

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 (SiO₂) in sands.

**Virginia Test Method
For
Anti-Stripping Additive
Designation: VTM-13**

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 and #10 Quartzite. The blend shall be separated by dry-sieving and proportioned to meet the following gradation for each test batch.

Sieve Size	Percent Passing
1/2"	100.0
3/8"	90.0
No. 4	62.0
No. 8	42.0
No. 30	18.0
No. 50	12.0
No. 100	8.0
No. 200	4.0

- 3.2 The asphalt is AC-20 and meets Virginia specifications.

4. Procedure

- 4.1 500 grams 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°F ± 5°F. 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 grams. The total mix shall be 24 grams treated asphalt, and 376 grams of proportioned aggregate (one test batch). Heat on hot plate and stir until coated.
- 4.4 After complete coating, allow mixture to cool to $230^{\circ}\text{F} \pm 10^{\circ}\text{F}$, place approximately 200 grams on a paper towel before boiling. Place the remainder (approximately 200 grams) 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 unboiled portions on the paper towels. If the boiled portion shows more signs of stripping than the unboiled 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. 1/2-inch sieve.
- b. A balance, accurate to one gram.
- c. Beakers, approximately 600 ml., 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 grams of the mixture passing the 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 $230^{\circ}\text{F} \pm 10^{\circ}\text{F}$ (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 $230^{\circ}\text{F} \pm 10^{\circ}\text{F}$.

NOTE: Remove plus 1/2-inch material from mixture prior to attaining specified temperature.

- c. Place approximately 200 grams on a paper towel before boiling.
- d. Place the remainder (approximately 200 grams) of the mixture in boiling water and continue boiling for 10 minutes \pm 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 unboiled portions on the paper towels. If the boiled portion shows more signs of stripping than the unboiled 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
For
Wet Track Abrasion
Designation: VTM-14**

1. Scope

The wet track abrasion is intended for measuring the wearing qualities of thin, fine aggregate bituminous surfacing, such as slurry seal, under wet abrasion conditions. It may be used for design purposes to establish the optimum quality and type of binder consistent with wear resistance of the surfacing.

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

1. Balance

- a. Capable of weighing 5,000 gms. to within 1.0 gm.

2. Planetary Type Mechanical Stirrer

- a. (Such as the Hobart C-100 made by Hobart Mfg. Co., Troy Ohio) equipped with an abrasion head weighing 5 lbs. (including rubber hose) \pm 5 grams.
- b. Has 1/2 in. up and down movement in the shaft sleeve.

3. Has 1/8 in. Flat Bottom Metal Pan

- a. 13 in. diameter.
- b. 2 in. vertical side walls (20 gage or heavier).
- c. 4 Equally spaced screw clamps capable of securing 11.75 in. dia. sample to bottom of pan.

4. Suitable Heavy Gage Round Bottom Bowl to be used for mixing sample.

5. Long Handled Serving Spoon should project 4 in. or more from bottom of round bottom mixing bowl.

6. Disk

- a. 11.75 in. diameter or larger circular cut from 40 - 60 lbs. roofing felt.

7. Metal Plates

- a. 15 in. square with 4 rods space 14 in. center to center.
- b. Rods 1 in. tall and 1/4 in. in diameter.

8. Plastic Templates

- a. 15 in. square 1/4 in. thick with 4 holes spaced 14 in. center to center.

- b. Holes 3/16 in. diameter.
 - c. 11 in. circle cut into center of template.
9. Window Squeegee
- a. 12 in. to 14 in. long with short handle (rubber edge).
10. Funnel
- a. Metal or nalgene with top diameter opening minimum 5 in. to maximum 7.0 in.
 - b. To tubular opening minimum 3/4 in. to maximum 1.0 in.
 - c. Bottom tubular opening 1/2 inch.
11. Oven
- a. Forced draft constant temperature.
 - b. Thermostatically controlled at 140°F (60°C).
12. Water Bath
- a. Constant temperature controlled 77°F ± 2°F (25°C ± 1°C).
 - b. 1 in. water above top sample.
 - c. Will hold minimum of 3 samples at a time.
13. Reinforced Rubber Hose
- a. 3/4 in. inside diameter (2 braid, Oil-Resistant Cover, equivalent to Parker 3292 OZEX general purpose hose).
 - b. Cut into 5 inch lengths.
 - c. 2 holes drilled on 4 inch center to center.
 - d. Diameter of holes should be 3/8 in.
Note: Do not drill through concave or convex sides.
14. Thermometers
- a. ASTM 49°C range 20°C to 70°F (140°F oven).
 - b. ASTM 17°F range 66°F to 80°F (77°F water bath).
15. Sample Rack
- a. Should be large enough to place sample without any overhang.
 - b. 1 in. spacers between samples.
 - c. Rack should be secured together without any movement.
16. Support for Flat Bottom Metal Pan should be secured to machine.
17. Squares for Towel Test (VTM-60)
- a. 8 in. square.
 - b. 40 - 60 lbs. roofing felt.
18. Paper Towel for Test
- a. White hand towel.

3. Procedure

PART I - PREPARATION OF TEST SPECIMEN

1. Making Specimens:

- a. Air dry (May be oven dried not to exceed 140°F) a sufficient quantity of aggregate to obtain the required number of batches. Sieve material over the #4 sieve. (Filler to be considered as part of the aggregate).
NOTE: Three test specimens to be made for each percent residual asphalt content
- b. Weigh 800 grams of aggregate into the mixing bowl. Dry mix the sample with the spoon, a minimum of one minute. Add all the predetermined amount of water and mix for one minute or until all aggregate particles are uniformly wetted.
- c. Add the predetermined amount of emulsion (For example 13, 15, and 17% emulsion based on the weight of aggregate). Stir with a spoon using a circular, combined with a back and forth, motion for a period of three minutes (± 5 seconds). NOTE: After 3 minutes if compatibility fails part A or part B from VTM-60, design test will not be run. Check funnel flow mix consistency by testing the ability of the slurry to flow through the one-half inch opening on the bottom of the funnel. (Trial batches should be run prior to making specimens for lowest possible water content) NOTE: Mixtures which segregate will not flow through the funnel. They are unsuitable for slurry work unless this segregation can be overcome by additions of hydrated lime or Portland Cement or by a change of gradation (Blending). If free flowing consistency is unattainable without segregation discard the batch. Repeat Steps b and c with the addition of hydrated lime or Portland Cement to the aggregate. (Suggest 0.5% increments based on the weight of the aggregate). All subsequent mixtures would include the lowest amount of hydrated lime or Portland Cement to overcome segregation.
- d. Place the opening in the lucite template over the 11.75 in. diameter disc or roofing felt. Pour the slurry onto the top part of the felt.
- e. Squeegee the slurry level with the top of the lucite template with a minimum of manipulation (Excessive squeegeeing contributes to segregation). Scrape off excess material and discard.
- f. After one hour (± 5 min.) remove the lucite template. Place the molded specimen in the 140°F oven and dry to constant weight (Minimum 24 hours drying time).

PART II - WET TRACK ABRASION TEST

- a. Remove the dried specimen from the 140°F oven, cool to room temperature and weigh.
- b. After weighing, place the specimen in the 77°F water bath for 1 to 1 1/4 hours.
- c. Remove the specimen from the water bath and place in the 13 in. diameter flat bottom pan. Secure the specimen to the pan bottom by tightening the four wing-nut washers.
- d. Completely cover the specimen with at least 0.25 in. depth of distilled water (temperature 77°F \pm 5°F).
- e. Secure the pan, so as to avoid movement during testing, containing the specimen on the platform of the Hobart Machine. Lock the rubber hose abrasion head on the shaft of the Hobart Machine. Elevate the platform of the Hobart Machine until the rubber hose bears on the surface on the specimen. Use the prop block or other device to support the platform assembly during testing.
- f. Switch to the low speed of the Hobart Machine and run for 5 minutes.

NOTE: Install a fresh section of hose after completion of each test.

- g. Remove the specimen from the pan after the abrasion cycle and wash off debris. Place the washed test specimen in the 140°F oven and dry to constant weight.
- h. The dried specimen is removed from the 140°F oven, allowed to reach room temperature, and weighed. The difference between this weight and the weight obtained in Step(a) Part II is multiplied by 3.06 to express the loss in grams per square foot (Wear Value).

NOTE: The factor 3.06 is used to convert the loss for the actual abraded area, 0.327 sq. ft. to a one square foot basis. (The 3.06 value only applies to the Hobart C-100 Machine with a 5 in. rubber hose).

- i. To compensate for the +4 material in a slurry mixture, the optimum residual asphalt content (As determined by the WTAT) may be reduced as follows:

For each 1% of +4 material, (Not to exceed 15.0%) reduce the optimum residual asphalt content by 0.1%. However, in no case should the asphalt content be lower than the specification limits.

Example:

10.0	Percent Residual Asphalt for Mix
15.0	Percent +4 material
0.1%	x 15.0% = 1.5%
10.0%	
-1.5%	
<hr/>	
8.5%	Adjusted Residual Asphalt Content

PART III - DESIGN CHECK

On design check tests, the lower limit of the job mix design residual asphalt content acceptance range will be used. (Three test specimens). If compatibility fails part A or part B from VTM-60, design check test will not be run.

NOTE: For each 1% of +4 material, not to exceed 15%, the residual asphalt content may be increased by 0.1%.

Example:

8.5	Percent Residual Asphalt Content
15.0	Percent +4 Material
0.1%	X 15.0% = 1.5%
8.5%	
+ 1.5%	
<hr/>	
10.0%	Adjusted Residual Asphalt Content for Design Check Test

4. COMPATIBILITY

Materials must be checked for compatibility in accordance with VTM-60.

5. REPORT

- a. The average wear value (WTAT Loss) in grams, to the nearest whole number for each percentage of emulsified asphalt.
- b. Total water added.
- c. Percent emulsion.
- d. Percent residual asphalt in emulsion (actual or estimated).
- e. Percent hydrated lime or Portland Cement.
- f. Description of texture.
 - 1. poor - Surface skinning or tackiness.
 - 2. good - Freedom from surface skinning or tackiness.
- g. Gradation of aggregate.
- h. Pass or fail compatibility (VTM-60).

NOTE: Report separately for Part A and Part B of VTM-60.

**Virginia Test Method
For
Field Determination of Percent Density
of Compacted Asphalt Concrete Mixtures
Designation: VTM-22**

1. Scope

This method covers the procedure for determining the percent compaction of compressed 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 4x4 in. sawed specimens shall be taken per site or two 4 in. 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, CO₂, 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 Determine the theoretical maximum specific gravity of the asphalt concrete mixture in accordance with AASHTO T-209.

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

4.4 The theoretical maximum specific gravity used as the denominator for the percent compaction determination shall be determined by a moving average of five values.

4.5 Until five values are obtained, the theoretical maximum specific gravity used shall be a simple average.

5. Calculation

5.1 Calculate the percent density of each specimen as follows:

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

6. Report

6.1 Report depth to nearest 0.1 inch.

6.2 Report percent density of each test specimen to nearest 0.1 percent.

7. Precision

7.1 If the difference in percent compaction between two specimens from the same test site varies by more than 2.0%, discard and obtain two more specimens from a new test site.

**Virginia Test Method
For
Quantitative Extraction of Bitumen
From Asphalt Paving Mixtures
By the Reflux Method**

Designation: VTM-36

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. long, 8 in. wide, and 1 in. deep.
- 5.3 The balance shall be capable of weighing at least 2000 grams to an accuracy of 1.0 gram.
- 5.4 The hot plate shall be thermostatically controlled.
- 5.6 Ignition Dish - may be omitted.
- 5.7 Desiccator - 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	400 g
3/8 in.	500 g
1/2 in.	1000 g
3/4 in.	1200 g
1 in.	1400 g
1 1/2 in.	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. OD, 18 in. 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-plys 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
For
Sampling Asphalt Paving Mixtures
Designation: VTM-48**

AASHTO - T 168-82 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" 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.

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.

**Virginia Test Method
For
Compatibility Test of Slurry Seal Mixtures
Designation: VTM-60**

1. Scope

The compatibility test is used to determine the minimum mixing time and maximum setting time of a slurry seal mixture.

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

- a. Scale, capable of weighing 5000 grams to within ± 1.0 gram.
- b. Suitable heavy gauge round bottom bowl to contain the sample during mixing.
- c. Long-handled spoon of sufficient length to project 4 in. or more out of round bottom bowl during stirring.
- d. Supply of 6 in. (approximately) squares cut from smooth (40-60 lb.) roofing felt.
- e. Supply of white paper towels.

3. Procedure

PART A - MINIMUM MIXING TIME

To a total of 200 grams of aggregate and hydrated lime or Portland Cement, add the percentage of water and quick-setting emulsion (At 68-80° F), as established by the job mix formula, and mix for minimum of 3 minutes. This mixture shall form a free flowing, smooth, homogeneous slurry with no segregation, no balling, and no stiffening to pass the test requirement.

PART B - MAXIMUM SETTING TIME

Slurry seal setting time - Spread about half of the mix from Part A on a section of asphalt-saturated roofing felt to a thickness of approximately 0.25 in. and cured for one hour at 68-80° F. A piece of white paper towel, when pressed lightly on the surface of the slurry after the curing period, shall show no brown stain (black particles of asphalt shall be disregarded) to pass the test requirement.

NOTE: If a slow-set emulsion is specified, Part B will be voided.

4. Report

- a. Pass or fail Part A
- b. Pass or fail Part B

Virginia Test Method - 99

The Design of Stone Matrix Asphalt (SMA) Mixtures

March 2005

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. 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. sieve
SMA-12.5 Surface	22,26, and 30 percent passing the No. 4 sieve
SMA-9.5 Surface	15,20 and 25 percent passing the No. 8 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 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 No. 4 sieve for the SMA-12.5 and SMA-19.0 mixture types. For the SMA-9.5 the coarse aggregate is defined as all component materials with 10 percent or more retained on and above the No. 8 sieve. These two sieves are hereafter referred to as the breakpoint sieves. 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. Calculate the **VCA** of the coarse aggregate fraction by the following equation.

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

where,

γ_s	=	unit weight of the coarse aggregate fraction in the dry rodded condition (lbs/ft ³)
γ_w	=	unit weight of water (62.4 lbs/ft ³)
G_{ca}	=	combined bulk specific gravity of the material retained on and above the breakpoint sieve (No. 4 sieve for the SMA-12.5 and 19.0, No. 8 for SMA-9.5)

- 4.1.3 Selection of trial asphalt content - The initial asphalt content of the mixture for the gradation selection phase of the design should be a minimum of 6.8 percent for the SMA-9.5, 6.5 percent for the SMA-12.5 and 5.5 percent for the SMA-19.0. It is suggested that a good starting point be 7.0 percent for the SMA-9.5, 6.7 percent for the SMA-12.5 and 5.7 percent for the SMA-19.0 for mixtures with aggregate specific gravities equal to or less than 2.75. If the bulk specific gravity of the aggregate exceeds 2.75 the asphalt content can be reduced slightly, but the minimum trial asphalt content shall not be less than the minimum specified in the SMA special provision. **The VMA of the mixture must still meet the specified VMA criterion.**

- 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 aggregates and fibers should be dry mixed before adding the asphalt cement. The mixing and compaction temperature should be obtained from Section 211.03 (d) 6 of the Road and Bridge Specifications. Three of the four samples for each gradation shall be compacted with a gyratory compactor (AASHTO T312) using the specified gyrations listed in the SMA Special Provision. 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 - Compact the specimens, remove from the molds, and allow to cool. Determine the bulk specific gravity, G_{mb} , of the specimens (AASHTO T-166). The uncompacted samples are used to determine the theoretical maximum specific gravity, G_{mm} , (AASHTO T-209). Using G_{mb} and G_{mm} ; the percent air voids (V_a), VMA , VCA_{mix} , G_{se} , P_{ba} , P_{be} and $P_{0.075}/P_{be}$ are calculated by the following formulas.

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

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

$$P_{bp} = (P_s)(PA_{bp})x100$$

$$P_s = (100 - AC)$$

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

$$G_{se} = (100 - AC) / (100 / G_{mm} - AC / G_b)$$

$$P_{ba} = P_s * G_b * (G_{se} - G_{sb}) / (G_{se} * G_{sb})$$

$$P_{be} = AC - P_{ba}$$

$$\text{Fines to Effective binder content ratio} = P_{0.075} / P_{be}$$

Where,

G_{mb}	=	bulk specific gravity of compacted specimens
G_{mm}	=	theoretical maximum specific gravity of mix
G_{ca}	=	combined bulk specific gravity of the coarse aggregate ¹
P_{bp}	=	percent aggregate by total mixture weight retained on and above the breakpoint sieve
P_s	=	percent aggregate in the mixture expressed as a decimal (for calculating VMA, P_s is expressed as a whole number i.e. 90.0% = 90)
PA_{bp}	=	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% = .767)
G_{sb}	=	combined bulk specific gravity of the complete aggregate blend (coarse and fine aggregates) ¹
AC	=	asphalt content in the mix
G_{se}	=	The effective specific gravity
P_{ba}	=	The absorptive binder percent
P_{be}	=	The effective binder percent
$P_{0.07}$	=	Percent passing #200

¹A mathematical combination of individual aggregate specific gravities (see example computations in appendices).

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 desired mix design aggregate blend.

- 4.2 Determination of the optimum asphalt content - The optimum asphalt content is determined by the Gyratory procedure using the specified gyrations listed in the SMA Special Provision. 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 uncompactd at each of three asphalt contents). The uncompactd 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. 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 to VTM-102

5.0 Results

- 5.1 Gradation selection - Volumetric data obtained in the job mix gradation selection (Sections 4.1.1 - 4.1.5) shall be reported. Include V_a , **VMA**, **VCA_{DRC}**, **VCA_{MIX}**, Gse, P_{ba} , P_{be} and $P_{0.075} / P_{be}$.
- 5.2 Optimum asphalt content - The recommended optimum asphalt content and also V_a , **VMA**, **VCA_{MIX}**, **Gse**, P_{ba} , P_{be} and $P_{0.075} / P_{be}$ shall be reported.

Appendices

The following is an example for calculating Gse, P_{ba} , P_{be} , $P_{0.075} / P_{be}$, VCA_{DRC}, V_a , VCA_{mix}, P_{bp} , VMA on a SMA-9.5.

Example:

Available Aggregate Gradations & G_{sb}

% Blend	77%	10%	13%	
	Agg 1	Agg 2	Agg 3	Blend
Sieve Size	8's	10's	M.Filler	
1/2	100.0	100.0	100.0	100.0
3/8	86.5	100.0	100.0	89.7
#4	15.9	96.5	100.0	35.7
#8	2.9	70.7	100.0	23.3
#16	1.4	46.2	100.0	19.7
#30	1.1	30.3	100.0	17.9
#50	1.0	19.7	94.2	16.0
#100	0.9	12.7	79.6	13.3
#200	0.8	9.9	53.0	9.4
G_{sb}	2.628	2.644	2.582	2.623
				AC = 7.5%
γ_s	Obtained from AASHTO T-19 = 99.6 lbs/ft ³			
γ_w	Unit Weight of Water = 62.4 lbs/ft ³			
$G_{mb} =$	2.318			
$G_{mm} =$	2.397			
$G_b =$	1.026			

For a SMA-9.5 the breakpoint sieve is the No. 8

Calculate $G_{se} = (100 - AC) / (100 / G_{mm} - AC / G_b) = (100 - 7.5) / (100 / 2.397 - 7.5 / 1.026)$
 $= 2.688$

$$P_{ba} = P_s * G_b * (G_{se} - G_{sb}) / (G_{se} * G_{sb}) = 92.5 * 1.026 * (2.688 - 2.623) / (2.688 * 2.623) = 0.87$$

$$P_{be} = AC - P_{ba} = 7.5 - 0.87 = 6.63$$

$$P_{0.075} / P_{be} = \% \text{ Pasing \#200} / P_{be} = 9.4 / 6.63 = 1.42 \text{ Range (1.2-2.0)}$$

Calculate VCA_{DRC} :

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

Where,

γ_s = unit weight of the coarse aggregate fraction (retained on and above the No. 8 sieve) in the dry rodded condition (lbs/ft³)

γ_w = unit weight of water

G_{ca} = combined bulk specific gravity of the coarse aggregate material retained on and above the No. 8 sieve

First Calculate the G_{ca} :

$$G_{ca} = \frac{100}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \frac{P_n}{G_n}}$$

Where,

P_t = Percent total (Always 100)

P_1 = Percent of Aggregate 1 used

P_2 = Percent of Aggregate 2 used

P_n = Percent of Aggregate n used when more than 2 aggregates are used.

G_1 = Specific Gravity of Aggregate 1

G_2 = Specific Gravity of Aggregate 2

G_n = Specific Gravity of Aggregate n

NOTE: The coarse aggregate does not represent 100 percent of the aggregate blend, for that reason a weighted average of the combined coarse aggregate specific gravity (G_{ca}) must be determined by the following calculations.

For this example, the 8's and 10's are considered coarse aggregate

Weighted Average:

8's = 77 percent of blend and 10's = 10 percent of blend

$$77 + 10 = 87$$

Total percent of coarse aggregate used in blend is 87%

Weighted Average of 8's (P_1): $(77 \div 87) \times 100 = 88.5\%$

Weighted Average of 10's (P_2): $(10 \div 87) \times 100 = 11.5\%$

Now, Calculate G_{ca} :

$$G_{ca} = \frac{100}{\frac{88.5}{2.628} + \frac{11.5}{2.644}}$$

$$G_{ca} = \frac{100}{33.676 + 4.349}$$

$$G_{ca} = \frac{100}{38.025}$$

$$G_{ca} = \mathbf{2.630}$$

Calculate VCA_{DRC} :

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

$$VCA_{DRC} = \left(\frac{2.630 \times 62.4 - 99.6}{2.630 \times 62.4} \right) \times 100$$

$$VCA_{DRC} = \left(\frac{64.51}{164.1} \right) \times 100$$

$$VCA_{DRC} = (0.3931) \times 100 = 39.3\%$$

Calculate Voids in Total Mix (V_a)

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

Where,

G_{mb} = bulk specific gravity of compacted specimens

G_{mm} = theoretical maximum specific gravity of mix

Example:

$$G_{mb} = 2.318$$

$$G_{mm} = 2.397$$

Calculate V_a :

$$V_a = 100x\left(1 - \left(\frac{2.318}{2.397}\right)\right)$$

$$V_a = 100x(1 - 0.967)$$

$$V_a = 100x0.033$$

$$V_a = 3.3\%$$

Calculate 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 material retained on and above the No. 8 sieve

P_{bp} = percent aggregate by total mixture weight retained on and above the No. 8 sieve

P_s = percent aggregate in the mixture expressed as a decimal

PA_{bp} = percent aggregate by total aggregate weight retained on and above the No. 8 sieve, expressed as a decimal

Example:

$$\begin{aligned}G_{mb} &= 2.318 \\G_{ca} &= 2.630 \\P_{bp} &= (P_s)(PA_{bp}) \times 100 \\P_s &= 100 - AC = 100 - 7.5 = 92.5\%, \text{ expressed as a decimal} = 0.925 \\PA_{bp} &= \% \text{ retained on and above the No. 8 sieve} = 100 \\&\text{minus \% passing No. 8 sieve} \\&\% \text{ retained} = 100 - 23.3 = 76.7\%, \\&\text{expressed as a decimal} = 0.767 \\P_{bp} &= (0.925)(0.767) \times 100 = 70.9\%\end{aligned}$$

Calculate VCA_{mix} :

$$VCA_{mix} = 100 - \left(\frac{2.318}{2.630} \times 70.9 \right)$$

$$VCA_{mix} = 100 - (0.881 \times 70.9)$$

$$VCA_{mix} = 100 - 62.5 = 37.5\% \text{ **}$$

** VCA_{mix} must be equal to or less than VCA_{DRC}

Calculate VMA :

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

Where,

$$\begin{aligned}G_{mb} &= \text{bulk specific gravity of compacted specimens} \\G_{sb} &= \text{combined bulk specific gravity of the complete aggregate blend} \\P_s &= \text{percent aggregate in the mixture}\end{aligned}$$

Example: $G_{mb} = 2.318$

$$P_s = 92.5$$

Calculate G_{sb} :

$$G_{sb} = \frac{100}{\frac{77}{2.628} + \frac{10}{2.644} + \frac{13}{2.582}} = 2.623$$

Calculate *VMA*:

$$VMA = 100 - \left(\left(\frac{2.318}{2.623} \right) \times 92.5 \right)$$

$$VMA = 100 - (0.8837 \times 92.5)$$

$$VMA = 100 - 81.7$$

$$VMA = 18.3$$

The following is an example for calculating *G_{se}*, *P_{ba}*, *P_{be}*, *P_{0.075} / P_{be}* *VCA_{DRC}*, *V_a*, *VCA_{mix}*, *P_{bp}*, and *VMA* on a **SMA-12.5**.

Example:

Available Aggregate Gradations & *G_{sb}*

% Blend	71%	10%	9%	10%	
	Agg 1	Agg 2	Agg 3	Agg 4	Blend
Sieve Size	78's	8's	10's	M.Filler	
3/4	100.0	100.0	100.0	100.0	100.0
1/2	90.6	98.3	100.0	100.0	93.2
3/8	59.9	81.4	100.0	100.0	69.7
#4	5.8	22.4	92.0	100.0	24.6
#8	2.3	4.6	53.2	100.0	16.9
#16	2.1	1.8	34.2	100.0	14.7
#30	2.0	1.2	23.3	100.0	13.6
#50	1.8	1.0	15.4	96.3	12.4
#100	1.6	.9	9.2	93.3	11.4
#200	1.5	.8	4.5	68.3	8.4
<i>G_{sb}</i>	2.960	2.975	2.919	2.780	2.939
					AC = 6.5%
<i>γ_s</i>	Obtained from AASHTO T-19 = 106.6 lbs/ft ³				
<i>γ_w</i>	Unit Weight of Water = 62.4 lbs/ft ³				
<i>G_{mb}</i> =	2.517				
<i>G_{mm}</i> =	2.638				
<i>G_b</i> =	1.026				

For a SMA-12.5 the breakpoint sieve is the No. 4

Calculate

$$G_{se} = (100 - AC) / (100 / G_{mm} - AC / G_b) = (100 - 6.5) / (100 / 2.638 - 6.5 / 1.026) = 2.961$$

$$P_{ba} = P_s * G_b * (G_{se} - G_{sb}) / (G_{se} * G_{sb}) = 93.5 * 1.026 * (2.961 - 2.939) / (2.961 * 2.939) = 0.25$$

$$P_{be} = AC - P_{ba} = 6.5 - 0.25 = 6.25$$

$$P_{0.075} / P_{be} = \% \text{ Pasing \#200} / P_{be} = 8.4 / 6.25 = 1.34 \text{ Range (1.2-2.0)}$$

Calculate

VCA_{DRC} :

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

Where,

- γ_s = unit weight of the coarse aggregate fraction (retained on and above the No. 4 sieve) in the dry rodded condition (lbs/ft³)
- γ_w = unit weight of water
- G_{ca} = combined bulk specific gravity of the material retained on and above the No. 4 sieve

First Calculate the G_{ca} :

$$G_{ca} = \frac{P_t}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \frac{P_n}{G_n}}$$

Where,

- P_t = Percent total (Always 100)
- P_1 = Percent of Aggregate 1 used
- P_2 = Percent of Aggregate 2 used
- P_n = Percent of Aggregate n used when more than 2 aggregates are used.
- G_1 = Specific Gravity of Aggregate 1
- G_2 = Specific Gravity of Aggregate 2
- G_n = Specific Gravity of Aggregate n

NOTE: The coarse aggregate does not represent 100 percent of the aggregate blend, for that reason a weighted average of the combined coarse aggregate specific gravity (G_{ca}) must be determined by the following calculations.

For this example, the 78's and 8's are considered coarse aggregate

Weighted Average:

78's = 71 percent of the blend and 8's = 10 percent of the blend

$$71 + 10 = 81$$

Total percent of coarse aggregate used in blend is 81%

Weighted Average of 78's (P₁): $(71 \div 81) \times 100 = 88.0\%$

Weighted Average of 8's (P₂): $(10 \div 81) \times 100 = 12.0\%$

Now, Calculate G_{ca} :

$$G_{ca} = \frac{100}{\frac{88.0}{2.960} + \frac{12.0}{2.975}}$$

$$G_{ca} = \frac{100}{29.730 + 4.034}$$

$$G_{ca} = \frac{100}{33.764}$$

$$G_{ca} = \mathbf{2.962}$$

Calculate VCA_{DRC} :

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

$$VCA_{DRC} = \left(\frac{2.962 \times 62.4 - 106.6}{2.962 \times 62.4} \right) \times 100$$

$$VCA_{DRC} = \left(\frac{78.23}{184.83} \right) \times 100$$

$$VCA_{DRC} = (0.4233) \times 100 = 42.3\%$$

Calculate Voids in Total Mix (V_a)

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

Where,

G_{mb} = bulk specific gravity of compacted specimens

G_{mm} = theoretical maximum specific gravity of mix

Example:

$$G_{mb} = 2.517$$

$$G_{mm} = 2.638$$

Calculate V_a :

$$V_a = 100 \times \left(1 - \left(\frac{2.517}{2.638} \right) \right)$$

$$V_a = 100 \times (1 - 0.954)$$

$$V_a = 100 \times 0.046$$

$$V_a = 4.6\%$$

Calculate VCA_{mix} :

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

Where,

G_{mb} = bulk specific gravity of compacted specimens

G_{ca} = combined bulk specific gravity of the material retained on and above the No. 4 sieve

P_{bp} = percent aggregate by total mixture weight retained on and above the No. 4 sieve

$$P_{bp} = (P_s)(PA_{bp}) \times 100$$

P_s = percent aggregate in the mixture expressed as a decimal

PA_{bp} = percent aggregate by total aggregate weight retained on the No. 4 sieve, expressed as a decimal

Where,

G_{mb} = bulk specific gravity of compacted specimens

G_{mm} = theoretical maximum specific gravity of mix

Example:

$$G_{mb} = 2.517$$

$$G_{mm} = 2.638$$

Calculate V_a :

$$V_a = 100 \times \left(1 - \left(\frac{2.517}{2.638} \right) \right)$$

$$V_a = 100 \times (1 - 0.954)$$

$$V_a = 100 \times 0.046$$

$$V_a = 4.6\%$$

Calculate VCA_{mix} :

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

Where,

G_{mb} = bulk specific gravity of compacted specimens

G_{ca} = combined bulk specific gravity of the material retained on and above the No. 4 sieve

P_{bp} = percent aggregate by total mixture weight retained on and above the No. 4 sieve

$$P_{bp} = (P_s)(PA_{bp}) \times 100$$

P_s = percent aggregate in the mixture expressed as a decimal

PA_{bp} = percent aggregate by total aggregate weight retained on the No. 4 sieve, expressed as a decimal

Example:

$$G_{mb} = 2.517$$

$$G_{ca} = 2.962$$

$$P_{bp} = (P_s)(PA_{bp}) \times 100$$

$$P_s = 100 - AC = 100 - 6.5 = 93.5\%,$$

expressed as a decimal = 0.935

$$PA_{bp} = \% \text{ retained on and above the No. 4 sieve} =$$

100 minus % passing No. 4 sieve
 % retained = 100 - 24.6 = 75.4%
 expressed as a decimal = 0.754

$$P_{bp} = (0.935)(0.754) \times 100 = 70.5\%$$

Calculate VCA_{mix} :

$$VCA_{mix} = 100 - \left(\frac{2.517}{2.962} \times 70.5 \right)$$

$$VCA_{mix} = 100 - (0.850 \times 70.5)$$

$$VCA_{mix} = 100 - 59.9 = 40.1\% \text{ **}$$

** VCA_{mix} must be equal to or less than VCA_{DRC}

Calculate VMA :

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

Where,

G_{mb} = Bulk specific gravity of compacted specimens

G_{sb} = Combined bulk specific gravity of the complete aggregate blend

P_s = Percent aggregate in the mixture

Example:

$$G_{mb} = 2.517$$

$$G_{sb} = 2.939 \text{ (See 6.1 for the method to compute this value)}$$

$$P_s = 93.5\%$$

Calculate *VMA*:

$$VMA = 100 - \left(\left(\frac{2.517}{2.939} \right) \times 93.5 \right)$$

$$VMA = 100 - (0.8564 \times 93.5)$$

$$VMA = 100 - 80.1$$

$$VMA = 19.9$$

The following is an example for calculating G_{se} , P_{ba} , P_{be} , $P_{0.075}$ / P_{be} , VCA_{DRC} , V_a , VCA_{mix} , P_{bp} , and *VMA* on a SMA-19.0.

Example:

Available Aggregate Gradations & G_{sb}

% Blend	60%	24%	16%	
	Agg 1	Agg 2	Agg 3	Blend
Sieve Size	57's	68's	M.Filler	
1	100.0	100.0		100.0
3/4	82.0	92.0	100.0	87.5
1/2	47.0	52.0	100.0	57.2
3/8	31.0	35.0	100.0	43.7
#4	6.0	6.0	100.0	22.0
#8	2.0	2.0	100.0	18.7
#16	1.5	1.5	99.0	18.1
#30	.8	.9	91.0	16.2
#50	.6	.8	87.0	15.5
#100	.5	.7	68.0	12.3
#200	.2	.5	45.0	8.3
G_{sb}	2.654	2.650	2.582	2.641
				AC = 6.5%
γ_s	Obtained from AASHTO T-19 = 97.4 lbs/ft ³			
γ_w	Unit Weight of Water = 62.4 lbs/ft ³			
G_{mb} =	2.356			
G_{mm} =	2.425			
G_b =	1.026			

For a SMA-19.0 the breakpoint sieve is the No. 4

Calculate $G_{se} = (100 - AC) / (100 / G_{mm} - AC / G_b) = (100 - 6.5) / (100 / 2.425 - 6.5 / 1.026) = 2.679$

$$P_{ba} = P_s * G_b * (G_{se} - G_{sb}) / (G_{se} * G_{sb}) = 93.5 * 1.026 * (2.679 - 2.641) / (2.679 * 2.641) = 0.51$$

$$P_{be} = AC - P_{ba} = 6.5 - 0.51 = 5.99$$

$$P_{0.075} / P_{be} = \% \text{ Pasing} \#200 / P_{be} = 8.3 / 5.99 = 1.39 \text{ Range}(1.2 - 2.0)$$

Calculate VCA_{DRC} :

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

Where,

γ_s = unit weight of the coarse aggregate fraction (retained on and above No. 4 sieve) in the dry rodded condition (lbs/ft³)

γ_w = unit weight of water

G_{ca} = combined bulk specific gravity of the material retained on and above No. 4 sieve

First Calculate the G_{ca} :

$$G_{ca} = \frac{P_t}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \frac{P_n}{G_n}}$$

Where,

P_t = Percent total (Always 100)

P_1 = Percent of Aggregate 1 used

P_2 = Percent of Aggregate 2 used

P_n = Percent of Aggregate n used when more than 2 aggregates are used.

G_1 = Specific Gravity of Aggregate 1

G_2 = Specific Gravity of Aggregate 2

G_n = Specific Gravity of Aggregate n

NOTE: The coarse aggregate does not represent 100 percent of the aggregate blend, for that reason a weighted average of the combined coarse aggregate specific gravity (G_{ca}) must be determined by the following calculations.

For this example, the 57's and 68's are considered coarse aggregate

Weighted Average:

57's = 60 percent of the blend and 68's = 24 percent of the blend

$$60 + 24 = 84$$

Total percent of coarse aggregate used in blend is 84%

Weighted Average of 57's (P₁): $(60 \div 84) \times 100 = 71.4\%$

Weighted Average of 68's (P₂): $(24 \div 84) \times 100 = 28.6\%$

Now, Calculate G_{ca} :

$$G_{ca} = \frac{100}{\frac{71.4}{2.654} + \frac{28.6}{2.650}}$$

$$G_{ca} = \frac{100}{26.903 + 10.792}$$

$$G_{ca} = \frac{100}{37.695}$$

$$G_{ca} = \mathbf{2.653}$$

Calculate VCA_{DRC} :

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

$$VCA_{DRC} = \left(\frac{2.653 \times 62.4 - 97.4}{2.653 \times 62.4} \right) \times 100$$

$$VCA_{DRC} = \left(\frac{68.15}{165.55} \right) \times 100$$

$$VCA_{DRC} = (0.4117) \times 100 = \mathbf{41.2\%}$$

Calculate Voids in Total Mix (V_a)

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

Where,

G_{mb} = bulk specific gravity of compacted specimens

G_{mm} = theoretical maximum specific gravity of mix

Example: $G_{mb} = 2.356$

$G_{mm} = 2.425$

Calculate V_a :

$$V_a = 100 \times \left(1 - \left(\frac{2.356}{2.425} \right) \right)$$

$$V_a = 100 \times (1 - 0.972)$$

$$V_a = 100 \times 0.028$$

$$V_a = 2.8\%$$

Calculate VCA_{mix} :

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

Where,

G_{mb} = bulk specific gravity of compacted specimens

G_{ca} = combined bulk specific gravity of the material retained on and above No. 4 sieve

P_{bp} = percent aggregate by total mixture weight retained on and above the No. 4 sieve breakpoint sieve

$P_{bp} = (P_s)(PA_{bp}) \times 100$

P_s = percent aggregate in the mixture expressed as a decimal

PA_{bp} = percent aggregate by total aggregate weight retained on the breakpoint sieve, expressed as a decimal

Example

$$\begin{aligned}G_{mb} &= 2.356 \\G_{ca} &= 2.653 \\P_{bp} &= (P_s)(PA_{bp}) \times 100 \\P_s &= 100 - AC = 100 - 6.5 = 93.5\%, \\&\text{expressed as a decimal} = 0.935 \\PA_{bp} &= \% \text{ retained on and above the No. 4 sieve} = 100 \\&\text{minus \% passing the No. 4 sieve} \\&\% \text{ retained} = 100 - 22.0 = 78.0\% \text{ expressed} \\&\text{as a decimal} = 0.78 \\P_{bp} &= (0.935)(0.78) \times 100 = 72.9\%\end{aligned}$$

Calculate VCA_{mix} :

$$VCA_{mix} = 100 - \left(\frac{2.356}{2.653} \times 72.9 \right)$$

$$VCA_{mix} = 100 - (0.888 \times 72.9)$$

$$VCA_{mix} = 100 - 64.7 = 35.3\% \text{ **}$$

** VCA_{mix} must be equal to or less than VCA_{DRC}

Calculate VMA :

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

Where,

G_{mb} = bulk specific gravity of compacted specimens

G_{sb} = combined bulk specific gravity of the complete aggregate blend

P_s = percent aggregate in the mixture

Example: $G_{mb} = 2.356$

$G_{sb} = 2.641$ (See 6.1 for the method to compute this value)

$P_s = 93.5\%$

Calculate VMA:

$$VMA = 100 - \left(\left(\frac{2.356}{2.641} \right) \times 93.5 \right)$$

$$VMA = 100 - (0.8921 \times 93.5)$$

$$VMA = 100 - 83.4$$

$$VMA = 16.6\% \text{ **Failed**}$$

****This blend failed to meet the minimum requirement for VMA at design. Consequently, an adjustment must be made to the blending percentages to increase the VMA of the mix.**

**Virginia Test Method
For
Determination of Asphalt Content
From Asphalt Paving Mixtures
By the Ignition Method
Designation: VTM-102
June 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 538°C (1000°F) 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 who ever 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 538°C (1000°F). 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

- 4.1.1 A forced air ignition furnace, capable of maintaining the temperature at 650°C (1200°F), with an internal balance thermally isolated from the furnace chamber accurate to 0.1 g. The balance shall be capable of weighing a 3,500 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 2.36 mm (No. 8) 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 125 ±5°C (257 ±9°F).
- 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 650°C (1200oF) 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 125°C ±5°C (257°F ±9°F) 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).

Table 1 Size of Sample

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	½ in.	1500
19.0	¾ in.	2000
25.0	1 in.	3000
37.5	1 ½ 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 538°C (1000°F). 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 482°C (900°F) 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 125°C (257°F) oven for 25 minutes. Do not preheat the sample basket(s).

6A.4 Preheat the ignition furnace to 538°C (1000°F) 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 125°C (257°F) oven for 25 minutes. Do not preheat the sample basket(s).
- 6B.4 Preheat the ignition furnace to 538°C (1000°F) 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 ± 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.
- 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 538°C (1000°F). 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.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).
- 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 ± 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 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 538°C (1000°F). 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	0.17	0.06

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.

