extracted aggregate.

15.2.7 May be omitted.

**Virginia Test Methods - 48**  
**Sampling Asphalt Paving Mixtures**

**November 1, 2000**

AASHTO T 168 shall be followed, except as modified below.

**1. Scope**

- 1.1 These methods cover the procedures for sampling mixtures of asphalt materials with mineral aggregate as prepared for use in paving. The samples may be used for either of two purposes:
  - 1.1.1 To ascertain the periodic variation in characteristics of the mixture for the purpose of controlling uniformity, or
  - 1.1.2 To represent an average of the asphalt mixture.
- 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 whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

**3. Size of Sample**

- 3.1 The size of sample shall be governed by the Materials Division Manual of Instructions.

**4. Sampling Plant Mixed Asphalt Mixtures at Place of Manufacture**

- 4.1 Production Control (Producer) and Acceptance (Monitor) samples for determination of gradation and asphalt content shall be taken from the truck by means of a square point shovel. Using the square point shovel, remove a minimum of 6" (150 mm) of the material from the top by scraping horizontally across the location to be sampled. This will leave a relatively flat area in which to take the sample. With horizontal movements of the square point shovel through the area to be sampled, take sufficient material for the type of sample. A stratified random method of sampling shall be used as approved by the Engineer.
- 4.2 All other samples of asphalt mixtures shall be obtained from two or more locations in the truck and combined to form a representative sample. With the exception of the stratified random method of sampling, the sampling procedure as outlined in 4.1 above shall apply.
- 4.3 Delete
- 4.4 Delete

**5. Sampling Plant Mixed Asphalt Mixtures from Roadway**

- 5.1 Samples of asphalt paving mixtures taken from the finished pavement for determination of gradation and asphalt content shall be taken in accordance with Section 211.10 of the specifications. Samples taken for the purpose of density determination shall be in accordance with Section 315.03 (d) of the specifications.
- 5.2 Samples taken for other purposes shall be taken as directed by the Engineer.
- 5.2 Samples taken for other purposes shall be taken as directed by the Engineer.

## Virginia Test Method – 99

### *The Design of Stone Matrix Asphalt (SMA) Mixtures – (Asphalt Lab)*

March 2008

#### 1. Scope

- 1.1 This test method covers the design of stone matrix asphalt (SMA) mixtures. It is based on the idea of designing the aggregate skeleton so that stone-on-stone contact is maintained in the mixture. Stone-on-stone contact will provide load carrying capacity for heavy traffic situations. This method is organized into three distinct sections: **Procedures, Calculations and Equations and a Design Example**. The method involves the determination of volumetric properties of the coarse aggregate fraction compacted by a dry rodding procedure and of specimens prepared with a SUPERPAVE gyratory compactor.
- 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 whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

#### 2. Significance and Use

- 2.1 This method is used in the laboratory mix design of SMA mixtures. The Voids in the Coarse Aggregate (*VCA*) is determined for the coarse aggregate fraction of the mixture by a dry rodding procedure for three aggregate blends. These blends are combined with asphalt cement, compacted and the volumetric properties are determined. The desired stone-on-stone contact of the coarse aggregate fraction exists when the *VCA* of the mixture is equal to or less than the *VCA* of the coarse aggregate obtained by the dry rodding procedure. The selected job mixture gradation blend is then used to make additional samples with a Gyratory device at additional asphalt contents. The optimum asphalt content is then selected to give the desired volumetric properties. Additional drainage tests shall be performed as specified to assure that the asphalt will not drain from the mixture during construction.

#### 3. Referenced Documents

##### 3.1 AASHTO Standards

**MP8** Standard Specification for Designing SMA

**PP41** Standard Practice for Designing SMA

**T19** Bulk Density ("Unit Weight") and Voids in Aggregate

**T166** Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens

**T209** Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures

**T283** Resistance of Compacted Bituminous Mixture to Moisture-Induced Damage

**T312** Preparing and Determining the Density of HMA Specimens by Means of the Superpave Gyratory Compactor

### 3.2 Virginia Test Methods

**VTM-100** Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures

**VTM-102** Determining the Asphalt Binder Content of HMA by the Ignition Method

## 4. Procedure

- 4.1.1 Selection of gradation - At least three gradations within the SMA Design Range should be evaluated. The trial gradations, which are obtained by adjusting the amount of fine and coarse aggregates in each blend, should have the following approximate percents passing:

SMA-19.0 Intermediate	30, 37 and 45 percent passing the 3/8-in. (9.5 mm) sieve
SMA-12.5 Surface	22, 26 and 30 percent passing the No. 4 (4.75 mm) sieve
SMA-9.5 Surface	15, 20, and 25 percent passing the No. 8 (2.36 mm) sieve

These blends are obtained by combining various percentages of the raw aggregates that are available for the project. It is recommended that the percentage of material passing the No. 200 (0.075 mm) sieve should be approximately 10.0 percent.

- 4.1.2 Determination of *VCA* in the coarse aggregate fraction - The coarse aggregate is defined as all component materials with 10 percent or more retained on and above the Break Point (B.P.) Sieve:

Mix Type	Break Point Sieve
SMA-9.5	#8 (2.36 mm)
SMA-12.5	#4 (4.75 mm)
SMA-19.0	#4 (4.75 mm)

Combine the coarse aggregates in the percentages determined in 4.1.1 and then remove the particles passing the breakpoint sieve for the mixture type being designed. Wash the coarse aggregate and determine the Dry Rodded Unit Weight of the resulting combined coarse aggregate fraction in accordance with AASHTO T-19.

$$VCA_{DRC} = \left( \frac{(G_{ca})\gamma_w - \gamma_s}{(G_{ca})\gamma_w} \right) \times 100$$

where,

$\gamma_s$ =	Unit weight of the coarse aggregate fraction in the dry rodded condition (lbs/ft <sup>3</sup> ) (kg/m <sup>3</sup> ) <sup>2</sup>
$\gamma_w$ =	unit weight of water (62.4 lbs/ft <sup>3</sup> ) (1000 kg/m <sup>3</sup> )
$G_{ca}$ =	The bulk specific gravity ( $G_{sb}$ ) of the coarse aggregate

These values will be compared to the  $VCA_{mix}$  values of the compacted mix to ensure that stone on stone contact is achieved.

- 4.1.3 Selection of trial asphalt content – Use the following table in choosing the initial asphalt content of the mixture for the gradation selection phase. Each trial blend will be evaluated at this same AC content.

Mix Type	Recommended AC Content	Minimum AC Content <sup>1</sup>
SMA-9.5	7.0%	6.3%
SMA-12.5	6.7%	6.3%
SMA-19.0	5.7%	5.5%

Note 1: The minimum AC content should only be approached when using aggregates with a  $G_{sb}$  greater than 2.75; otherwise the VMA criteria will not meet the minimum VMA specified by VDOT

- 4.1.4 Sample preparation and testing - Twelve samples are required; four samples at each of the three trial gradations at the asphalt content selected above.

The mixing and compaction temperature shall be as follows:

- For mix designated as a 70-22, i.e. SMA-12.5 (70-22), the mix temperature shall be 310 degrees F to 320 degrees F and the compaction temperature shall be 295 degrees F to 300 degrees F.
- For mixes designated as PG 76-22 or modified binders, the temperatures shall be based on documented supplier's recommendations.

The aggregates are to be heated to no more than 50 (°F) higher than the mixing temperature. Heat the asphalt binder to the mixing temperature.

Aggregates and fibers should be dry mixed before adding the asphalt cement. Specimens shall be short term conditioned according to AASHTO R 30.

Three of the four samples for each trial gradation shall be compacted with a gyratory compactor (AASHTO T-312) to 75 Gyration. The fourth sample shall be used to determine the theoretical maximum specific gravity according to AASHTO T-209 (sample size should be determined based on the maximum aggregate size).

Note: Prior to mixing specimens, a butter batch is required for coating the mixing equipment. The gyratory compactor shall be one from the Materials Division's Approved List for Gyratory Compactors.

- 4.1.5 Selection of the job mix gradation – For each trial gradation calculate the following properties:

$$VCA_{mix} = 100 - \left( \frac{G_{mb}}{G_{ca}} x P_{bp} \right)$$

$$\text{VMA} = 100 - \left( \frac{G_{mb}}{G_{sb}} \right) P_s \text{ and}$$

$$\text{VTM} = 100 \left( 1 - \frac{G_{mb}}{G_{mm}} \right)$$

Where:

$G_{mb}$  = average bulk specific gravity of the mix

$G_{sb}$  = the bulk specific gravity of total aggregate

$P_s$  = the percent aggregate in the total mix

$G_{ca}$  = the bulk specific gravity of the coarse aggregate

$P_{bp}$  = the coarse aggregate fraction as percent of the total mix

$G_{mm}$  = the theoretical maximum density of the mixture

The blend that exceeds the minimum VMA requirement and has a  $VCA_{mix}$  that is less than the  $VCA_{DRC}$  should be selected as the mix design aggregate blend. Consideration should be given to the mix with least coarse aggregate if more than one of the blends satisfies the VMA and VCA criteria.

- 4.2 Determination of the optimum asphalt content - The optimum asphalt content is determined by the Gyratory procedure using a compactive effort of 75 Gyration. The mixing and compaction temperature shall be the same as specified in section 4.1.4. The number of samples required shall be 12 (three compacted and one un-compacted at each of **three** asphalt contents). The un-compacted samples shall be used for the maximum theoretical specific gravity determination. The design air void content,  $V_a$ , shall be 3.5 percent and the remaining properties shall meet those specified in the Special Provision for SMA. The optimum asphalt content shall be at a minimum 6.3 percent for the SMA-9.5, and SMA-12.5 and 5.5 percent for the SMA-19.0. The fines to effective binder content ratio ( $P_{0.075}/P_{be}$ ) for SMA-9.5, 12.5 and 19.0 shall be greater or equal to 1.2 and less or equal to 2.0.
- 4.3 Draindown test - Draindown shall be determined according to VTM 100. The test should be performed at the anticipated plant production temperature and should satisfy the specified maximum of 0.30 percent. If the mixture fails to meet this requirement then the percent fibers should be increased to a level that reduces draindown to the acceptable limit.
- 4.4 Tensile Strength Ratio (TSR) – Determine in accordance with AASHTO T-283 accept as modified in section 211 of the Road and Bridge specifications.
- 4.5 Furnace correction factor – Determined in accordance with VTM-102.
- 4.6 Aggregate Properties

Fine Aggregate Angularity (FAA):

The FAA for all SMAs containing RAP shall be run in accordance with AASHTO T 304 Method A during design. The materials for the FAA tests shall be collected from the aggregates extracted from the ignition oven blanks used in determining the oven correction factor at the final Job Mix Formula AC content and Gradation.

Flat and Elongated (F&E):

The F&E test for all SMAs shall be run in accordance with VTM 121 and ASTM 4791. Materials for the F&E tests shall be collected from the aggregates extracted from the ignition oven blanks used in determining the oven correction factor at the final Job Mix Formula AC content and Gradation.

## 5. Equations and Calculations

This section will expand upon the equations used in Section 4 and define how to use each property in the design and production of SMA for VDOT.

Selection of Design Aggregate Structure:  $VCA_{DRC}$ ,  $VCA_{mix}$  and VMA

### 5.2.1 $VCA_{DRC}$ & $G_{ca}$

$$VCA_{DRC} = \left( \frac{(G_{ca})\gamma_w - \gamma_s}{(G_{ca})\gamma_w} \right) \times 100$$

where,

$$\begin{aligned} \gamma_s &= \text{Unit weight of the coarse aggregate fraction in} \\ &\text{the dry rodded condition (lbs/ft}^3\text{) (kg/m}^3\text{)}^2 \\ \gamma_w &= \text{unit weight of water (62.4 lbs/ft}^3\text{) (1000 kg/m}^3\text{)} \\ G_{ca} &= \text{The bulk specific gravity of the coarse aggregate} \\ &\text{using only virgin aggregates for design purposes} \end{aligned}$$

**Note:** For each trial aggregate structure combine each aggregate component together at the percentages required to meet the targeted trial gradation. Scalp this blended portion of coarse aggregates over the appropriate breakpoint sieve, and determine  $\gamma_s$  according to AASHTO T-19.

When determining the Rodded Unit weight of the coarse aggregate for mixes containing RAP, use the aggregate retained on the B.P. Sieve extracted from the RAP by ignition oven samples as one of the components.

Calculate  $G_{ca}$  for each trial gradation:

$$G_{ca} = \frac{100}{\frac{P_{C_1}}{G_1} + \frac{P_{C_2}}{G_2} + \dots + \frac{P_{C_n}}{G_n}}$$

Where,

$P_{C_1}$	=	Percent of Aggregate 1 as a percent of the coarse aggregate (only include aggregates that have 10% or more retained on the BP sieve)
$P_{C_2}$	=	Percent of Aggregate 2 as a percent of the coarse aggregate (only include aggregates that have 10% or

		more retained on the BP sieve)
$\dots + P_{C_n}$	=	Denoting to include all coarse aggregate components (only include aggregates that have 10% or more retained on the BP sieve)
$G_1$	=	Specific Gravity of Aggregate 1
$G_2$	=	Specific Gravity of Aggregate 2
$G_n$	=	Specific Gravity of Aggregate n

To calculate  $P_{C_n}$ , the individual coarse aggregate component as a percentage of the total coarse aggregate:

$$P_{C_n} = \frac{P_{n_c}}{\sum_{i=1}^n P_{n_c}}$$

Where,

$P_{n_c}$	=	The individual coarse aggregate's <b>bin percentage of the total blend</b> (for aggregates that retain more than 10% above the break point sieve)
$\sum_{i=1}^n P_{n_c}$	=	The sum of bin percentages of all aggregate components that retain 10% or more above the break point sieve

When using RAP, each component's contribution to the coarse aggregate bulk specific gravity  $\left( P_{C_n} / G_n \right)$  is calculated the same as for virgin mixes. However the coarse bulk specific gravity (G) and coarse aggregate contribution of the RAP ( $P_C$ ) must be estimated as follows:

Determine the  $G_{se}$  of the coarse portion of the RAP and convert to  $G_{sb}$ :

Determine the  $G_{se}$  (effective bulk specific gravity) of the coarse portion of the RAP (the portion retained above the break point sieve) by determining its AC content via VTM-102 and its maximum specific gravity ( $G_{mm}$ ) via AASHTO T 209 and apply the following formula:

$$G_{se} = \frac{100 - \%AC}{100 - \frac{\%AC}{G_{mm} - G_b}}$$

Where  $G_b$  is the binder gravity and is estimated to be 1.03.

For use in the  $G_{ca}$  and subsequent  $VCA_{mix}$  and  $VCA_{DRC}$  calculations the  $G_{se}$  must be converted to a  $G_{sb}$  by applying the following formula:

$$G_{sb} = \frac{G_{se}}{\left( \frac{P_{ba} G_{se}}{100 * G_b} \right) + 1}$$

Where  $P_{ba}$  is the percent binder absorbed and is estimated to be 0.8.

Determine  $P_{C_n}$  for coarse portion of RAP:

Determine the RAP's contribution to the total coarse aggregate in the mix:

$$P_{n_c} RAP = (\%RAP \text{ in the mix}) * (RAP's \%Retained \text{ on the Break Point Sieve})$$

Determine the RAP's coarse aggregate contribution as a percent of just the coarse aggregate:

$$P_{C_n} RAP = \frac{P_{n_c} RAP}{\sum_{i=1}^n P_{n_c}}$$

Use the RAP's Coarse Aggregate  $G_{sb}$  and  $P_{C_n} RAP$  when calculating  $G_{ca}$  for use with  $VCA_{mix}$  and  $VCA_{DRC}$ .

### 5.2.2 $VCA_{mix}$

$$VCA_{mix} = 100 - \left( \frac{G_{mb}}{G_{ca}} x P_{bp} \right)$$

Where:

$G_{mb}$	=	bulk specific gravity of compacted specimens
$G_{ca}$	=	combined bulk specific gravity of the coarse aggregate $G_{ca} = \frac{100}{\frac{P_{C_1}}{G_1} + \frac{P_{C_2}}{G_2} + \dots + \frac{P_{C_n}}{G_n}}$
$P_{bp}$	=	$P_{bp} = (P_s)(PA_{bp})x100$ Percent aggregate <b>by total mixture weight</b> retained on and above the breakpoint sieve: Where: $P_s = (100 - AC) =$ Percent aggregate in the mixture expressed as a decimal (94% = 0.94)

	<p style="text-align: center;">and</p> $PA_{bp} = (100 - \% \text{ passing the break point sieve})$ <p style="text-align: center;">=</p> <p>Percent aggregate by total aggregate weight retained on and above the breakpoint sieve (for calculations must be expressed as a decimal i.e. 76.7% = 0.767)</p>
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## 6. Design Example

**Step 1:** Determine aggregate and RAP components to be used and choose a target gradation for Blend 1:

Target Gradation	Sieve Size [mm]	CA1	CA2	CA3	FA1	MF	BH	RAP 1
	25	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
<b>100</b>	19	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
<b>90</b>	12.5	100.0%	94.0%	64.0%	100.0%	100.0%	100.0%	98.0%
<b>69</b>	9.5	89.3%	65.0%	33.0%	100.0%	100.0%	100.0%	94.0%
<b>27</b>	4.75	12.0%	8.0%	6.0%	96.0%	100.0%	100.0%	71.0%
<b>20</b>	2.36	1.5%	2.0%	1.6%	67.0%	100.0%	100.0%	56.0%
<b>17</b>	1.18	0.9%	1.4%	1.5%	48.0%	100.0%	100.0%	44.0%
<b>16</b>	0.6	0.9%	1.2%	1.3%	35.0%	100.0%	100.0%	33.0%
	0.3	0.5%	1.0%	1.2%	25.0%	87.0%	100.0%	21.0%
	0.15	0.5%	0.9%	1.0%	16.0%	75.0%	100.0%	13.0%
<b>9</b>	0.075	0.5%	0.8%	0.9%	11.0%	70.0%	98.0%	9.0%

**Step 2:** Determine the required Bin Percentages to meet the target Gradation:

### Aggregate Bin Percentages

Blend 1 15% RAP	CA1	CA2	CA3	FA1	MF	BH	RAP 1
	15	36	23	0	10	1	15

**Step 3:** Resultant Gradation:

Sieve Size [mm]	Target Gradation	Blend 1 15% RAP
25	100	100
19	100	100
12.5	90	89
9.5	69	69
4.75	27	28
2.36	20	21
1.18		19
0.6	16	17
0.3		14
0.15		11
0.075	9	10

**Step 4:** Determine Aggregate and RAP gravities:

		Aggregate Bin Percentages and Gravities					
Blend 1	15% RAP	CA1	CA2	CA3	FA1	MF	BH
		15	36	23	0	10	1
	Gsb	2.660	2.680	2.660	2.777	2.822	2.660
	Gsa	2.681	2.703	2.681	2.844	2.853	2.681

		RAP Gravities	
		RAP 1	RAP 1* (+BP)
Gmm		2.499	2.599
%AC		5.60%	2.70%
<b>Gse</b>		<b>2.730</b>	<b>2.714</b>
<b>Gsb</b>		<b>2.670</b>	<b>2.654</b>
Gb		1.03	
Pba		0.8	

Where:

$$G_{se} = \frac{100 - \%AC}{100 - \frac{\%AC}{G_{mm}}} G_b$$

And

$$G_{sb} = \frac{G_{se}}{\left( \frac{P_{ba} G_{se}}{100 * G_b} \right) + 1}$$

\* Separate RAP Gravities must be determined for the coarse component of the RAP if the percent retained on the break point (BP) sieve is greater than 10%.

**Step 5:** Determine the RAP's percentage of the coarse aggregate (CA) on a component basis for the  $G_{ca}$  Calculation.

RAP's Percent of the CA Component, $P_{nc} RAP$	4.35	= (0.15) * (100-71)
Sum of Non RAP Coarse Aggregate Components (Virgin aggregates that retain 10% or more on the BP sieve)	74	= 15 + 36 + 23
Total CA Components to include RAP $\sum_{i=1}^n P_{nc}$	78.35	= 4.35 + 74

**Step 6:** Determine  $G_{ca}$  for the VCA calculations:

G <sub>ca</sub> Calculation				
	$P_{C_n} = \frac{P_{n_c}}{\sum_{i=1}^n P_{n_c}}$		$\left( P_{C_n} / G_n \right)$	
CA1	19.1%	= 15 / 78.35	7.2%	= 19.1 / 2.660
CA2	45.9%	= 36 / 78.35	17.1%	= 45.9 / 2.680
CA3	29.4%	= 23 / 78.35	11.0%	= 29.4 / 2.660
RAP1	5.6%	= 4.35 / 78.35	2.1%	= 5.6 / 2.654 <b>See note</b>
Sum			37.5%	
<b>G<sub>ca</sub></b>			<b>2.669</b>	= 100 / 37.5

Where:

$$G_{ca} = \frac{100}{\frac{P_{C_1}}{G_1} + \frac{P_{C_2}}{G_2} + \dots + \frac{P_{C_n}}{G_n}}$$

**Note:** the G<sub>sb</sub> used for the RAP is that calculated for the material retained on and above the break point sieve.

**Step 7:** Determine VCA<sub>DRC</sub> for trial blend 1 in accordance with AASTHO T-19 using  $G_{ca}$  calculated in Step 6.

Using virgin aggregates and RAP aggregates (ignition oven extracted) retained on the B.P. Sieve at the trial blend percentages, determine the Dry Rodded Unit weight of the coarse aggregate.

Unit Weight of Dry Rodded Stone (per AASHTO T-19)		
Mass of Aggregate & Measure[kg]	1.7635	
Mass of Measure [kg]	6.1145	
Volume of Measure [m <sup>3</sup> ]	0.00283	
Unit Weight of Rodded Stone [kg/m <sup>3</sup> ]	1537.5	= (6.1145 – 1.7635) / .00283

Using this unit weight and the  $G_{ca}$  from Step 6 calculate VCA<sub>DRC</sub>.

VCA <sub>DRC</sub>		
G <sub>ca</sub>	2.669	
Unit Weight of Water ( $\gamma_w$ )	997.5	[kg/m <sup>3</sup> ]
Unit Weight of Stone ( $\gamma_s$ )	1537.5	[kg/m <sup>3</sup> ]
<b>VCA<sub>DRC</sub></b>	<b>42.2%</b>	= $\left( \frac{(2.669 * 997.5) - 1537.5}{(2.669 * 997.5)} \right) \times 100$

$$VCA_{DRC} = \left( \frac{(G_{ca})\gamma_w - \gamma_s}{(G_{ca})\gamma_w} \right) \times 100$$

**Step 8: Determine the Blend Gsb for VMA calculations.**

$$BlendG_{sb} = \frac{100}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \dots + \frac{P_n}{G_n}}$$

	G <sub>SB</sub>	BIN % (P <sub>n</sub> )	(P <sub>n</sub> ) / G <sub>SB</sub>	
CA1	2.660	15	5.64	=15 / 2.660
CA2	2.680	36	13.43	= 36 / 2.680
CA3	2.660	23	8.65	= 23 / 2.660
MF	2.882	10	3.54	=10 / 2.822
BH	2.660	1	0.38	=1 / 2.660
RAP1 (G <sub>se</sub> )	2.730	15	5.49	= 15 / 2.730
SUM			37.13	= 5.64 + 13.43 + 8.65 + 3.54 + 0.38 + 5.49
Blend G <sub>sb</sub>			<b>2.693</b>	= 100 / 37.13

**Step 9:** Batch and compact the required samples to calculate the volumetric properties of the trial blend.

Gmm	2.437
Blend Gsb	2.693
Blend Gca	2.669
Trial %AC	6.70%

  

Weight in Air	Weight in Water	SSD Weight	Bulk Sp. Gravity G <sub>mb</sub>	VTM %	VMA %
A	C	B	$\frac{A}{B-C}$	$100\left(1 - \frac{G_{mb}}{G_{mm}}\right)$	$100 - \left(\frac{G_{mb}}{G_{sb}}\right) P_s$
4628.6	2659.6	4635.9	2.342	3.9%	18.9%
4638.9	2668.0	4648.1	2.343	3.9%	18.9%
4640.2	2669.3	4650.6	2.342	3.9%	18.9%
Averages			<b>2.342</b>	<b>3.9%</b>	<b>18.9%</b>

Using the information from the gyratory volumetrics calculate VCA<sub>mix</sub>

$G_{mb}$	2.342	
$G_{ca}$	2.669	
$PA_{pb}$	72.3%	= 100 - 27.7
$P_s$	93.3%	= 100 - 6.7
$P_{bp}$	67.4%	= (72.3 * 93.3)/100
<b><math>VCA_{mix}</math></b>	<b>40.8%</b>	= 100 - $\left(\frac{2.342}{2.669} \times 67.4\right)$

Where:

$$VCA_{mix} = 100 - \left( \frac{G_{mb}}{G_{ca}} \times P_{bp} \right)$$

Results:  $VCA_{mix} = 40.8 < VCA_{DRC} = 42.2$ , OK

VMA = 18.9 > Minimum VMA = 17, OK

VTM = 3.9 > Design VTM = 3.5%

**Step 9:** Repeat Steps 1 – 8 for Trial Blends 2 and 3

**Step 10:** Select the Blend that satisfies both the VCA and VMA requirements. If more than one meets both requirements take into account:

Plant break down on the VMA (VMA will usually decrease by ~1% during production)  
and  
Lower percent total coarse aggregate.

**Step 11:** Optimize AC content in accordance with Section 4.2 and VDOT's Special Provision for Stone Matrix Asphalt

**Step 12:** Once a design AC and Aggregate Structure have been finalized then verify the aggregate properties that are measured on the blend (F&E and FAA) and determine the Oven Correction Factor. The materials for the aggregate tests should be collected from the aggregates extracted from the ignition oven blanks used in determining the correction factor.

## Virginia Test Method – 102

### Determination of Asphalt Content From Asphalt Paving Mixtures By the Ignition Method – (Asphalt Lab)

December 1, 2002

#### 1. **Scope**

- 1.1 This test method covers the determination of asphalt content of hot-mixed paving mixtures by ignition of the asphalt cement at 1000° F (538° C) in a furnace. The aggregate remaining can be used for sieve analysis using AASHTO Test Method T 30.
- 1.2 The values stated in metric units are to be regarded as the standard.
- 1.3 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 whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

#### 2. **Referenced Documents**

AASHTO Standards:

- T 248 Reducing Field Samples of Aggregate to Testing Size
- T 168 Sampling Bituminous Paving Materials
- T 30 Mechanical Analysis of Extracted Aggregate

#### 3. **Summary of Test Methods**

- 3.1 The asphalt in a sample of hot-mix paving material is burned by ignition at 1000° F (538° C). The asphalt content is calculated from the mass of ignited aggregate, moisture content, and temperature compensation for the change in mass of the sample container. The asphalt content is expressed as mass percentage of the moisture-free mixtures. This method may not be applicable to mixes containing fibers or ground tire rubber (dry process).

#### 4. **Apparatus**

- 4.1 A forced air ignition furnace, capable of maintaining the temperature at 1200° F (650° C) with an internal balance thermally isolated from the furnace chamber accurate to 0.1 g. The balance shall be capable of weighing a 3,500 gram sample in addition to the sample baskets. The furnace shall calculate a temperature compensation factor for the change in weight of the sample basket(s) and provide for the input of a calibration factor for aggregate loss. The furnace shall provide a printed ticket with the initial specimen weight, specimen

weight loss, temperature compensation, calibration factor, corrected asphalt content (%), test time, and test temperature. A method for reducing furnace emissions shall be provided. The furnace shall provide an audible alarm and indicator light when the sample weight loss does not exceed 0.02 percent of the total sample weight for two consecutive minutes. The furnace door shall be locked until the completion of the test procedure.

4.2 Tempered stainless steel No. 8 (2.36 mm) mesh or otherwise perforated basket(s) with legs. If multiple baskets are used, the baskets shall be nested. The basket(s) shall be provided with screening to confine the aggregate.

4.3 A stainless steel catch pan.

4.4 Oven capable of maintaining  $257 \pm 9^{\circ}\text{F}$  ( $125 \pm 5^{\circ}\text{C}$ ).

4.5 Balance, 8-kg or greater capacity, sensitive to 0.5 g for weighing sample in basket(s).

4.6 Safety Equipment: safety glasses or face shield, high temperature gloves, and long sleeve jacket. Additionally, a heat resistant surface capable of withstanding  $1200^{\circ}\text{F}$  ( $650^{\circ}\text{C}$ ) and a protective cage capable of surrounding the sample baskets shall be provided.

4.7 Miscellaneous Equipment: pan for transferring samples after ignition, spatulas, bowls, and wire brushes.

## 5. **Sampling**

5.1 The test sample shall be the end result of quartering a larger sample taken in accordance with VTM-48 (AASHTO T 248 may be used as a guide to quartering.)

Note: VTM-48 is a modified version of AASHTO T 168

5.2 Preparation of Test Specimens:

5.2.1 If the mixture is not sufficiently soft to separate with a spatula or trowel, place it in a large flat pan and warm to  $257^{\circ}\text{F} \pm 9^{\circ}\text{F}$  ( $125^{\circ}\text{C} \pm 5^{\circ}\text{C}$ ) for 25 minutes. The sample shall not be heated for more than 1 hour.

5.2.2 The size of the test sample shall be governed by the nominal maximum aggregate size of the mixture and shall conform to the mass requirement shown in Table 1 (Note 1):

Note 1-When the mass of the test specimen exceeds the capacity of the equipment used, the test specimen may be divided into suitable increments, tested, and the results appropriately combined for calculation of the asphalt content (weighted average).

<b>Table 1 Size of Sample</b>		
Nominal Maximum Aggregate Size, mm	Sieve Size	Minimum Mass of Sample g
4.75	(No. 4)	1200
9.5	3/8 in.	1200
12.5	1/2 in.	1500
19.0	3/4 in.	2000
25.0	1 in.	3000
37.5	1 1/2 in	4000

Sample sizes should not be more than 800 g greater than the minimum recommended sample mass. Large samples of fine mixes tend to result in incomplete ignition of the asphalt.

- 5.2.3 In addition, a test specimen for moisture determination (VTM-49) will be made as deemed necessary. The specimen used for moisture determination may not be used for asphalt content determination.

## **6. Calibration**

A mixture calibration procedure is required. For mix designs containing RAP, sufficient quantity of RAP should be sampled such that the binder content of the RAP may be estimated, and to provide for the RAP to be used in the mix calibration. The binder content of the RAP will be estimated from the average of four samples (RAP only) burned in the furnace. The portions of RAP should be obtained using a sample splitter.

Typically, calibration testing will be performed at 1000° F (538 °C). However, certain aggregate types may result in an unusually high calibration factor and erroneous gradation results. Such mixes should be calibrated and tested at a lower temperature, typically 900 °F (482° C) as approved by the Engineer.

### **6A. Calibration Procedure for Hot-Mix Asphalt**

- 6A.1 This method may be effected 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.
- 6A.2 Four calibration specimens conforming to the mass requirements of Section 5.2.2 shall be prepared at the optimum asphalt content. A butter mix shall be prepared at the design asphalt content, mixed and discarded prior to mixing any of the calibration specimens to ensure an accurate asphalt content. Aggregate used for the calibration specimens shall be sampled from stockpiled material produced in the current construction season. Any method may be

used to combine the aggregates, however an additional “blank” specimen shall be batched and tested according to AASHTO T 30. The washed gradation shall fall within the JMF (mix design) tolerances.

NOTE: When batching calibration samples, be sure to account for the AC% contribution of the RAP to the total asphalt content of the specimens.

- 6A.3 The freshly mixed specimens may be placed directly in the sample basket(s). If allowed to cool, the samples must be preheated in a 257° F (125° C) oven for 25 minutes. Do not preheat the sample basket(s).
- 6A.4 Preheat the ignition furnace to 1000° F (538° C) Record the furnace temperature (set point) prior to the initiation of the test.
- 6A.4 Enter a calibration factor of 0.00 in the ignition furnace.
- 6A.5 Weigh and record the weight of the sample basket(s) and catch pan (with guards in place) .
- 6A.6 Place the sample basket in the catch pan. Evenly distribute the calibration specimen in the basket taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the specimen.
- 6A.7 When multiple sample baskets are used, place a sample basket in the catch pan. Evenly distribute an equal portion of the specimen in the basket, taking care to keep the material away from the edges of the basket. Each subsequent basket should be placed on top of the preceding basket with an equal portion of the specimen evenly distributed in each basket. Care should be taken to keep the material away from the edges of the baskets. Use a spatula or trowel to level the specimen.
- 6A.8 Weigh and record the sample, basket(s), catch pan, and basket guards. Calculate and record the initial weight of the sample specimen (total weight - the weight of the sample basket assembly).
- 6A.9 Input the initial weight of the sample specimen in whole grams into the ignition furnace controller. Verify that the correct weight has been entered.
- 6A.10 Open the chamber door and place the sample basket(s) in the furnace. Close the chamber door and verify that the sample weight (including the basket(s) displayed on the furnace scale equals the total weight recorded in Section 6.8 within  $\pm 5g$ . Differences greater than 5 grams 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.

- 6A.11 Allow the test to continue until the stable light and audible stable indicator indicates the test is complete. Press the start/stop button. This will unlock the sample chamber and cause the printer to print out the test results.
- 6A.12 Open the chamber door, remove the sample basket(s) and allow to cool to room temperature (approx. 30 minutes).
- 6A.13 Perform a gradation analysis on the residual aggregate as indicted in Section 8.
- 6A.14 Once all of the calibration specimens have been burned, determine the difference between the actual and measured asphalt contents for each sample. The mix calibration factor is calculated as follows:

$$\text{MCA} = \frac{\text{AC\% test 1} + \text{AC\% test 2} + \text{AC\% test 3} + \text{AC\% test 4}}{4}$$

where:

MCA = Mixture Calibration Average

AC % = Difference between actual binder content (including RAP AC%) and measured asphalt content

## **6B. Calibration Procedure for Slurry Seal and Micro-surfacing**

- 6B.1 This method may be effected 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.
- 6B.2 Four calibration specimens conforming to the mass requirements of Section 5.2.2 shall be prepared at the optimum asphalt content. The calibration samples will be batched using base asphalt. A butter mix shall be prepared at the design asphalt content, mixed and discarded prior to mixing any of the calibration specimens to ensure an accurate asphalt content. Aggregate used for the calibration specimens shall be sampled from stockpiled material produced in the current construction season. Any method may be used to combine the aggregates, however an additional "blank" specimen shall be batched and tested according to AASHTO T 30. The washed gradation shall fall within the JMF (mix design) tolerances.
- 6B.3 The freshly mixed specimens may be placed directly in the sample basket(s). If allowed to cool, the samples must be preheated in a 257° F (125° C) oven for 25 minutes. Do not preheat the sample basket(s).

- 6B.4 Preheat the ignition furnace to 1000° F (538° C). Record the furnace temperature (set point) prior to the initiation of the test.
- 6B.4 Enter a calibration factor of 0.00 in the ignition furnace.
- 6B.5 Weigh and record the weight of the sample basket(s) and catch pan (with guards in place).
- 6B.6 Place the sample basket in the catch pan. Evenly distribute the calibration specimen in the basket taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the specimen.
- 6B.7 When multiple sample baskets are used, place a sample basket in the catch pan. Evenly distribute an equal portion of the specimen in the basket, taking care to keep the material away from the edges of the basket. Each subsequent basket should be placed on top of the preceding basket with an equal portion of the specimen evenly distributed in each basket. Care should be taken to keep the material away from the edges of the baskets. Use a spatula or trowel to level the specimen.
- 6B.8 Weigh and record the sample, basket(s), catch pan, and basket guards. Calculate and record the initial weight of the sample specimen (total weight - the weight of the sample basket assembly).
- 6B.9 Input the initial weight of the sample specimen in whole grams into the ignition furnace controller. Verify that the correct weight has been entered.
- 6B.10 Open the chamber door and place the sample basket(s) in the furnace. Close the chamber door and verify that the sample weight (including the basket(s) displayed on the furnaces scale equals the total weight recorded in Section 6.8 within  $\pm 5$ g. Differences greater than 5 grams 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.
- 6B.11 Allow the test to continue until the stable light and audible stable indicator indicates the test is complete. Press the start/stop button. This will unlock the sample chamber and cause the printer to print out the test results.

NOTE: Do not use the asphalt content given by the print out. Calculate the measured asphalt content as shown in 6B.14.

6B.12 Open the chamber door, remove the sample basket(s) and allow to cool to room temperature (approx. 30 minutes).

6B.13 Weigh and record sample weight.

6B.14 Calculate measured asphalt content as follows:

$$\text{Measured AC} = \frac{\text{Weight of sample (before)} - \text{Weight of sample (after)}}{\text{Weight of sample (after)}}$$

6B.15 Once all of the calibration specimens have been burned, determine the difference between the actual and measured asphalt contents for each sample. The mix calibration factor is calculated as follows:

$$\text{MCA} = \frac{\text{AC\% test 1} + \text{AC\% test 2} + \text{AC\% test 3} + \text{AC\% test 4}}{4}$$

where:

MCA = Mixture Calibration Average

AC % = Difference between actual binder content and measured asphalt content (as determined in 6B.14)

## 7. Test Procedure

### 7A Hot-Mix Asphalt Mixtures

7A.1 Preheat the ignition furnace to 1000° F (538° C) Record the furnace temperature (set point) prior to the initiation of the test.

7A.2 Enter the calibration factor for the specific mix to be tested as determined in Section 6A in the ignition furnace.

7A.3 Weigh and record the weight of the sample basket(s) and catch pan (with guards in place).

7A.4 Prepare the sample as described in Section 5.2. Place the sample basket in the catch pan. Evenly distribute the specimen in the sample basket taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the specimen.

7A.5 When multiple sample baskets are used, place a sample basket in the catch pan. Evenly distribute an equal portion of the specimen in the basket, taking care to keep the material away from the edges of the basket. Each subsequent basket should be placed on top of the preceding basket with an equal portion of the specimen evenly distributed in each basket. Care should be taken to keep the material away from the edges of the baskets. Use a spatula or trowel to level the specimen.

- 7A.7 Input the initial weight of the sample specimen in whole grams into the ignition furnace controller. Verify that the correct weight has been entered.
- 7A.8 Open the chamber door and place the sample basket(s) in the furnace. Close the chamber door and verify that the sample weight (including the basket(s)) displayed on the furnaces scale equals the total weight recorded in Section 7.8  $\pm$  5g. Differences greater than 5 grams 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.
- 7A.9 Allow the test to continue until the stable light and audible stable indicator indicate the test is complete. Press the start/stop button. This will unlock the sample chamber and cause the printer to print out the test results.
- 7A.10 Open the chamber door, remove the sample basket(s) and allow to cool to room temperature (approximately 30 minutes).

**7B. Slurry Seal and Micro-surfacing**

- 7B.1 Cure the material in an oven at 225° F (107° C) until the weight loss in a two hour period does not exceed 0.02% by weight ( i.e. for 5000 gms., the material does not loose more than 1 gm in a two hour period).
- 7B.2 Preheat the ignition furnace to 1000° F (538° C) Record the furnace temperature (set point) prior to the initiation of the test.
- 7B.3 Weigh and record the weight of the sample basket(s) and catch pan (with guards in place).
- 7B.4 Prepare the sample as described in Section 5.2. Place the sample basket in the catch pan. Evenly distribute the specimen in the sample basket taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the specimen.
- 7B.5 When multiple sample baskets are used, place a sample basket in the catch pan. Evenly distribute an equal portion of the specimen in the basket, taking care to keep the material away from the edges of the basket. Each subsequent basket should be placed on top of the preceding basket with an equal portion of the specimen evenly distributed in each basket. Care should be taken to keep the material away from the edges of the baskets. Use a spatula or trowel to level the specimen.

- 7B.6 Weigh and record the sample, basket(s), catch pan, and basket guards. Calculate and record the initial weight of the sample specimen (total weight - the weight of the sample basket assembly)
- 7B.7 Input the initial weight of the sample specimen in whole grams into the ignition furnace controller. Verify that the correct weight has been entered.
- 7B.8 Open the chamber door and place the sample basket(s) in the furnace. Close the chamber door and verify that the sample weight (including the basket(s)) displayed on the furnaces scale equals the total weight recorded in Section 7.8  $\pm$  5g. Differences greater than 5 grams 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.
- 7B.9 Allow the test to continue until the stable light and audible stable indicator indicate the test is complete. Press the start/stop button. This will unlock the sample chamber and cause the printer to print out the test results.

NOTE: Do not use the asphalt content given by the print out.

- 7B.10 Open the chamber door, remove the sample basket(s) and allow to cool to room temperature (approximately 30 minutes).
- 7B.11 Weigh and record the sample weight.
- 7B.12 Calculate asphalt content using the following:

$$\text{Measured AC} = \frac{\text{Weight of sample (before)} - \text{Weight of sample (after)}}{\text{Weight of sample (after)}}$$

- 7B.13 Calculate actual asphalt content using the following:

$$\text{Actual AC} = \text{Measured AC} - \text{MCA}$$

- 7B.14 Report Actual AC.

## 8. **Gradation**

- 8.1 Allow the specimen to cool to room temperature in the sample basket(s).
- 8.2 Empty the contents of the basket(s) into a flat pan. Use a small wire sieve brush to ensure that any residual fines are removed from the basket(s).

8.3 Perform the gradation analysis according to AASHTO T 30.

**9. Report**

9.1 Always report corrected asphalt content, mix calibration factor, temperature compensation factor, total percent loss, sample mass, and test temperature. Attach the original printed ticket to the report. An example data sheet is attached.

**10. Precision and Bias**

10.1 Precision and Bias were determined in an NCAT Round-Robin study for surface mixes.

Asphalt Content	Standard Deviation, %	Acceptable Range of Two Test Results, %
Single-Operator Precision	0.04	0.11
Multi laboratory Precision	0.06	0.17

Note: These precision statements are based on 4 aggregate types, 4 replicates, and 12 laboratories participating with 0 laboratory results deleted as outlying observations. All 4 aggregates were tested in surface mixes and had relatively low absorption values.

