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Virginia Test Method – 1

Laboratory Determination of Theoretical Maximum Density Optimum Moisture Content of Soils, Granular Subbase, and Base Materials – (Soils Lab)

June 13, 2013

AASHTO T 99 Method A shall be followed, except as modified below:

12. Moisture-Density Relationship

Note 12a If there is 10% or greater material retained on the No. 4 (4.75 mm) sieve, use the following corrective procedure for determining the theoretical maximum dry density and optimum moisture content.

Material Containing Plus No. 4 (4.75 mm) Sieve Particles

AASHTO T 99 Method A procedure is applicable to soil that contains little or no material retained on the No. 4 (4.75 mm) sieve. Since the maximum density curve determined in the laboratory is obtained by utilizing only that material passing the No. 4 (4.75 mm) sieve, any appreciable amount of larger material contained in the embankment, which is being checked for compaction, will increase the apparent density, due to the higher specific gravity of the stone as compared to the bulk gravity of the compacted dry soil. At the same time, the optimum moisture content will be less, because some of the material passing the No. 4 (4.75 mm) sieve is replaced with coarser material (the void space is reduced and the total surface area is decreased).

(1) The theoretical maximum density, "D" of mixtures containing coarse aggregate larger than a No. 4 (4.75 mm) sieve will be determined by the formula:

$$D = \frac{D_f \times D_c}{P_c D_f + P_f D_c}$$

Where:

D_f = Maximum dry laboratory density of minus No. 4 (4.75 mm) material (by AASHTO Designation: T 99), in lb/ft^3 (kg/m^3)

D_c = Maximum density of Plus No. 4 material {62.4 lb/ft^3 (1000 kg/m^3) x bulk specific gravity by AASHTO Designation: T85 or as estimated by the engineer} in lb/ft^3 (kg/m^3).

P_c = Percent plus No. 4 material (4.75 mm), expressed as a decimal, and

P_f = Percent minus No. 4 material (4.75 mm), expressed as a decimal or by nomograph (Figure 1).

(2) The optimum moisture content for the total soil will be determined by the formula:

$$W_t = (P_c W_c + P_f W_f)100$$

Where:

W_t = Optimum moisture content for total soil,

W_c = Optimum moisture content, expressed as a decimal, for material retained on No. 4 sieve (4.75 mm) (estimated between 1% and 3%),

W_f = Optimum moisture content, expressed as a decimal, for material passing No. 4 (4.75 mm) sieve.

P_c = Percent, expressed as a decimal, of material retained on a No. 4 (4.75 mm) Sieve, and

P_f = Percent, expressed as a decimal, of material passing a No. 4 (4.75 mm) Sieve.

General Notes:

1. The density required in the work will be a variable percentage of the theoretical maximum density, "D", depending upon variations in the percentage of plus No. 4 (4.75 mm) material in the mixture and upon the position of the material in the work, and will be specified in the applicable section of the specifications.

2. The District Materials Engineer will inform the Inspector of the results of the compaction tests on the -4 (4.75 mm) material and the specific gravity of the +4 (4.75 mm) material. With this information, the Inspector can then prepare a chart showing the density of the total sample for varying percentages of the +4 (4.75 mm) material.

3. When performing this test on #10 tertiary screenings (stone dust), be guided by the unique recommendations for field compaction as stated in the Materials Division Manual of Instructions, Section 309.06.”

NOMOGRAPH FOR DETERMINING TOTAL DENSITIES OF SOILS

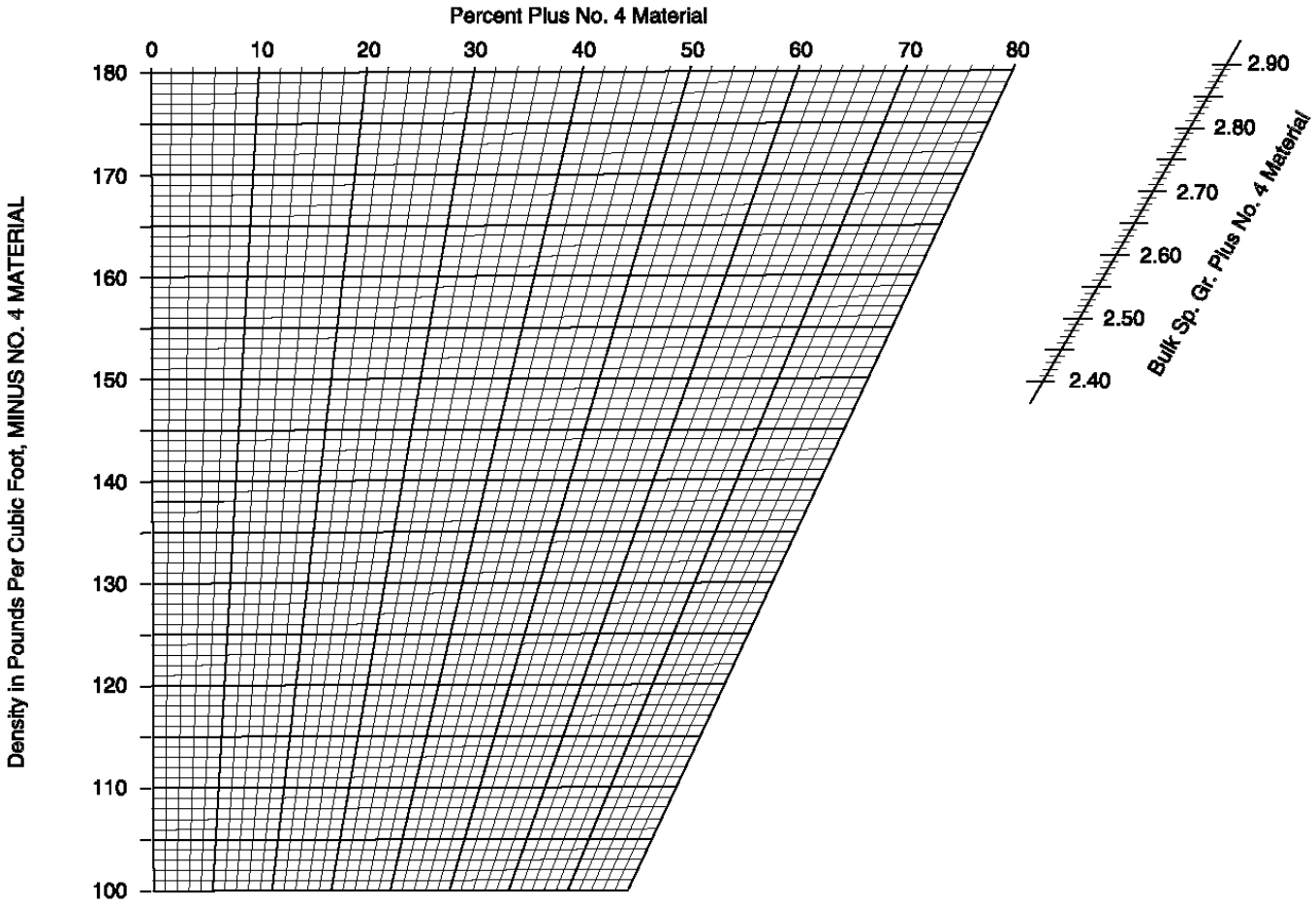


Figure 1

NOMOGRAPH FOR DETERMINING TOTAL DENSITIES OF SOILS

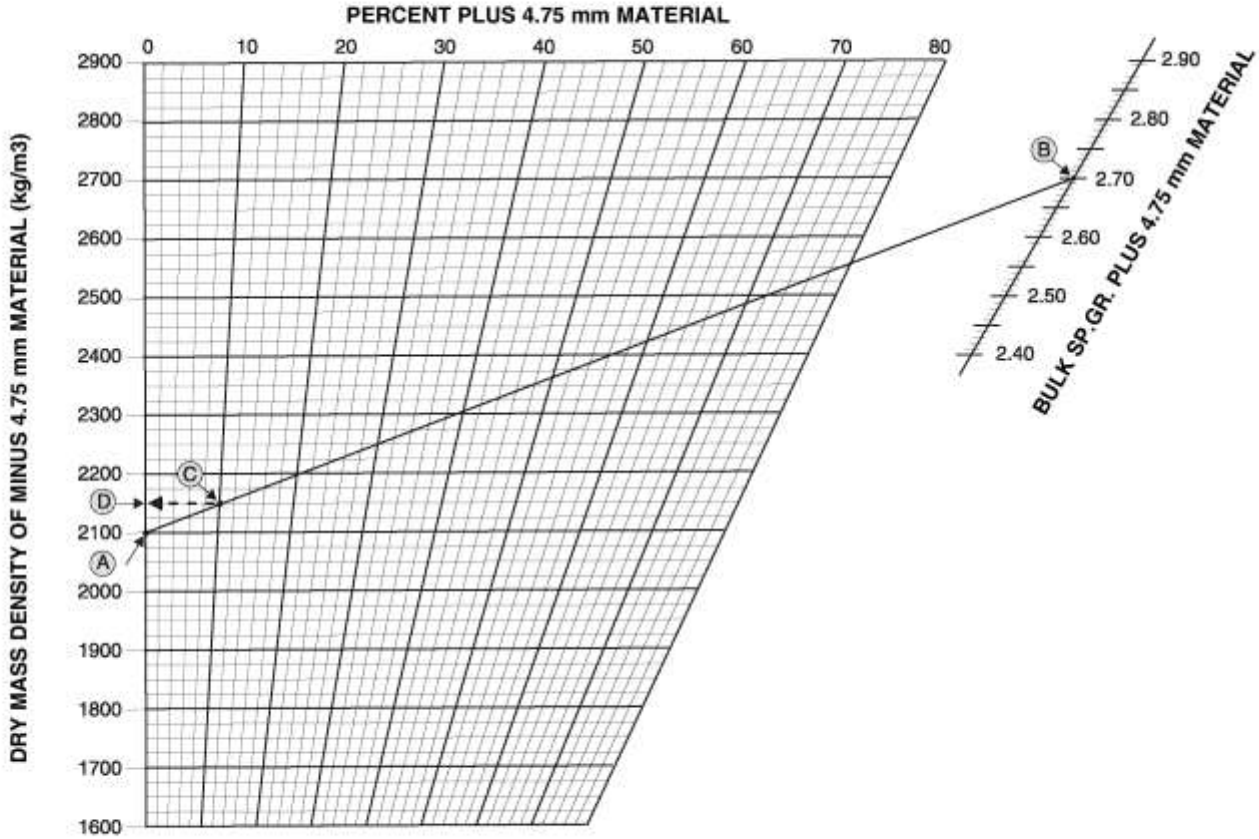


Figure 1

Virginia Test Method – 2

Water Retention by Concrete Curing Materials – (Physical Lab)

September, 2008

AASHTO T 155 shall be followed, except as modified below:

4. Apparatus

4.2 Molds - Molds shall be pie tins having the shape of the frustrum of a right cone approximately 5.8 in. (150 mm) in diameter at the top, approximately 5.3 in. (135 mm) in diameter at the bottom and 1.0 ± 0.05 in.(25 mm ± 1 mm) in depth, or other suitable containers of the same approximate dimensions.

4.7 Curing Cabinet - A cabinet for curing the specimen at a temperature of 100 ± 2º F (38° ± 2º C) and a relative humidity of 50 ±□10 percent.

5. Materials

5.1 Mortar shall be proportioned from hydraulic cement conforming to Section 214.

5.2 Fine aggregate conforming to Section 202 for Grading A of the Road and Bridge Specifications.

8. Proportioning and Mixing Mortar

8.1 Use 2600 grams of oven dry sand, 1,000 grams of Type II hydraulic cement, and approximately 400 grams of water. The flow of mortar used in the specimen shall be optional with the laboratory, but shall not exceed 40 when tested in accordance with AASHTO T 106, Section 9.

8.2 Premix the sand and cement at low speed for one minute. Add the water and mix for two minutes.

9. Preparing Specimens

9.2 The pie tins shall be filled in one layer, vibrated, and struck off with the top rim.

10. Surface Preparation and Edge Sealing

10.1 Remove the specimens from the cabinet immediately upon disappearance of the surface water (water loss will be between 0.6 and 0.8% of the weight of the mortar.) and lightly brush the surface with a stiff bristle paint brush using sufficient force to remove the laitance and glaze but not so as to scarify the mortar surface. If surface water appears upon brushing, return the specimen to the cabinet. After the surface water disappears, immediately remove the pan from the curing cabinet. Brush again.

10.2 Except when the curing medium being tested is a sheet material, form a V-shaped groove approximately 0.125 in.(3 mm) deep and not more than 0.0625 in.(1.5 mm) wide between the edge of the mortar specimen and the mold. Fill the groove with a suitable sealing compound that will not be affected by the curing material. The sealing compound shall

effectively seal against moisture loss between the boundary of the specimen and the mold, and shall not extend more than 0.25 in. (6 mm) from the mold onto the surface of the specimen.

12. Determination of Non-Volatile Content of Curing

12.1 Determine the loss in weight of volatile from a liquid membrane-forming curing compound by coating a metal pan or plate having an area equal to the top of the test specimen with the same quantity of curing material as used on the specimen. Place the pan or plate in the curing cabinet with the test specimen and weigh each time the specimen is weighed. Use the loss in weight of the liquid curing material as a correction in calculating the curing material added. The curing compound, when applied to a clean and dry tin panel at the rate specified in the determination of water loss, shall dry to touch in one hour and dry through in not more than 4 hours. When used in the field, it shall show drying properties satisfactory to the Engineer.

13. Duration of Test

13.1 The amount of water loss shall be determined at 24 hours and 72 hours after application of the curing material by weighing the Specimen. After the 72-hour weight determination, take the reflectance measurements.

14. Calculations

14.1 Use attached worksheet for calculations.
After the reflectance measurements and if failing moisture loss results are obtained, remove the cured mortar from the pans; check for adequate consolidation. If excessive voids are observed, discard the test data and repeat the test.

15. Report

15.2.7 At the end of 24 and 72 hour period, the loss of water from the mortar, based on the weight of the specimen and mold prior to the application of the curing material, shall be calculated with corrections allowed for the curing material added and volatile matter loss. All weights shall be in grams and the water loss reported in grams per square centimeter.

Worksheet for Liquid Concrete Curing Compound

LM _____
Date _____
Manufacturer _____
Plant Location _____
Consigned To _____

_____ White Pigmented
_____ Cure with Dye
Lot number _____
Quantity _____

Tin Data			
	Amount to be sprayed		g
	Tin Number		
A	Weight of tin before cure application		g
B	Weight of tin after cure application		g
C=B-A	Amount of cure applied		g
D	Weight of tin after 24 hrs.		g
E	Weight of tin after 72 hrs.		g
F=B-E	Volatile Loss		g
G=C-F	Weight of Solids		g

DryTime(Hours) _____
Color (Appearance) _____
Reflectance _____

Time in _____
Weigh Time at 24 hrs. _____
Weigh Time at 72 hrs. _____

	Pan Data		Pan #	Pan #	Pan #	Pan #	Average
H	Weight of Pan	⇨					
I	Weight of Pan, Mortar before pre-drying	⇨					
J	Weight of Pan, Mortar after pre-drying	⇨					
K	Weight of Pan, Mortar, Wax seal	⇨					
L	Weight of Pan, Mortar, Wax seal and Cure	⇨					
M=K+G	Weight of "K" Plus weight of Solids, "G"						
N	Weight of Pan after 24 hrs.	⇨					
O=M-N	Moisture Weight loss, 24 hrs (grams)						
P=O x 0.001/T	Moisture Weight loss, 24 hrs (kg/m^2)						
Q	Weight of Pan after 72 hrs.	⇨					
R=M-Q	Moisture Weight loss, 72 hrs (grams)						
S=R x 0.001/T	Moisture Weight loss, 72 hrs (kg/m^2)						

T (Area of Specimen = 0.01824 m^2

	Specific Gravity (W x 0.012)	
U	Weight of empty S.G. Cup	132.29
V	Weight of S.G. Cup and Cure	
W+V-U	Weight of Cure	

Virginia Test Method – 3

Preformed Elastomeric Joint Sealer, Tube Type
for Concrete Pavement and Bridge Decks – (Physical Lab)

November 1, 2000

This method of test for preformed joint seals shall be in accordance with ASTM D2628, with the following exceptions:

1. A minimum of 2 linear ft. (0.6 m) shall constitute one sample for test purposes.

2. The high temperature recovery test shall be performed on a piece 5 inches (127 mm) in length as received. (No talc dusted between surfaces). Adhesion of surfaces will be cause for rejection.

3. The ozone resistance test shall be performed on each specimen under 20 percent strain and ozone concentration of 100 parts per hundred million (pphm) in air for 300 hours.

<u>Virginia Test Method – 4</u>

Deleted - ***Determining Flat and Elongated Particles In Coarse Aggregate***

Test Method is obsolete due to SuperPave Implementation (See VTM –121)

.

Virginia Test Method – 5

Determining Percent Voids in Fine Aggregate – (Physical Lab)

November 1, 2000

1. Scope

This method covers the procedure to be used in determining the average percent voids present in fine aggregate and is, therefore, a method for controlling particle shape.

2. Apparatus

The apparatus required shall consist of the following:

a. Standard set of fine aggregate sieves containing a No. 8, No. 16, No. 30, and No. 50 (2.36 mm, 1.18 mm, 0.600 mm, and 0.300 mm) sieve.

b. Set of balances.

c. Metal cylindrical cup calibrated for weight and volume, and having approximately a height of 5.5 in.(140 mm) and a diameter of 2 in (50 mm).

d. A metal frame with a base 6 in. (150 mm) square and a height of 10.75 in. (270 mm), with an opening in the top capable of supporting a funnel which, when suspended, will have its base one inch (25 mm) above the cup when the cup is placed on the base. The bottom opening of the funnel will have a diameter of one inch (25 mm). The base will be fitted with lugs that are so placed that they will center the cup directly below the funnel.

e. Small glass plate approximately 2 in. (50 mm) square.

f. Steel straight edge approximately 12 in. (300 mm) long

3. Procedure

The sample is sieved until ample material of the No. 16, No. 30 and No. 50 (1.18 mm, 0.600 mm, and 0.300 mm) sizes is present to fill the cup to overflowing. This will usually require at least 3 sievings.

Each size is introduced separately into the funnel of the apparatus, with the glass plate being held firmly against the bottom of the funnel. When the funnel is full, the glass plate is withdrawn and the material allowed to flow freely into the cup.

The cup is then struck off with the straightedge being careful not to jar the container and thus pack the material.

Three (3) separate weighings of each size are made and the average weight determined.

The specific gravity of the material, determined previously according to AASHTO T-84,is multiplied by the volume of the cup to obtain a theoretical solid weight.

Theoretical wt. of sand = Sp. Gr. x Vol. of Cont.

This computed value is compared to the weight obtained by weighing the material and the percentage is the percent solids present. This is subtracted from 100 to obtain the percent voids.

$$\% \text{ Voids} = \frac{\text{No. 16 (1.18 mm) Theo. Wt. - Act. Wt. x 100}}{\text{Theo. Wt.}}$$

The sum of the percent voids obtained from the 3 sizes is averaged and reported as the percent voids of the total sample.

$$\% \text{ Voids (Total Sample)} = \frac{\text{Total Voids}}{3}$$

Virginia Test Method – 6

Field Determination of Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface Dry Specimens

October 1, 2008

1. Scope

1.1 This method of test covers the field determination of bulk specific gravity of compacted asphalt mixtures.

1.2 The bulk specific gravity of the compacted asphalt mixtures may be used in calculating the unit of mass of the mixture.

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

ASTM D 7227 Standard Practice for Rapid Drying of Compacted Asphalt Specimens Using Vacuum Drying Apparatus

3. Test Specimens

3.1 Test specimens are from any course of asphalt pavements.

3.2 Size of specimen shall be as specified in VTM-22.

4. Apparatus

4.1 Balance: A 2000 gram balance with an accuracy of 1.0 gram. The balance shall be equipped with suitable suspension apparatus and holder to permit weighing the specimen while suspended from the center of scale pan of balance. (Note 1).

NOTE 1: The holder shall be immersed in water to a depth sufficient to cover it and the test sample during weighing. Wire suspending the holder should be the smallest practical size to minimize any possible effects of a variable immersed length.

4.2 Water Bath: For immersing the specimen in water while suspended under the balance.

4.3 Water used in water bath shall meet the requirements for water used with cement or lime in the Road and Bridge Specifications.

5. Procedure

5.1 Mass of dry specimen in air [Notes 2,3, & 4] - Weigh the specimen in air. Designate this mass as "A".

5.2 Mass of specimen in water - Immerse the specimen in water bath for a minimum one minute and determine the weight. Designate this mass as "C".

5.3 Mass of saturated surface dry specimen in air - Surface dry the specimen by blotting all sides quickly with a damp towel and then weigh in air. Designate this mass as "B".

NOTE 2: Specimens removed by a process that does not use water will require no further drying.

NOTE 3: Samples saturated with water initially either from wet coring or other source of water shall be dried to a constant mass until further drying does not alter the mass more than 0.1 percent.

Specimens shall be either dried overnight at 125 ± 5°F (52 ± 3°C) and then weighed at two-hour intervals, or vacuum-dried in accordance with ASTM D 7227, until constant mass is obtained.

NOTE 4: If desired, the sequence of testing operations may be changed to expedite the test results. For example, first the immersed mass (C) can be taken, then the surface dry mass (B), and finally the dry mass (A).

When the sequence of testing operations is changed, the method outlined in Note 3 shall be used to determine the Dry Mass of the Specimen in Air (A) once the specimen has cooled to room temperature.

6. Calculation

6.1 Calculate the bulk specific gravity of the specimen as follows: (Report the value up to two decimal places.)

$$\text{Bulk Specific Gravity} = \frac{A}{B-C}$$

Where:

A = mass, in grams, of sample in air.
B = mass, in grams, of surface dry specimen in air.
C = mass, in grams, of sample of water.

Virginia Test Method – 7

Atterberg Limits – (Soils Lab)

November 1, 2004

Except as modified below, the method of test for the liquid limit shall be in accordance with AASHTO T 89 Method B for routine testing and Method A for referee testing:

3. Apparatus

3.7 Balance – a balance sensitive to 0.1 gram may be used.

The method of test for the plastic limit and plasticity index shall be in accordance with AASHTO T 90 with the following exceptions:

3. Apparatus

3.7 Balance – a balance sensitive to 0.1 gram may be used.

Virginia Test Method – 8

Conducting California Bearing Ratio Test – (Soils Lab)

September 6, 2013

AASHTO T 193 shall be followed, except as modified below:

1. Scope

This test method provides for the determination of the CBR of a material at optimum water content and maximum dry density determined according to VTM-1.

Delete

2. Referenced Documents

Test Procedure	VTM	AASHTO
Gradation	VTM-25	AASHTO T 87, T 27
Atterberg Limits	VTM-7	AASHTO T 89, T 90
Moisture Density Relation	VTM-1	AASHTO T 99, T 180
Specific Gravity of Course Aggregate	No Modifications	AASHTO T 85
Moisture Content of Soils	No Modifications	AASHTO T 265

5. Sample

This sample shall be handled and specimens for compaction shall be prepared in accordance with the procedures given in VTM-1, except as follows:

5.1.2 From a sample having a mass of 25 lb or more, select a representative portion having a mass of approximately 7 lb for a moisture-density test and retain the remainder of the sample for CBR testing.

5.1.3 Delete

6. Moisture-Density Relation

Using the 7 lb portion prepared as described in Section 5.1, determine the optimum water content and maximum dry density in accordance with VTM-1.

Delete

6.2.1 Delete

7. Procedure

7.1.1 Delete

7.1.3 Obtain a representative portion having a mass of approximately 15 lb from the retained portion of the sample in section 5.1.2 and mix with sufficient water to obtain a moisture content within ±2.0 percentage points of the optimum water content determined in Section 6.1.

7.1.4 Prepare one CBR specimen. Compact the portion of soil-water into the mold, using three equal layers and appropriate rammer to give a total compacted depth of about 5 inches, compact each layer with an adequate number of blows in order to give a compacted density within ± 2.5 percent of the maximum theoretical dry density determined in Section 6.1.

7.1.7 Delete

7.2 Delete

7.2.1 Delete

8.0 Soaking

8.1 Unless specifically requested by the Engineer no additional surcharge weights shall be added to the sample in excess of the minimum specified. Place the swell plate with adjustable stem on the soil sample in the mold and apply sufficient annular weights to produce an intensity of loading equal to 10 lb. Additional mass, when requested, shall be added in increments of 5 lb.

10. Calculations

10.2.1 Replace with the following: The CBR is selected at 0.10 in. penetration.

10.3 Delete

10.4 Delete

11. Report

11.1.1 Delete

11.1.5 Replace with the following: California Bearing Ratio, percent. Include also the original uncorrected penetration-resistance curve, with corrections drawn on the curve.

Virginia Test Method – 9

Deleted - (See AASHTO T 216-83)

Virginia Test Method – 10

Determining Percent of Moisture and Density of Soils, Aggregate, and Full-Depth Reclamation Courses, and Density of Cold In-Place Recycling and Cold Plant Recycling (Nuclear Method) - (Soils Lab)

June 25, 2013

AASHTO T 310 shall be followed, except as modified below:

3. Scope

This test method covers the procedure to be used in determining the percent of moisture and density of embankment, base, subbase, subgrade, backfill, and Full-Depth Reclamation (FDR) courses, and the percent density of Cold In-Place Recycling (CIR) and Cold Plant Recycling (CPR).

4. Apparatus

The apparatus required shall consist of the following:

A. Portable Nuclear Moisture-Density Gauge (nuclear gauge or gauge)
B. Transport case (blue)
C. Charger
D. Reference Standard Block
E. Transport Documents (Bill of Lading)
F. Leveling Plate / Drive Pin Guide
G. Drive Pin w/ extraction tool
H. 4 lb Hammer used for Driving the Pin
I. Safety Glasses
J. Square-Point Shovel
K. No. 4 (4.75 mm) sieve
L. Set Balance Scales
M. Drying Apparatus
N. Miscellaneous Tools such as Mixing Pans and Spoons

5. Direct Transmission and Backscatter Procedures

There are two (2) different methods to determine percent density and percent moisture using the nuclear gauge. The methods are the direct transmission and backscatter.

The direct transmission method requires punching a hole into the surface of the material being tested and lowering the source rod to the desired depth of test. This method is used to test natural soil materials, aggregate backfill, FDR, CIR, and CPR courses, and as verification testing for aggregate base and subbase as it is more representative over the compacted layer than the backscatter method. It is also used as acceptance testing for those projects not having a sufficient quantity of aggregate base and/or subbase to run a roller pattern and control strip.

In the backscatter method the source rod is lowered to the first notch below the safe position placing the source and detectors in the same horizontal plane. No hole is required for the probe since it is flush with the bottom of the gauge. This method is used to test aggregate (subbase and base course) and asphalt materials. When testing soils, the backscatter position **shall not** be used as a means of acceptance for density.

6. Moisture-Density Determination for Embankment, Subgrade, and Backfill (Direct Transmission Method)

All nuclear gauge density tests on embankment, subgrade, backfill, FDR, CIR, and CPR courses using the nuclear gauge shall be tested using the Direct Transmission Method. This is because embankment, subgrade, and structure backfill (except aggregate pipe backfill) are typically comprised of natural soils that can be readily tested by Direct Transmission, and Full-Depth Reclamation courses are treated similarly. The method is as follows:

1. Establish an area at least ten feet from any structure and 33 ft. from other radioactive sources (another gauge) to take standard counts. This area can be concrete, asphalt, or a well compacted soil with a minimum dry density of 100 lb/ft^3. Do not use truck beds, tailgates, tabletops, etc. When using the nuclear gauge, turn it on and wait for it to perform its self-test. When it is completed the gauge will enter the "Ready" mode. At this time, standard counts can be taken and recorded.

   Note: A standard count will be taken each day of use. If counts fail, refer to the gauge's Manual of Operations and Instructions for further instructions or call your VDOT District Materials Section for assistance.

2. Level off an area of the embankment or subgrade on which to place the gauge using the leveling plate furnished with the gauge. The surface of this area should be as smooth as possible to obtain an accurate test. Care should be taken not to additionally compact the surface during its preparation.

3. Place the guide plate on the surface. Make a hole in the material with the driving pin provided, using the guide plate to be sure the hole is straight and vertical. The hole should extend approximately two (2) inches deeper than the desired test depth.

4. Extend the source rod just enough to place it in the hole in order to avoid soil disturbance around the hole. Then, after the minimal initial insertion, extend the rod to the desired depth of test making sure the device is sitting flush on the surface and the rod is pulled back tight against the backside of the hole. Take a one-minute count in this position.

5. The test is complete and the results are recorded on Form TL-124A.

If the material tested is represented by a predetermined Proctor Test (VTM-1 or VTM-12, which give the theoretical maximum density), the **dry** density (corrected for +4 oversize material when necessary) should be entered into the gauge prior to testing. This allows the gauge to calculate the percent of compaction.

When it is apparent that the material being placed is different from the material that is specified, due to noticeable changes in color, texture, rock size, etc., another Proctor Test may need to be made on the new material.

In the event the material contains appreciable amounts retained on the No. 4 sieve (greater than 10%, per VTM-1), the Proctor Test Density used shall be the corrected density. This corrected density is typically already furnished by the testing laboratory, but the gauge operator must ensure the corrected density is being used. (Not doing so is one of the most common errors made when testing field density.)

If the material being placed is determined to be "rock fill" an entry must be recorded on the TL-124A form, showing location and elevation of rock.

Direct Transmission testing of aggregate will be required in rare instances when the embankment, subgrade, or backfill material (except pipe backfill which is always aggregate to the springline and in some cases above that) is comprised not of natural soil but of a dense-graded aggregate, such as 21A or B or a dense-graded aggregate select material. Dry density of aggregate material shall always be compared to the theoretical maximum dry density as determined by VTM-1 or VTM-12. When Direct Transmission testing is performed on these occasions, because of the difficulty of driving the pin through dense-graded aggregate and the disturbance of the hole it causes, the density shall conform to the following requirements in Table I, which are reduced by 5% from the requirements for aggregate that may be tested by other means of less disturbance. These reduced densities in Table I also apply to natural soil embankment, subgrade, and backfill with greater than 50% retained on the No. 4 sieve.

Table I -
Reduced Density Requirements for Direct Transmission Testing of Aggregate

% Retained on No. 4 (4.75 mm) Sieve*	Minimum % Dry Density
0 – 50	95
51 – 60	90
61 – 70	85

*Percentages of material shall be reported to the nearest whole number.

5. Moisture-Density Determination for Aggregate Base and Subbase (Backscatter Method)

Aggregate base and subbase are tested by means of a roller pattern, control strip, and test sections. The backscatter method is used with the nuclear gauge when testing aggregate base and subbase courses and asphalt, because of the difficulty of driving a pin through these materials. (However, a direct transmission test on aggregate base and subbase courses is made to verify densities as described in Note 1 in Paragraph B below.)

The Roller Pattern is performed first. The purpose is to determine the number of passes to be made by the roller in various combinations of static and/or vibratory rolls to achieve the maximum density for that depth of material using that roller. The data collected from the gauge is entered on the TL-53A form. Properly plotted, this will provide a graphical comparison of the number of roller passes necessary to produce a properly compacted product. Once completed this information is used to establish a Control Strip(s).

The Control Strip determines the target values for density that will define the acceptance criteria for the material placed and compacted using the previous*ly* determined roller pattern. The values determined by the control strip will not change until a new roller pattern is

required. The data collected is to be entered on the TL-54A form. The Control Strip provides an accurate method of evaluating materials, which are relatively uniform and exhibit smooth surfaces.

A. Roller Pattern

The Roller Pattern is constructed on the same material being placed and once established, will be used for the remainder of the project. The Roller Pattern is 75 ft in length plus some additional area to accommodate the lateral positioning of the roller. The width and depth of the material depends on the project design.

Listed below are the steps used to construct a Roller Pattern:

1. Establish an area at least ten feet from any structure and 33 ft. from other radioactive sources (another gauge) to take standard counts. This area can be concrete, asphalt, or a well compacted soil with a minimum dry density of 100 lb/ft^3. Do not use truck beds, tailgates, tabletops, etc. When using the nuclear gauge, turn it on and wait for it to perform its self-test. When it is completed the gauge will enter the "Ready" mode. At this time, standard counts can be taken and recorded.

   Note: A standard count will be taken each day of use. If counts fail, refer to the gauge's Manual of Operations and Instructions for further instructions or call your VDOT district materials section for assistance.

2. To prepare a Roller Pattern, place the material on a section of roadway approximately 75 ft. in length for the typical application width (an area of at least 100 yd^2), and at the proper loose depth before any rolling is started. (The Contractor should be allowed to place 100 ft. of material prior to the 75 ft. section for plant mix stabilization, adjustment, and compaction purposes, with testing to be conducted at the completion of the roller pattern.) The compaction is to be completed uniformly and in the same manner for the remainder of the job. (It is also recommended that a 50 ft. section be placed before and after the roller pattern section for positioning of the roller.)

   The moisture content of aggregates should be kept as near optimum as possible throughout the rolling operation. Water must be added when needed to maintain optimum moisture in accordance with Section 308 and 309 of the Road and Bridge Specifications during the compaction process.

   To speed up operations, select 15-second mode on the read-out panel and record the density and moisture readings. When testing the control strip and test section, select the 60-second mode for acceptance.

3. Make two (2) passes (one (1) pass is counted each time the roller crosses the test site) with the roller over the entire surface of the Roller Pattern. Make sure the previous passes have been completed over the entire surface before the next pass is started. The above test on aggregates shall be made at three randomly selected points within the area to be tested. Choose points with good surface conditions and try to spread the three tests over most of the 75 ft. section, making sure not to place the gauge closer than 18 in. to an <u>unsupported</u> edge. Be sure to mark the exact location where the gauge is placed. (If using spray paint to mark the locations, do not spray the gauge with paint.) The gauge, when in use, shall always be positioned parallel with the roadway, with the source end toward the direction of the paver. Record these

results on the Roller Pattern Form TL-53A and obtain the total and average for both moisture and density.

All further tests for the Roller Pattern must be made in the same three locations, with the gauge source rod pointing in the same direction as the first test. Plot the average dry density versus the number of roller passes on the graph.

4. Make additional passes with the roller over the entire surface of the Roller Pattern, and again obtain and record the three readings for density and moisture in the same location as the previous set of readings. Calculate the average from the readings and record them on the Form TL-53A. Continue the rolling and testing of the section until the Roller Pattern reaches its maximum density before decreasing or the curve levels off. To be certain this is a sufficient degree of compaction, make one additional roll over the entire surface and test again.

Note 1: The number of passes that are indicated do not necessarily have to be set at two (2) each time. It may be found that in some instances one (1) pass would be sufficient between readings, and, in other instances, three (3) or four (4) passes would be required. An accurate count of the required passes should be maintained and may vary, depending on subgrade conditions, roller efficiency, type of materials and moisture content.

Note 2: Regarding determination of Maximum Attainable Density with Roller Pattern/Control Strip Technique:

The Control Strip shall be rolled until maximum dry density for granular materials is obtained. Materials compacted to maximum density provide a solid platform on which to construct pavement. Materials at maximum density increase pavement load carrying capacity and pavement life; opportunities for future pavement distress will be greatly decreased if maximum density is achieved. These guidelines should be considered good construction practice, not as an addition to the VDOT Road and Bridge Specifications.

In brief, the change in density in a typical Roller Pattern, for example, on Aggregate Base Material, Type I, Size 21B, may look as shown below in Table II below:

Table II -
Example Roller Pattern Density Readings

Number of Passes	Change in Density, lb/ft^3
4	+3.1
6	+2.1
8	+2.3
10	+0.9
11	+0.4

It can be seen from the above that continued rolling after ten (10) passes resulted in diminishing returns. This is typical for many Roller Patterns. Based on an analysis

of this type, the following is recommended as a guideline for granular materials: In the event that the increase in dry density for a Roller Pattern on granular material is less than 1 lb/ft^3, one (1) additional pass shall be required.

Occasionally, there will be instances where a decrease in density rather than a small increase will occur. This usually occurs for two (2) reasons: a false break, where the density levels off well before maximum density is achieved, and over rolling. In this case, consideration should be given to the number of passes already made and the materials involved, making certain that the break occurring in the Roller Pattern curve is not greater than 1.5 lb/ft^3. When the break is greater than the above value, re-compact the material to the maximum dry density based on the peak of the roller pattern.

A new roller pattern should be established whenever there are multiple lifts of material or there is a change in the following:

Source of material

Compaction equipment

Visual change in subsurface conditions

Gradation or type of material

Portable Nuclear Density Gauge: When this occurs, only another Control Strip is to be performed.

Test section readings are significantly above the target values by more than 8 lb/ft^3. When this occurs review the items in this list. Ask the roller operator if they are doing anything other than the number of passes that was established in the roller pattern. If these things do not produce the reason, then perform another Control Strip.

B. Control Strip

1. To prepare a Control Strip, an additional 300 ft. of roadway is required extending from Roller Pattern area (same spreaderbox width at the same design depth). This area is to be rolled the same number of passes from the Roller Pattern.

2. In order to determine the maximum dry density of the Control Strip, ten (10) readings for density and moisture should be performed and recorded over the entire 300 ft. section. Calculate and enter the data on the TL-54A Form. The Target Values of 98% and 95% of the average dry density can now be determined. The dry density determined from the average of the Control Strip densities should compare within 3 lb/ft^3 of the roller pattern's maximum dry density.

Note 1: Upon completion of the control strip, perform a direct transmission test to verify that compaction has been obtained comparing the result to the theoretical maximum dry density obtained by VTM-1 or VTM-12. Refer to Table I above for the minimum percent dry density required.

C. Test Sections

1. To complete a test section, five (5) readings are required. Each test section for aggregate base, subbase, and select materials will be one-half (1/2) mile in length per application width. The length of test sections for shoulders will be the same as the mainline. If possible, test alternating sides. Five (5) readings will be made on each test section for dry density and moisture for aggregate courses using the same method of test used on the Roller Pattern and Control Strip. Rolling is continued until none of the five (5) readings is less than 95% of the Control Strip density, and the average of the five (5) readings is equal to or greater than 98% of the Control Strip density. This does not apply to aggregate shoulder material, which requires an average density of 95 ± 2 percentage points of the control density, with individual densities within 95 ± 5 percentage points of the control density. No other test will be required, unless specified by the Engineer. When test section readings are significantly above or below the target values by more than 8 lb/ft^3 another Control Strip will be established.

2. When testing turn lanes, acceleration lanes, deceleration lanes, and crossovers, take two (2) or three (3) readings on each, whichever is needed, to complete the full test section.

   Note: For sections of roadway less than 900 ft., the direct transmission method or other approved testing methods for density determinations may be used.

   If obvious signs of distress are observed while rolling, cease rolling and evaluate the area of distress. Such signs include cracking, shoving, etc. Structural failures of the aggregate will cause the gauge to give an erroneous reading indicating more compaction is needed, when actually over-compaction is causing the failure. If this situation occurs, it should be brought to the attention of the VDOT district materials section for an evaluation.

6. Moisture-Density Determination for FDR, CIR, and CPR Courses (Direct Transmission Method)

FDR, CIR, and CPR courses require roller pattern and control strip determinations in the same manner as for aggregate base and subbase courses (Section 5 above), except that:

Density test locations shall be marked and labeled by the Contractor in accordance with the requirements of VTM-76.

The roller pattern and control strip shall not be used for density acceptance. These courses require density acceptance based on the maximum density from the approved mix design. Hence Part "C. Test Sections" of Section 5 above does not apply.

Where Section 5 requires backscatter method, direct transmission method shall be used for FDR, CIR, and CPR courses.

Where Section 5 refers to dry density, these courses require the recording of wet density. (Moisture content is determined from laboratory moisture tests, and the dry density obtained. However, in order to facilitate quicker dry density determinations, at the discretion of the District Materials Engineer on a project basis, a water content correction factor based on previous gauge readings or laboratory tests may be used.)

Where Section 5 refers to Standard Proctor tests (VTM-1 or VTM-12 or AASHTO T 99), these courses require use of the Modified Proctor test (AASHTO T 180).

For FDR, CIR, and CPR courses, the same guidelines as for granular materials should be used in Section 5 above, with the exception that after the increase becomes less than 0.5 lb/ft3 per pass, one (1) additional pass shall be required. If the density does not increase by 1.0 lb/ft3 with the additional pass, rolling should be discontinued.

7. Moisture and Trench Wall Offsets

1. Moisture Offsets

Moisture in certain soil properties containing high amounts of hydrogen rich compounds, such as ash, mica, organics, cement, boron and cadmium, will give inaccurate readings and as a result a moisture offset should be performed. The moisture offset should be a minus for ash, mica, organics and cement and a plus for boron and cadmium. See Page 5-4 in Troxler's Manual of Operation and Instruction for the 3440 Series gauge.

Other methods of determining moisture are the use of the Speedy Moisture Tester or the hotplate method.

2. Trench Wall Offsets

When a 3440 Nuclear Moisture-Density Gauge is operated within 24 in. of a vertical structure, the density and moisture counts will be influenced by the structure.

Due to the moisture present in trench walls on occasion, a higher moisture reading will be observed when testing backfill materials around pipe, culverts, abutments, etc. It is necessary, therefore, to determine the "background" effect and apply this correction to the observed moisture count readings. The background correction count should be determined each day of testing and when trench wall conditions (distance from wall, moisture content, material composition, etc.) vary. See Page 5.8 in Troxler's Manual of Operation and Instruction for the 3440 Series gauge.

The procedure to determine the background effect and apply the necessary correction is as follows:

1. Take a standard count with the gauge on the standard block outside the trench and record these values.
2. Place the gauge on the standard block inside the trench in the testing area and select trench offset. The density and moisture trench offset constants will be calculated and stored. When the gauge is not being used for trench measurements, disable the offset.

Virginia Test Method – 11

Lime Stabilization – (Soils Lab)

November 1, 2000

1. Scope

This method covers the procedure to be used to determine the percentage of lime to stabilize soils.

2. Apparatus

a. 1/30 ft^3 (0.000943 m^3) molds.

b. 5.5 lb (2.5 kg). rammer.

c. Balance capacity 20,000 grams accuracy 1 gram.

d. Straightedge, graduated cylinders, trowel and miscellaneous tools to mix sample, or a suitable mechanical device for thoroughly mixing the sample of soil with increments of water.

e. Drying oven controlled to maintain a temperature of 120 ± 4° F (49 ± 2° C).

f. Containers, such as gallon cans, with lids, and small cups approximately 2 in. (51 mm) in height and 3 in. (76 mm) in diameter.

3. Procedure

a. The sample is air-dried at a temperature not over 140° F (60° C).

b. It is then split and a portion of this is used to run all routine tests; such as, mechanical analysis (VTM-25), liquid limits (VTM-7) and compaction tests (VTM-1).

c. When performing the compaction test, add 6% of hydrated lime to the soil. This is necessary as lime affects the optimum moisture and maximum density of lime stabilized soil.

d. The remainder of the soil is screened over a No. 4 (4.75 mm) sieve and stored in cans with air-tight lids to control the percent of moisture.

e. From this material, compact 2 molds of soil and lime for each percent of lime. Usually 5% and 7% by weight is used, but this can be varied.

f. These molds are then sealed in gallon (3.8 L) cans with water in the bottom of the cans for humidity. The molds are placed on small cups to be above the water. They are cured in the oven at 120° F (60° C) for 3 days. After curing, they are removed from the cans, air-cooled for one hour and then weighed. They are then tested for unconfined compressive strength. The rate of loading is 2400 pounds (10.7 kN) per minute.

g. If the effects of lime on the Atterberg Limits is wanted, break down the molds used in the compression tests and re-test these to compare them to the raw soil tests. This is not done on all samples.

Virginia Test Method – 12

Use of One-Point Proctor Density_– (Soils Lab)

February 24, 2012

AASHTO T 272 (Method A) shall be followed, except as modified below:

4. Apparatus

Add the following to Section 4.1:

a. Drying apparatus (MARTCP SA 1.3) or "Speedy" moisture tester (AASHTO T217).

6. Procedure

6.3 Take a sample for moisture content determination by field stove method in accordance with MARTCP method SA 1.3. Use "Speedy" moisture tester, if available, except for heavy clays, in which case the field stove should be used. "Speedy" Tester shall be performed in accordance with AASHTO T 217, or the manufacturer's directions labeled on the instrument. Record the moisture content.

14. Maximum Density and Optimum Moisture Content Determination

14.1 Results for wet density of the soil in pounds per cubic foot and moisture content shall be plotted on Typical Moisture Density Curves Set "C" (Figure 1).

A. Correction for +No. 4 (4.75 mm) in the sample, if there is 10% or greater material retained on the No. 4 (4.75 mm) sieve.

The correction to be used for the +No. 4 (4.75 mm) material is determined by the following procedures:

(1) Record the percent of +No. 4 (4.75 mm) material from density hole.

(2) The theoretical maximum density, "D" of mixtures containing coarse aggregate larger than a No. 4 (4.75 mm) sieve will be determined by the formula:

Where: $$D = \frac{D_f \, x D_c}{P_c D_f + P_f D_c}$$

$D_f =$ Maximum dry laboratory density of minus No. 4 (4.75 mm)material (by AASHTO Designation: T 99), in lb/ft^3 (kg/m^3)

$D_c =$ Maximum density of Plus No. 4 material {62.4 lb/ft^3 (1000 kg/m^3) x bulk specific gravity by AASHTO Designation: T85 or as estimated by the engineer} in lb/ft^3 (kg/m^3).

$P_c =$ Percent plus No. 4 (4.75 mm) material, expressed as a decimal, and

P_f = Percent minus No. 4 (4.75 mm) material, expressed as a decimal or by nomograph (Figure 2).

(3) The optimum moisture content for the total soil will be determined by the formula:

Where: $W_t = (P_c W_c + P_f W_f)\ 100$

W_t = Optimum moisture content for total soil,

W_c = Optimum moisture content, expressed as a decimal, for material retained on No. 4 sieve (4.75 mm) (estimated between 1% and 3%),

W_f = Optimum moisture content, expressed as a decimal, for material passing No. 4 (4.75 mm) sieve.

P_c = Percent, expressed as a decimal, of material retained on a No. 4 (4.75 mm) sieve, and

P_f = Percent, expressed as a decimal, of material passing a No. 4 (4.75 mm) sieve.

Alternatively, the corrected maximum dry density can be determined herein with the aid of Figure 2.

B. Percent Compaction

$$\text{Percent Compaction} = \frac{\text{Field Dry Density}}{\text{Maximum Dry Density}} \times 100$$

General Notes:

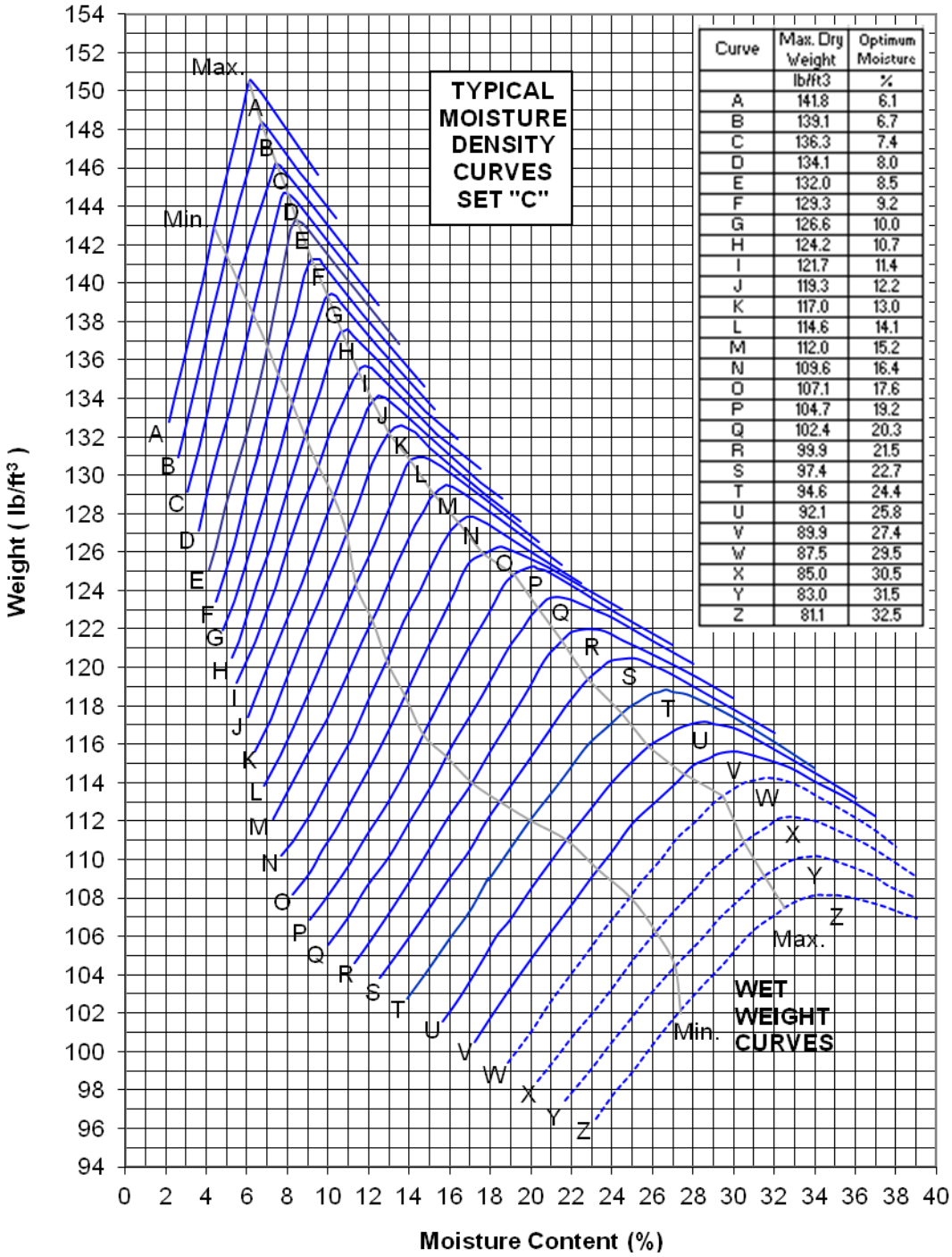
1 The density required in the work will be a variable percentage of the theoretical maximum density, "D", depending upon variations in the percentage of plus No. 4 (4.75 mm) material in the mixture and upon the position of the material in the work, and will be specified in the applicable section of the specifications.

2 The specific gravity of +4 material can be found in soil survey reports and contractor borrow material submittals for soils and Approved List No. 5 (http://www.virginiadot.org/business/resources/Materials/Approved_Lists.pdf) for aggregates. If this information is not available, the specific gravity can be assumed as directed by the District Material Engineer.

14.3 Replace Note 4 with the following:

Note 4 - If the one point plotted within or on the family of curves (Figure 1) does not fall within the minimum and maximum curve range, compact another specimen, using the same material, at an adjusted moisture content that will place the one-point within this range.

ONE-POINT PROCTOR



Curve	Max. Dry Weight	Optimum Moisture
	lb/ft3	%
A	141.8	6.1
B	139.1	6.7
C	136.3	7.4
D	134.1	8.0
E	132.0	8.5
F	129.3	9.2
G	126.6	10.0
H	124.2	10.7
I	121.7	11.4
J	119.3	12.2
K	117.0	13.0
L	114.6	14.1
M	112.0	15.2
N	109.6	16.4
O	107.1	17.6
P	104.7	19.2
Q	102.4	20.3
R	99.9	21.5
S	97.4	22.7
T	94.6	24.4
U	92.1	25.8
V	89.9	27.4
W	87.5	29.5
X	85.0	30.5
Y	83.0	31.5
Z	81.1	32.5

Figure 1

NOMOGRAPH FOR DETERMINING TOTAL DENSITIES OF SOILS

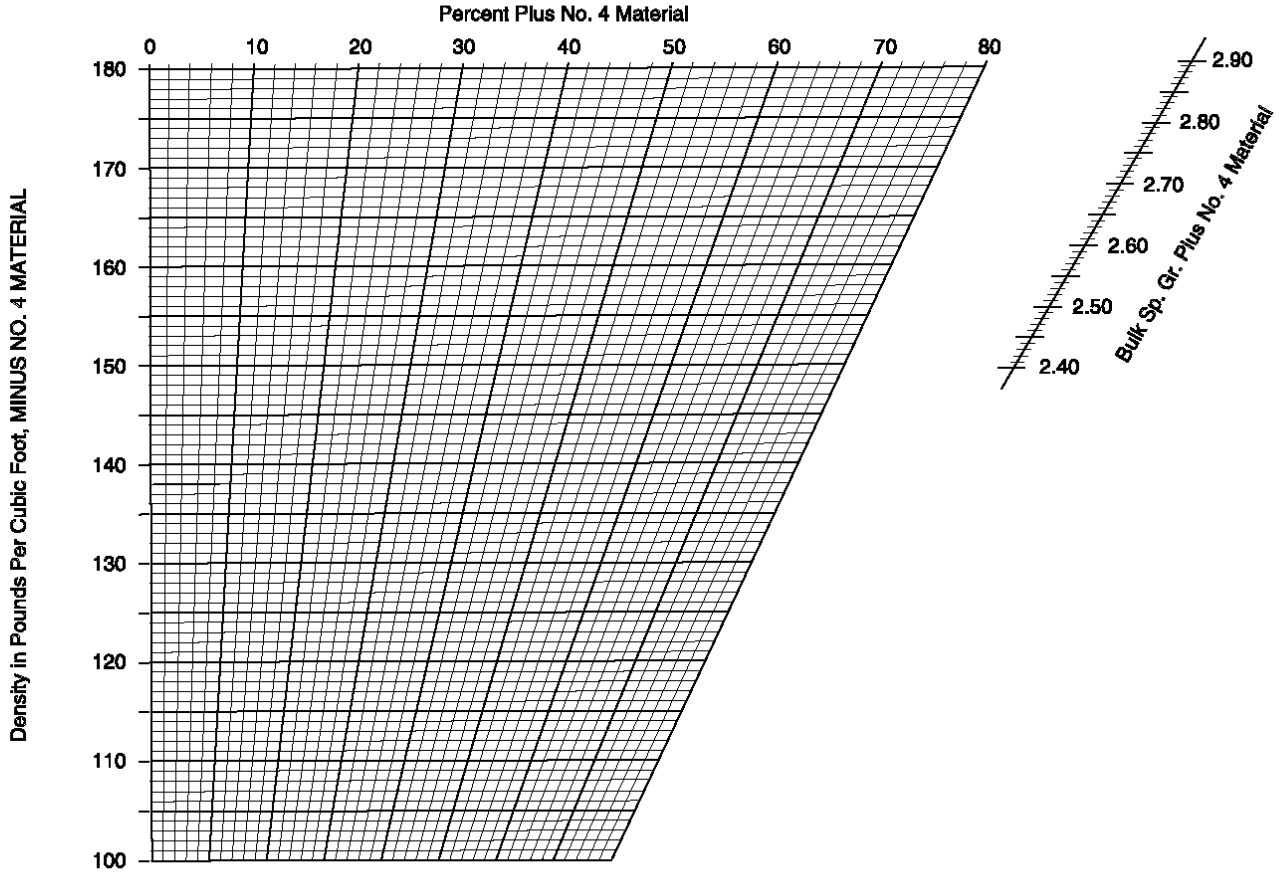
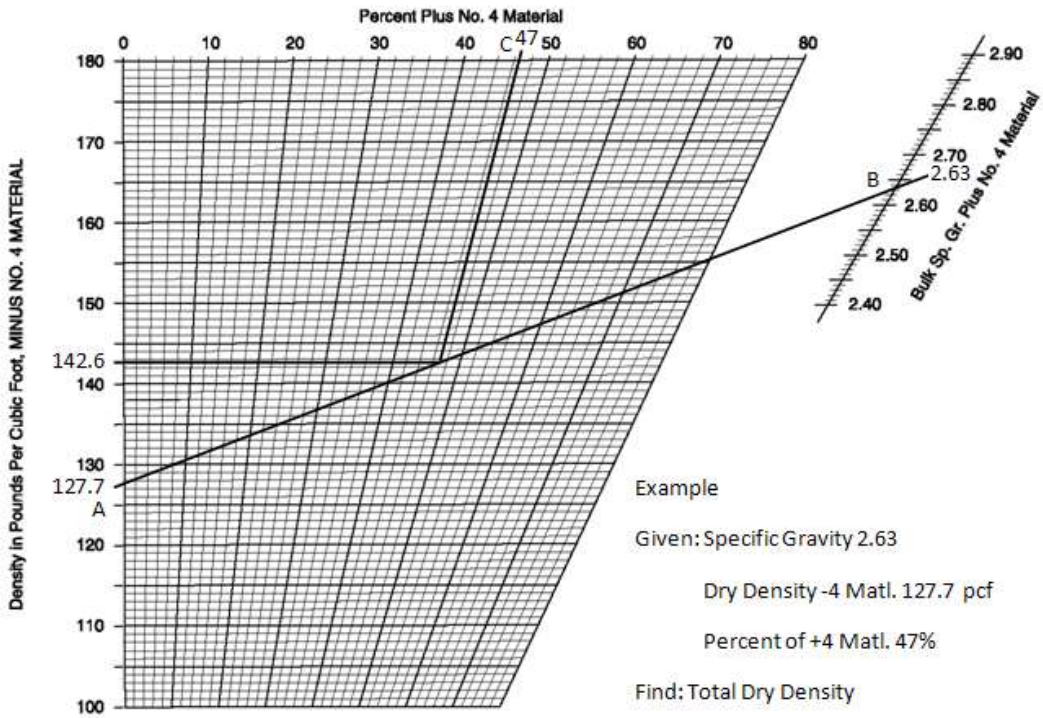


Figure 2a

NOMOGRAPH FOR DETERMINING TOTAL DENSITIES OF SOILS



Example

Given: Specific Gravity 2.63

Dry Density -4 Matl. 127.7 pcf

Percent of +4 Matl. 47%

Find: Total Dry Density

1. Plot A, B and C
2. Using a straight edge draw a line from A to B
3. From C draw a line at the same slant as the nomograph lines to intersect line AB
4. Draw a straight line from the point of intersection to the left edge of the nomograph
5. Total Dry Density =142.6 pcf

Figure 2b

Virginia Test Method – 13

Anti-Stripping Additive – (Asphalt Lab)

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.)	Sieve Size (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 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 ± 5ºF (135°C ± 3ºC). 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°F ± 10°F (110°C ± 5ºC), 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 ± 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.l 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. ½-in. (12.5 mm) 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 ½-in. (12.5 mm) 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 230ºF ± 10ºF (110°C ± 5ºC) (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 230ºF ± 10ºF (110°C ± 5ºC).

   NOTE: Remove plus ½-in. (12.5 mm) 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 ± 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 – 14

Wet Track Abrasion – (Asphalt Lab)

November 1, 2000

1. Scope

The wet track abrasion is intended for measuring the wearing qualities of thin, fine aggregate bituminous surfacings, 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 grams 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. ± .05 lbs (2.3 ± 0.02 kg) (including rubber hose).
   b. Has 1/2 in. (13 mm) up and down movement in the shaft sleeve.

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

   a. 13 in. (330 mm) diameter.
   b. 2 in. (50 mm) vertical side walls (20 gage or heavier).
   c. 4 equally spaced screw clamps capable of securing 11.75 in. (298 mm) diameter 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. (100 mm) or more from bottom of round bottom mixing bowl.

6. Disk

   a. 11.75 in. (298 mm) diameter or larger circular cut from 40 - 60 lbs. (18-27 kg) roofing felt.

7. Metal Plates

   a. 15 in. (381 mm) square with 4 rods space 14 in. (356 mm) center to center.
   b. Rods 1 in. (25 mm) tall and 1/4 in. (6.4 mm) in. diameter.

8. Plastic Templates

   a. 15 in. (381 mm) square 1/4 in. (6.4 mm) thick with 4 holes spaced 14 in. (356 mm) center to center.
   b. Holes 3/16 in. (4.8 mm) diameter.
   c. 11 in. (28 mm) circle cut into center of template.

9. Window Squeegee

   a. 12 in. to 14 in. (305 mm to 356 mm) long with short handle (rubber edge).

10. Funnel

   a. Metal or nalgene with top diameter opening min. 5 in. to max. 7.0 in. (127 mm – 175 mm).
   b. To tubular opening minimum 3/4 in. (19 mm) to maximum 1.0 in. (25 mm).
   c. Bottom tubular opening 1/2 in. (13 mm).

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. (25 mm) water above top sample.
   c. Will hold minimum of 3 samples at a time.

13. Reinforced Rubber Hose

   a. 3/4 in. (19 mm) inside diameter (2 braid, Oil-Resistant Cover, equivalent to Parker 3292 OZEX general purpose hose).
   b. Cut into 5 in. (127 mm) lengths.
   c. 2 holes drilled on 4 inch (102 mm) center to center.
   d. Diameter of holes should be 3/8 in. (9.5 mm).

   NOTE: Do not drill through concave or convex sides.

14. Thermometers

   a. ASTM 49° C range 20° C to 70° F (140° F oven) (60° C).
   b. ASTM 17° F range 66° F to 80° F (77° F water bath) (25° C).

15. Sample Rack

   a. Should be large enough to place sample without any overhang.
   b. 1 in.(25 mm) 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. (203 mm) square.
   b. 40 - 60 lbs. (18-27 kg) 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 (60° C)) a sufficient quantity of aggregate to obtain the required number of batches. Sieve material over the #4 sieve (4.75 mm). (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 (12.5 mm) 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. (298 mm) 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 the 140° F (60° C) 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 (60° C) oven, allow to cool to room temperature and weigh.

b. After weighing, place the specimen in the 77° F (25° C) water batch for 1 to 1 l/4 hours

c. Remove the specimen from the water bath and place in the 13 in. (330 mm) 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. (6 mm) depth of distilled water (Temperature 77° ± 5° F) (25° ± 2° C).

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 (60° C) oven and dry to constant weight.

h. The dried specimen is removed from the 140° F (60° C) 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, 0.32 $ft.^2$ (0.03 m^2) to a one square foot basis. (The 3.06 value only applies to the Hobart C-100 Machine with a 5 in. (127 mm) rubber hose).

i. To compensate for the +4 (+4.75 mm) 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 (+4.75 mm) 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 (+4.75 mm) material
0.1%	x 15.0% = 1.5%
10.0%	
-1.5%	
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 (+4.75 mm)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 (+4.75 mm) Material
0.1% X 15.0% = 1.5%	
8.5%	
+ 1.5%	
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 – 15

Determining Amount of Fractured Particles in Crushed Gravel – (Physical Lab)

November 1, 2000

1. Scope

This method covers the procedure to be used in determining the percent of fractured particles in crushed gravel.

2. Apparatus

a. Balance accurate to 1.0 gram.

b. Set of fine aggregate sieves containing the No. 4 and No. 10 (4.75 mm and 2.00 mm) sieves

c. Weighing Pans.

3. Procedure

The size of sample shall be approximately 1000 grams for 1/2 in. (12.5 mm) materials and 2000 grams for material larger than 1/2 in (12.5 mm). A representative sample of material is screened over a No. 4 sieve (4.75 mm), except for crusher run material which is screened over a No. 10 (2.00 mm) sieve.

The sample is then examined visually and the crushed and uncrushed particles separated. When completed, the crushed particles are weighed and the percent of the original weight determined of +4 (or + 10) (4.75 mm or + 2.00 mm) material.

Virginia Test Method – 16

Cement-Water Reducing and Retarding Admixtures Compatibility Test – (Physical Lab)

October 1, 2004

1. Scope

This method provides the procedures for establishing the compatibility of cement-water reducing and retarding admixture combinations.

2. Apparatus

As required in:

a. ASTM C403
b. ASTM C231
c. ASTM C39
d. ASTM C143

3. Procedure

a. Initial Approval - Initial approval shall be based upon independent laboratory data submitted by the manufacturer. The data shall conform to AASHTO M194.

b. Compatibility - Either prior to or at any time during construction, the Engineer may require the selected admixture to be tested with the cement and aggregate actually proposed for job use and in the proportions to be used or being used on the job, for compliance with the requirements of Table 1. A reference mix of equal cement content without the admixtures shall be made and tested with the concrete containing the admixture as basis for comparison.

TABLE I

Water content, maximum % of reference	95
Time of initial setting, deviation from reference[1]	100% of Required[5]
Air content, retarded mix[2]	As Required[6]
Compressive Strength at 28 days, minimum % of design[3] minimum % of reference[3]	110[6] 100
Slump, minimum % of reference[4]	100[6]

1. AASHTO T197.

2. AASHTO T152.

3. AASHTO T22. Average of 4 standard cylinders for the retarded and the reference mixes.

4. AASHTO T119.

5. Time required is dependent on average mortar temperature during test & is determined from the plot of time vs. temperature using 1 hr. for 87° F (30.6° C) & 2 hrs. for 70.4° F (21.3° C).

6. As required in Table II-11 of the Road and Bridge Specifications for the class of concrete being tested for the project.

Virginia Test Method – 17

Plastic Concrete Performance Test for Reducing Mixing Time of a Central Mix Plant - (Physical Lab)

October 1, 2004

1. Scope

This method covers the procedures to be used in determining the minimum or optimum mixing time of a Central Concrete Plant.

2. Apparatus

The apparatus required shall consist of standard equipment for running slump, ASTM C143; air content, ASTM C231; weight per cubic foot, ASTM C138; and a set of sieves.

3. Procedure

Seven (7) separate batches of plastic concrete shall be tested at the proposed reduced mixing time. Each batch shall be sampled in 3 increments, at the 1/6 point, midpoint, and 5/6 point of discharge, both at the plant and at the roadway. The within batch variability for the tests specified shall not exceed the following requirements in more than one out of the 7 batches.

Test	Permissible within Batch Range	
	Plant	Roadway
Slump, in. (mm)	2.25(57)	1.75 (44.4)
Air content, percent	2.00	1.50
Weight per cubic foot, lbs. (m^3)	4.00 (0.11)	5.50 (0.16)
Coarse aggregate retained on No. 4 (4.75 mm) sieve expressed as a percent of three-sample average weight retained	11.00	9.00

Virginia Test Method – 18

Deleted - *Roundness of Glass Beads*

April 1, 1996

Virginia Test Method – 19

Deleted

(See AASHTO - M-243)

Virginia Test Method – 20

Prestressed Concrete Beam Load Test – (Structures)

November 1, 2000

1. Scope

This method covers the procedures to be used in determining the amount of residual deflection in a prestressed concrete member after removing a required maximum load.

2. Apparatus

a. Supports that are adequate to maintain the member of minimum of 18 in. (450 mm) above the ground.

b. Accurate jack gage or gages that has been calibrated within six (6) months.

c. Adequate jack or jacks for attaining and maintaining the required load.

d. Piano wire.

e. Mirror.

f. Scale graduated to 1/32 in (1 mm).

g. An approved apparatus for applying the required load.

3. Procedure

Member resting on the supports in an upright manner on end bearings. Points of load should be at center or third points, or as designated, to produce a computed tensile stress of (0.95) (7.5) f' in the bottom fiber of the beam, where f' equals concrete test cylinder strength of member at time of test.

A piano wire shall be attached to the beam at the ends and offset from the face of the beam and stretched tight to remove as much sag as possible. The scale shall be mounted on the mirror, and the mirror shall be attached to the approximate, center of the beam behind the wire.

The load shall be conducted in the following manner:

The member shall be loaded to 50 percent of the maximum test load, the deflection measured, the results recorded, the load removed, and the residual deflection measured and the results recorded. In a like manner, at least 2 other loads, having values of more than 50 percent and less than 100 percent of the maximum test load, and each being increasingly higher than the last, shall be applied separately to the member, the corresponding deflections measured, results recorded, the loads removed the corresponding residual deflections measured, and the end results recorded.

Finally, the maximum test load shall be applied, the deflection measured, the results recorded, the load maintained for a minimum of 5 minutes, members examined for cracks, load removed, the residual deflection measured, and the results recorded. The percent of recovery of the member on removal of the final load shall be determined as follows:

$$R = \frac{100\ (d_1 - d_2)}{d_1}$$

Where: R = Percent of recovery,

d_1 = Deflection after maximum test load is applied, and

d_2 = Deflection after maximum test load is removed.

Virginia Test Method – 21

Ozone Susceptibility of Elastomers – (Physical Lab)

November 1, 2000

1. Scope

This method is for use in estimating the resistance of polychloroprene rubber and similar materials to cracking and hardening when exposed to a controlled ozone atmosphere.

2. Apparatus

a. A chamber in which both temperature and ozone concentration can be controlled and maintained.

b. A device for accurately shaping the test specimens.

c. A holder for the test specimens.

d. A manual titration device (MTD) for checking the ozone concentration in the test chamber.

3. Chemicals

The chemicals needed for checking the ozone concentration should be of reagent grade and consist of the following:

a. Potassium iodide (KI).

b. Sodium thiosulfate ($Na_2S_2O_3$).

c. Sodium phosphate dibasic anhydrous (Na_2HPO_4).

d. Sodium phosphate monabasic ($NaH_2PO_4H_2O$).

A sodium thiosulfate solution may be used provided the normality (0.1N) is accurate to the fourth place. The solution must be replaced every thirty days to insure chemical purity.

4. Procedure

a. The procedure for preparation and testing of specimen shall consist of the following: A specimen of the material to be tested, 0.125 in. (3.3 mm) thick, is cut into a rectangle 0.875 in. by 3.75 in. (22.2 mm by 95.2 mm) and clamped end to end in the specimen holder. The specimen is subjected to an ozone atmosphere of 100 pphm (parts per hundred million) ozone at 100° F (38° C) for 100 hours. The test specimen is examined at intervals of 24, 48, 72, 96, and 100 hours for evidence of reaction with the ozone.

b. The procedure for checking the ozone concentration in the test chamber shall consist of the following:

(1) Preparation of stock solution needed in the titration:

(a) Buffered KI is made by placing 8 grams KI, 0.591 grams Na_2HPO_4, and 0.575 grams $NaH_2PO_4H_2O$ in a one liter volumetric flask and diluting to the one liter mark with distilled water.

(b) Sodium thiosulfate (0.0005N) is made by diluting 5 ml of the 0.1N parent solution to one liter with distilled water.

(2) Titrating the ozone by use of the manual titrating device:

(a) Obtaining a known flow of ozone into the MTD: A small port located on the test chamber is connected to the entrance port of the vacuum pump on the manual titrating device. When the pump is started, a manometer connected to the Kjeldahl registers a pressure which can be converted into known flowrate of ozone.

(b) Titrating the ozone: The Microammeter is zeroed by turning on the switch and setting the needle on zero using the adjusting screw. The tubing, mentioned under paragraph (2) (a) above, is connected to the sampling port in the test chamber. Eighteen (18) ml of buffered KI is introduced into the Kjeldahl by means of a buret. This buret tip (10 ml capacity especially designed for this purpose) and stopper are inserted into the port of the Kjeldahl). The pressure in the chamber is set at 12.2 and the needle allowed to rise until it registers one on the scale. At this point, open the buret and introduce 3-10 ml of sodium thiosulfate into the Kjeldahl starting the watch at the same time. The needle will return to zero and then start to rise. When the needle passes one, stop the watch and record the time. The total titration time should be from 7 to 25 minutes.

(c) Calculating the ozone in pphm (parts per hundred million): The ozone concentration is calculated:

$$\text{pphm ozone} = \frac{(N)\,(ml)\,(4.035 \times 10^5)\,(T)}{T_1}$$

Where:

N = Normality of the sodium thiosulfate,

ml = milliliters sodium thiosulfate introduced,

T = temperature in degrees K (273 +°C) of the solution being titrated (room temperature), and

T_1 = time in seconds.

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_2, 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:

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

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 – 23

Compression for Deflection of Elastomeric Bridge Pads – (Physical Lab)

November 1, 2000

The compression deflection is performed in accordance with ASTM D575, Method A (Modified by use of No. 40 grit cemented to loading surface).

The durometer hardness is determined according to ASTM D2240 and the surface loaded within the range 300 to 800 psi (2 MPa to 5.5 MPa). The compression deflection of the elastomeric pad is obtained from charts 1, 2, or 3, interpolating for the measured hardness using the calculated shape factor. This test shall be made on full size pads when practicable.

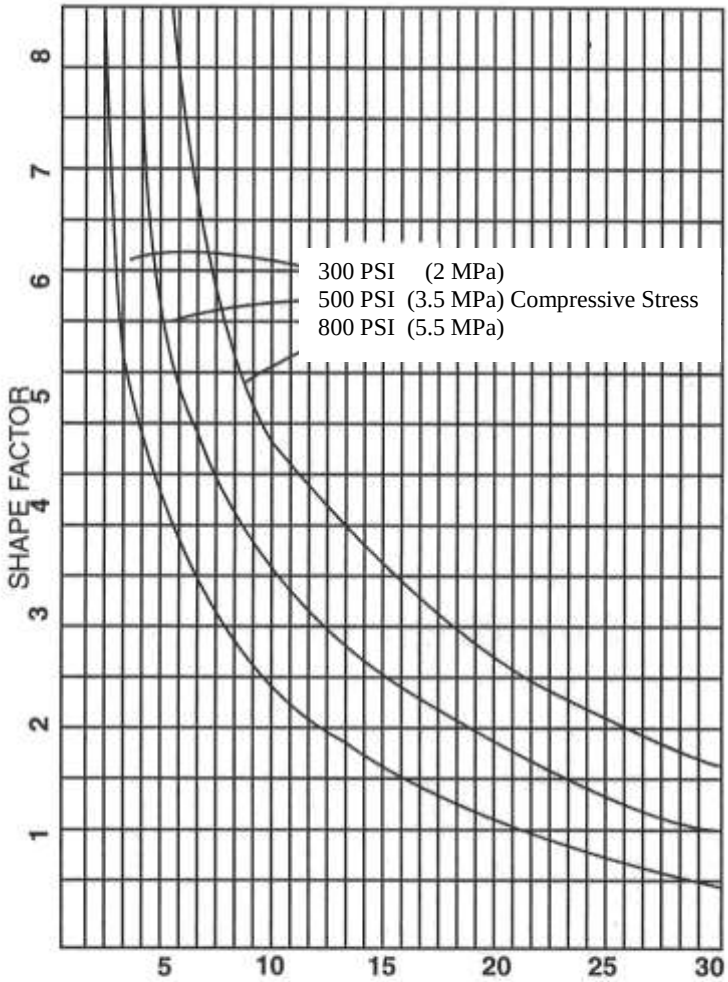


CHART 1

DUROMETER HARDNESS 50

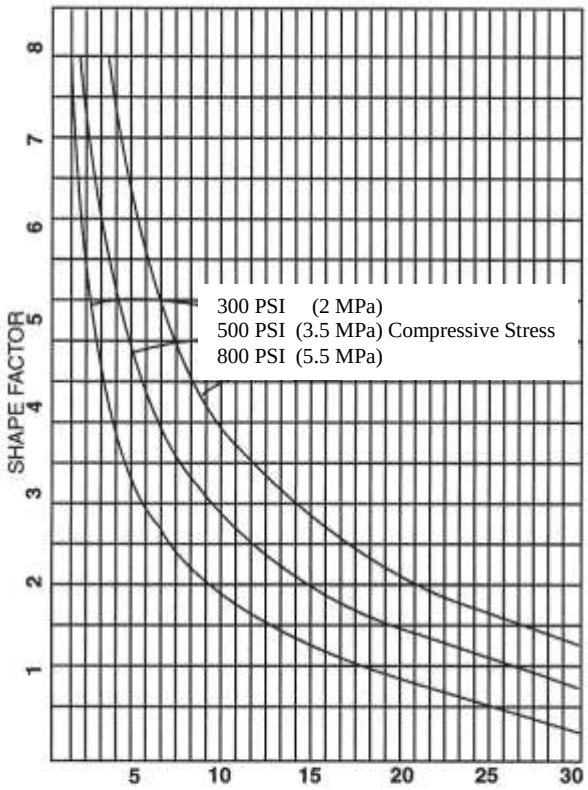


CHART 2

DUROMETER HARDNESS 60

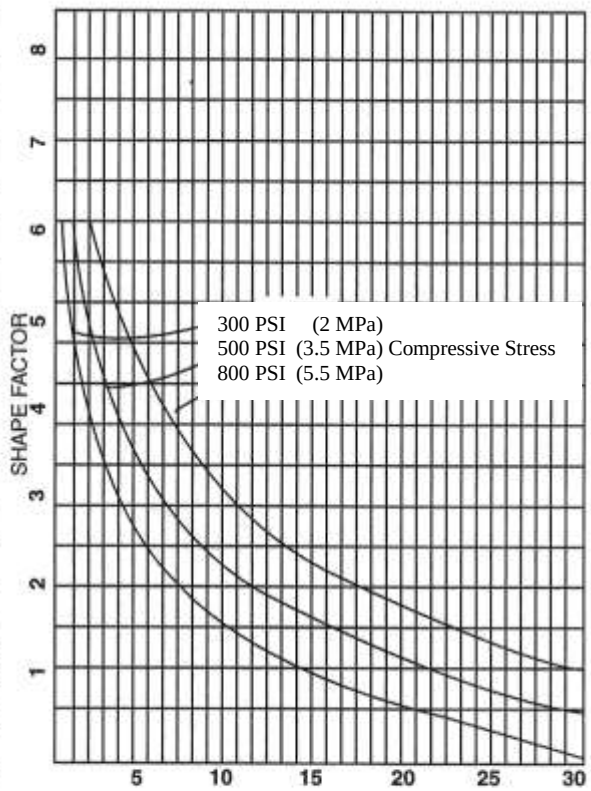


CHART 3

DUROMETER HARDNESS 70

Virginia Test Method – 24

Deleted (See AASHTO T 30)

Virginia Test Method – 25

Dry Preparation, and Mechanical Analysis of Soils, Select Material, Subbase, and Aggregate Bases- (Soils Lab)

November 1, 2000

DRY PREPARATION

1. Scope

1.1 This method describes the dry preparation of soil and soil-aggregate samples, as received from the field, for mechanical analysis, physical tests, moisture-density relations and other tests as may be desired.

1.4 The method of dry preparation shall be in accordance with AASHTO T87-86, except as modified below:

4. Initial Preparation of Test Samples

4.1 Add-*DENSE GRADED AGGREGATE* (Select Materials, Subbase and Aggregate Base Materials) shall not be processed in the pulverizing apparatus unless clay or particle lumps remain on the sieves after the sieving operation or the aggregate material has a history of failing Atterberg Limits.

5. Test Sample for Fine Particle Size Analysis

5.2 Add –The material passing the No. 10 (2.0 mm) sieve to be used for the fine sieve analysis shall weigh between 125 and 200 grams. The weight of the sample shall be recorded and used for the fine sieve analysis computation. The sample is to be gently washed over a No. 200 (0.075 mm) sieve until the water runs clear. The material retained on the No. 200 (0.075 mm) sieve is then transferred to a drying dish and dried in an oven at a temperature of 230 ± 9º F (110 ± 5° C).

MECHANICAL ANALYSIS OF SOILS, SELECT MATERIALS, SUBBASE AND AGGREGATE BASES

1. Scope

1.1 This method covers the determination of the particle size distribution of fine and coarse aggregate portions by sieving.

1.4 This method of mechanical analysis for soils, select material, subbase, and aggregate bases shall be in accordance with AASHTO T27-99, except as modified below:

6. Apparatus

6.3 A sieve analysis is performed on the fraction in Section 7.3 in accordance with AASHTO T27-99. The exception is that Dense Graded Aggregates shall be agitated in a mechanical shaker for 10 minutes or until the sieving action shall be such that the criterion for adequacy of sieving described in Section 8.4 is met in a reasonable time period. This is

also applicable to the fraction of material from Section 5.1 of AASHTO T87-86 (1996) if the pulverizing apparatus has been used.

NOTE: The hydrometer analysis and specific gravity may be deleted.

7. Sampling

7.4 Add. Sieves – A series of sieves of the following sizes 3.0 in. (75.0 mm), 2½ in (63.0 mm), 2 in. (50.0 mm), 1½ in. (37.5 mm), 1 in. (25 mm), ¾ in (19 mm), 3/8 in. (9.5 mm), No. 4 (4.75mm), No. 10 (2.0 mm), No. 20 (0.85 mm), No. 40 (0.425 mm), No. 60 (0250mm), No. 80 (0.180mm), No. 100 (0.150mm), and No. 200 (0.075mm).

Virginia Test Method – 26

Depth Test of Portland Cement Concrete Pavements – (Physical Lab)

November 1, 2000

1. Scope

This method describes the methods and frequency of pavement depth tests.

2. Procedure

The units for establishing an adjusted unit price for pavement are defined as 0.25 miles (0.4 km) of pavement in each traffic lane, starting at the end of the pavement bearing the smaller station number. A traffic lane shall be considered the pavement surface between longitudinal joints, between a longitudinal joint and the pavement edge or from the edge to edge of the pavement if constructed without longitudinal joints. A section will end at each bridge or approach slab, or change of pavement type, and a new unit will begin at the other end of the bridge, approach slab, or pavement change. If the last unit of a section is less than 500 ft. (150 m), it shall be considered part of the preceding unit. A minimum of one core will be taken at random by the Department from each unit. A separate boring shall be made for each intersection, entrance, crossover, etc., having an area of 50 yds^2 (42 m^2). or more. A ramp shall be considered as one lane unless designed for more travel lanes, regardless of longitudinal joint.

The location of the core shall be determined by a randomization procedure similar to the suggested randomization procedure shown in VTM-32, Depth Test of Bituminous Concrete Base Course.

The length of the core shall be measured in accordance with AASHTO Method T 148. (See Note below for alternate procedure.) If the length of the core is in excess of the specified depth of pavement, T 148 will be modified such that only three readings will be made. If the core is deficient, all nine readings shall be made. When the measurement of the core from a unit is not deficient more than 0.20 inch (5.1 mm) from the plan thickness, full payment will be made. When such measurement is deficient more than 0.20 inch (5.1 mm) and not more than 1.00 inch (25 mm) from the plan thickness, 2 additional cores at intervals not less than 300 feet, and contained within the unit, will be taken, and the average thickness of the 3 cores determined. If the average thickness of these 3 cores is not deficient by more than 0.20 inches (5.1 mm)from the plan thickness, full payment will be made. If the average thickness of the 3 cores is deficient by more than 0.20 inch (5.1 mm) and less than 1.00 inch (25 mm) from the plan thickness, an adjusted unit price as provided in the Road and Bridge Specifications, will be paid from the unit represented by these cores. In calculating the average thickness of the pavement, measurements in excess of the specified thickness by more than 0.20 inch (5.1 mm) will be considered as the specified thickness plus 0.20 inch (5.1 mm), and measurements less than the specified thickness by more than 1.00 inch (25 mm) will not be included in the average. When the measurement of any core is less than the specified thickness of the pavement by more than 1.00 inch (25 mm), the actual thickness of the pavement in this area shall be determined by taking additional cores at not less than 10 foot (3 m) intervals parallel to the center line in each direction from the affected location, until in each direction a core is found which is not deficient by more than 1.00 inch (25 mm).

Note: If using AASHTO T 148 is unsuitable due to the nature of the subbase, this alternate method may be used in measuring the length of the specimen. The length of the core shall be measured by placing a rubber band at the base of the core such that the top surface of the rubber band averages the depth of the bottom surface of the core. The top of the rubber band is then used as the bottom measuring point in determining the length of the specimen. Measure with a callipering device from the top surface of the rubber band at four locations equally spaced around the core to the nearest 0.05 inches (1.3 mm). The average of the four readings will be recorded to the nearest 0.01 inches (0.25 mm).

A visual investigation will be made of all cores to determine conformance with the specifications on the location of the reinforcing steel, the quality of the consolidation, or any other problems readily visible. If the core shows any problems, the core shall be saved and the deficiencies discussed with the Project Inspector. Otherwise, the core may be discarded after measurement.

Virginia Test Method – 27

Galvanizing Repair Compound – (Chemistry Lab)

November 1, 2000

1. Scope

This method outlines test procedures for determining compliance of either stick or powder galvanizing repair compounds.

2. Procedure

One container of powder or one stick shall be sampled at random from a shipment.

a A sample shall be treated to 475° F (246° C), at which time it must liquefy.

b. A sample shall be applied, according to the manufacturer's instructions, to a 4 in. (102 mm) square of ungalvanized steel or galvanized steel with artificial defects and then placed in the standard moisture room for 100 hours. Upon removal there shall be no indication of oxidation in the applied coating or the junction of the application and the original galvanizing.

c. A minimum of 3 galvanized steel plates shall be thoroughly cleaned. A coating of the repair compound shall be applied as follows: One plate shall be placed in a horizontal position and a light layer of the compound applied to the surface to be coated. Heat shall then be applied to the plate by means of a portable torch. Similar plates shall be prepared in the vertical and overhead positions. If the compound is in powder form, it shall be mixed with water to provide a thick paste to facilitate application. The stick form may be applied directly to the surface to be coated. The surface shall be heated with a torch. The molten metal shall be worked over the plate to complete coverage of the exposed portions of steel, and the excess metal wiped off. Note the ease of application of the compound. There shall be no irregularities or imperfections and no distinct or objectionable line of demarcation between the applied coating and the galvanizing.

d. A minimum of 3 galvanized steel plates shall be butt-welded by electric arc welding, using a coated rod. After welding, the slag shall be removed from the weld-bead by means of a chipping hammer and wire brush; the plates shall be placed in a horizontal position, vertical position, and overhead position. Heat shall then be applied to the weld area of the plates by means of an oxyacetylene torch. The compound shall be applied to the surface for "tinning" between the metal temperatures of from 500 to 650° F (260 - 343° C). While the alloy remains in a liquid state on the weld or galvanized surface, a wire brush shall be used to spread the alloy evenly over the surface to bond it to the base metal. Note the ease of operation. There shall be no irregularities or imperfections and no distinct or objectionable line of demarcation between the applied coating and the galvanizing.

3. Report

Results will be reported in letter form, indicating brand name and date of shipment, with a statement that the material did (not) meet the requirements of the specifications.

Virginia Test Method – 28

Moisture Content,Gradation and Chemical Analysis
of Sodium Chloride (Rock Salt) – (Chemistry Lab)

July 1, 2001

1. Scope

This method covers the procedure to be used in determining moisture content, gradation by sieve size, and sodium chloride content of sodium chloride as received from the field.

2. Apparatus and Chemicals

2.1 Apparatus

2.1.1 Mettler DL40RC MemoTitrator.

2.1.2 Mettler DM141 Combination Silver Ring Electrode.

2.1.3 Balance having a capacity ofat least 200 gm accurate and readable to 0.10 g.

2.1.4 Analytical Balance accurate and readable to 0.1 mg.

2.1.5 Sample splitter with the capacity to handle the contents of a one quart size sample container.

2.1.6 A sieve set containing sieves with mesh sizes of 3/4", 1/2", 3/8", No. 4, No. 8, and No. 30 (19.5 mm, 12.5 mm, 9.5 mm, 4.75 mm, 2.36 mm, 0.6 mm) and a pan.

2.1.7 A brush

2.1.8 Metal drug cans 8 oz. (235 ml)

2.1.9 Metal drug cans 3 oz. (90 ml)

2.1.10 Vented oven capable of maintaining 230° F (110º C).

2.1.11 Desiccator

2.1.12 Mortar and Pestle

2.2 Glassware

2.2.1 1000 ml volumetric flasks

2.2.2 10 ml pipets

2.2.3 120 ml Memo beakers, plastic

2.3 Reagents

2.3.1 0.1 N Silver Nitrate (AgNO3)

2.3.2 O.1 N Sodium Chloride (NaCl)

2.3.3 Deionized water

3. Procedure for determining moisture and gradation of sodium chloride sample

3.1 The sample is split to approximately 150 gm (± 50) and placed in a tared 8 oz. (235 ml) metal can and weighed to the nearest 0.10 gram.

3.2 The metal can with sample is placed in an oven at 230° F (110º C), dried overnight, cooled in desiccator and reweighed. The loss in weight is the amount of water present. The percent water is calculated as:

$$\% \text{ Water} = \frac{A - B}{A} \times 100$$

A = weight of wet salt
B = weight of dried salt

3.3 The dried sample is then sieved and the gradation is determined by calculating percent sample retained on each sieve to total sample sieved. The gradation should conform to AASHTO M143 Type I.

3.4 The sample is recombined, split down to about 5 gm, ground with a mortar and pestle and placed in a 3 oz. (90 ml) metal can.

4. Procedure for determining chloride content of sodium chloride sample.

4.1 Weigh 2 gm of ground sample to the nearest 0.1 mg and transfer to a 1000 ml volumetric flask. Fill to the mark with deionized water and mix well.

4.2 Pipet a 10 ml aliquot into a 120 ml plastic memo beaker and add enough deionized water to cover the electrode.

4.3 Standardize the 0.1 N AgNO3 titrant with the 0.1 N NaCl using the Method 900 on the MemoTitrator.

4.4 Titrate the sample using Method 91102. The instrument will ask for weight of the sample and the identification number. It will titrate the sample automatically and record the results as % NaCl in a dried sample. Results are reported as % of NaCl in sample as received from the field.

5. Calculations

Sample report will look like this:

```
*** 01 - Dec - 05 ***

METHOD NO.      91102    1
IDENT
SAMPLE NO.               1

*R*     %              99.302
```

Sample No. 1 was titrated with 3.9230 ml of 0.08912 N $AgNO_3$.

%NaCl = A x N x 584.5/W

A = ml AgNO3 used for sample	3.9230
N = normality of Silver Nitrate approximately 0.1N	0.08912
W = weight of sample approximately 2.0g	2.04

584.5 = Molar Mass of NaCl multiplied by dilution factor.

Preparation of standard 0.1 N $AgNO_3$ solution: Weigh 17.0 grams of reagent grade silver nitrate into a 1 liter volumetric flask, dissolve in deionized water and dilute to 1 liter.

Preparation of standard 0.1 N NaCl: Dry NaCl in an oven overnight at 110 ºC. Weigh exactly 5.844 grams into a 1 liter volumetric flask, dissolve in deionized water and dilute to 1 liter.

Procedure for Standardizing 0.1 N $AgNO_3$: Place 70 ml of deionized water in three 120 ml plastic Memo beakers. Then add 10 ml. 0.1N NaCl to the beakers using 10 ml volumetric pipette.

Titrate the three beakers according to MemoTitrator Method No. 900.

Virginia Test Method – 29

Radiographic Inspection of Groove Welds – (Structures)

November 1, 2000

1. Scope

1.1 Radiographic inspection of groove welds shall conform to the requirements of the Virginia Department of Transportation Road and Bridge Specifications and AASHTO/AWS D1.5, with additional requirements noted in the following procedures.

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 requlatory limitations prior to use

2. Welds to be Examined

2.1 Shop and Field Groove Welds

1. Flange and vertical web splices in girders.
2. Longitudinal stiffener splices in beams and girders.
3. Splices of rolled beams and cover plates.
4. Twenty-five percent (25%) of each horizontal web splice beginning at the point of maximum tension.
5. Splices in sign structures and structural support systems for luminaires and traffic signals.
6. Other splices with groove welds.

3. Marking and Identification

3.1 One or more read points, depending on the length of the weld, shall be visible on each radiograph to identify the area being examined. These read points should be outside the area being interpreted. Steel to be radiographed shall be stamped with 0.25" or 0.375" (6 mm or 10 mm) round face steel dies, and these stamp points in the steel shall coincide with read points on the film. The location of these stamps shall be a minimum of 3/8" (10 mm) from the welded area and 1.0" (25 mm) from edge of plate. Read points shall be stamped in the steel prior to radiographic examination.

3.2 Read points shall be numbered 1-2 for cover plate and flange splices 20 in. (500 mm) or less in width. For flange splices greater than 20 in., read points shall be numbered 1-2, 2-3, etc. For flanges that have been welded to web, read points shall be umbered consecutively across both sides of the web with no number repeating. Read points shall be numbered 1-2 for web splices where only one exposure is required.

3.3 A minimum of one splice in each flange, web and cover plate shall be stamped with steel stamps indicating the piece number, splice number and location number.

Typical stampings are as follows:

10G5 TF A 11B2 BF A
5B3 W A 5G9 CP A

Abbreviation Summary:

A - indicates first joint from left end of member.
TF - Top Flange CP - Cover Plate
BF - Bottom Flange W - Web

4. Edge Blocking

4.1 Edge blocking shall be used as detailed in Figure A, on all welds over 3/8" (10 mm) thick.

5. Marking of Film

5.1 Read points as specified in Paragraph 3. The lead read points shall coincide with the steel stamped points. Lead letters and numbers shall be of the same type and size.

5.2 Project number and one bridge number. This number shall correspond to the bridge in which the piece will be incorporated.

5.3 Two image quality indicators.

5.4 Fabricator.

5.5 Date.

5.6 Girder number, splice number, and splice location.

5.7 Radiographer's initials.

5.8 In the event that repairs are necessary, films of first repaired weld shall bear the Mark R_1 and any additional repairs - R_2, R_3, etc.

Example - 10G5 TF A R_1 indicating: Girder 10G5
Top Flange
First Weld
First Repair

6. Film

6.1 Film shall be Type 2, as designated in ASTM E-94, Table 2, and shall be from dated stock. Type I may be used in an examination of material 0.5 in. (13 mm) thickness and less. Size of film shall be 4.5 x 17.0 in. (115 mm x 430 mm) unless otherwise specified or permitted by the Engineer.

7. Hole Type Image Quality Indicators

7.1 Hole type image quality indicators shall be placed in the source side, parallel to the welded point with the holes at the other end as detailed in Figure A.

8. Interpretation

8.1 Discontinuities shall be evaluated using the tension code of AWS D1.5.

9. Film Quality

9.1 Film corners shall be rounded with a corner cutter and shall be free of mechanical, chemical, or other blemishes.

10 Personnel Qualifications

10.1 Personnel performing radiographic inspection shall be certified by the VDOT Materials Division.

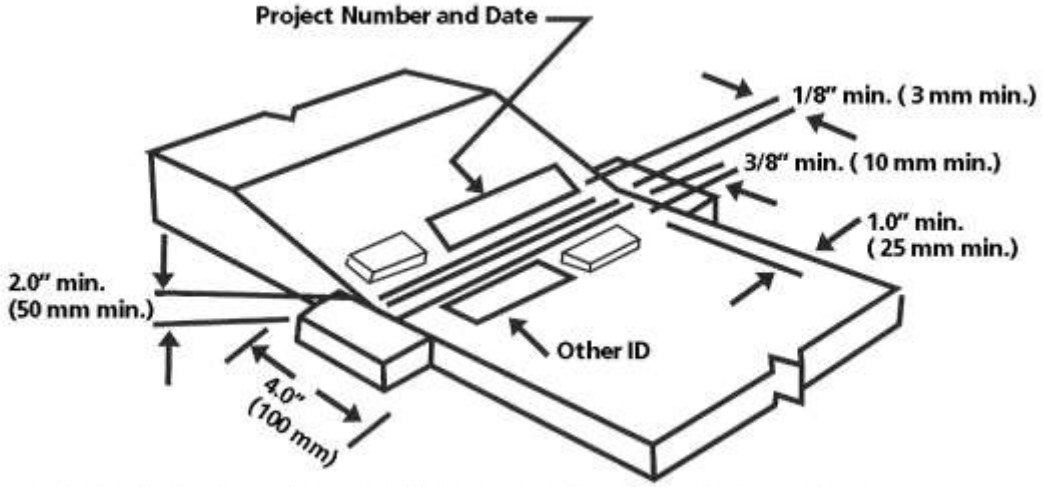
11. Reports

11.1 Typed reports as per sample Page 4 shall be submitted to the Department.

11.2 Film for each piece (girder, rolled beam, etc.) shall all be packaged together and in the order of Top Flange, Web and Bottom Flange. Each film shall be covered by a paper wrapper, which shall marked with the joint and piece mark. Film shall be boxed in the order as shown on the report.

11.3 Distribution of reports: 2 copies of report, packaged with film, to VDOT Materials Division.

Figure A



Edge block surface finished to 125 micro inch (3.2 micrometers).
H & D Density of edge block shall not be less than 2.0 nor more than 4.0

REPORT OF RADIOGRAPHIC EXAMINATION OF WELDS

Report No_____1_____
Sheet No._____1 of 1_____
PROJECT #_____6029-023-103.C502_____ Bridge No._____B602_____
QUALITY REQUIREMENTS_____VTM-29-90_____
REPORTED TO_____VDOT_____

1990			INTERPRETATION		
DATE	WELD IDENTIFICATION	AREA	ACCEPT	REJECT	REMARKS
7-16	1 G1 TF A	1-2	X		
		2-3	X		
7-19	1 G1 Web A	1-2	X		
		2-3	X		
		3-4	X		
7-16	1 G1 BF A	1-2	X		Surface
		2-3	X		
8-1	2G1 TF A	1-2		X	Slag
8-6	R1	1-2	X		
8-1	B	1-2	X		
8-1	2 G1 Web A	1-2	X		
		2-3	X		
		3-4	X		
8-15	2 G1 BF A	1-2	X		Film Artifact
	B	1-2	X		
8-1	3 G1 TF A	1-2	X		
	B	1-2	X		
	C	1-2	X		
8-1	3 G1 Web A	1-2	X		
		2-3	X		
		3-4		X	Slag
8-15	R1	3-4	X		
8-15	3 G1 BF A	1-2	X		
	B	1-2	X		
	C	1-2	X		

We, the undersigned, certify that the statements in this record are correct and that the welds were prepared and tested in accordance with the requirements of AASHTO/AWS [D1.5(__88_) Bridge Welding Code.
year

Radiographer____S. T. Blank_____ Manufacturer____Capitol Steel_____
Interpreter____I. M. Smooth_____ Signature_____

Virginia Test Method – 30

Ultrasonic Inspection of Groove Welds – (Structures)

November 1, 2000

1. Scope

1.1 Ultrasonic inspection of groove welds shall conform to the requirements of the latest Virginia Department of Transportation Road and Bridge Specifications and AASHTO/AWS D1.5, with additional requirements noted in the following procedures.

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. Welds to be Examined

2.1 Ultrasonic inspection shall be performed when shown on the plans, specified by the Engineer or when complying with VTM-44.

3. Marking and Identification

3.1 Material to be inspected shall be stamped with 0.25 or 0.375 in. (6 mm or 10 mm) round face dies. The location of these stamps shall be a minimum of 1.0 in. from the edge of the piece and a minimum of 1.0 in. (25 mm) from the welded area.

3.2 A minimum of one splice in each flange, web and cover plate shall be stamped with steel stamps indicating the piece number, splice number, and location number.

Examples of the steel stamps are as follows:

1G1 BF A	12G2 TF A
2B3 W A	7G2 CP A

Abbreviation Summary:

A - indicates first joint from left end of member.

TF - Top Flange	CP - Cover Plate
BF - Bottom Flange	W - Web

4. Personnel Qualifications

4.1 Personnel performing ultrasonic inspection shall be certified by VDOT Materials Division.

5. Reports

5.1 Typed reports as per sample and shall be submitted to the Department.

5.2 Report shall show acceptable indications in the remarks column. Unacceptable defects shall be indicated as reject and further reported.

5.3 Distribution of reports: 1 copy to VDOT Materials Division.

Sample

Report No. 1

REPORT OF ULTRASONIC TESTING OF WELDS Sheet 1 of 1

Project 0064-131-105,C501 Bridge No. B602

Quality requirements VTM-30

Reported to VDOT

2005 Date	Weld Identification	Area	Interpretation Accept/Reject	Remarks
7-16	1 G1 TF A		Accept	
7-16	1 G1 Web A		Accept	Slag - 20" from edge*
7-19	1 G1 BF A		Accept	
8-1	2 G1 TF A		Reject	See Report 30-4
8-6	R_1		Accept	
8-1	2 G1 TF B		Accept	
8-1	2 G1 Web A		Accept	
8-15	2 G1 BF A		Accept	
8-15	2 G1 BF B		Accept	Porosity 4" from edge ½" deep*
8-15	3 G1 BF	W/F	Reject	See Report 30-4
8-20	R_1		Accept	

We, the undersigned, certify that the statements in this record are correct and that the welds were prepared and tested in accordance with the requirements of AASHTO/AWS D1.5 (95) Bridge Welding Code.

Inspector _____ Manufacturer _____

Signature _____

* Note: Metric projects shall use metric units in all reports.

Sample

Report No. 2

REPORT OF ULTRASONIC TESTING OF WELDS Sheet 1 of 1

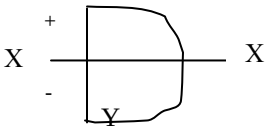
Project 0064-131-105,C501 Bridge No. B602

Quality requirements VTM-30

Reported to VDOT

Instrument USL 38

Couplant Glycerine



Date	Weld Identification	Thickness *	Welding process	Transducer angle	frequency	Decibels: Identification level a	Decibels: Reference level b	Decibels: Attenuation factor c	Decibels: Indication level d	Discontinuity: Length *	Discontinuity: Angular distance (sound path)	Discontinuity: Depth *	Distance*: From X	Distance*: From Y
8-1	2 G1 TF A	1 ¼	SAW	70	2.25	44	34	4	+6	1 ½	3	1	½	4
8-15	3 G1 BF	½	SAW	70	2.25	36	34	0	2	2	1	¼	⅛	36

*Note: Metric projects shall use the metric units in all reports.

We, the undersigned, certify that the statement in this record are correct and that the welds are prepared and tested in accordance with the requirements of AASHTO/AWS D1.5 ( ) Bridge Welding Code.

Inspector _____ Manufacturer _____

Signature _____

Virginia Test Method – 31

Magnetic Particle Inspection of Fillet Welds – (Structures)

November 1, 2000

1. Scope

1.1 Magnetic particle inspection shall conform to the requirements of the latest Virginia Department of Transportation Road and Bridge Specifications and AASHTO/AWS D1.5, with additional requirements noted in the following procedures.

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 responsiblity of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.3 Dye penetrant inspection as set forth in the specifications may be substituted for magnetic particle inspection only when permitted by the Engineer.

1.4 The prod method with aluminum prods shall be used for acceptability testing. The yoke method may only be used to verify suspected cracking and consequently to reject the weld.

2. Welds to be Examined

2.1 Shop Welds

Fillet welds in the following members shall be tested by the magnetic particle method.

Girders	Trusses
Beams	Bearing assemblies
Floor beams	Curved girder cross frames
Stringers	

The tests shall be located at random in the members so as to be typical for each size and type of weld and shall include end connections.

2.2 Field Welds

Procedures and methods shall be identical to those specified for shop inspection, except that examination of field welds shall be done only when required by specification or directed by the Engineer.

3. Defects

3.1 Welds shown by magnetic particle inspection to have defects prohibited by the specifications shall be repaired by methods permitted by specifications, or the entire piece shall be rejected as determined by the Engineer.

4. Reports

4.1 Typed reports as per sample a shall be submitted to the Department indicating the members inspected and defects found by magnetic particle inspection, together with a description of any repairs made.

4.2 Distribution of reports: 1 Copy to VDOT Materials Division.

Sample

REPORT OF MAGNETIC PARTICLE EXAMINATION OF WELDS

Project 0064-131-105, C501 Bridge No. B602
Quality requirements VTM 31
Reported to VDOT

We, the undersigned, certify that the statements in this record are correct and that the welds were prepared and tested

2005 Date	Weld Identification	Area	Interpretation		Repairs		Remarks
			Accept	Reject	Accept	Reject	
3-17	3-G1	W/F	x				
3-17	3-G1	W/S	x				
3-20	5-G1	W/F		x	x		Sub Surface Crack
3-20	5-G1	W/S		x	x		Transverse Cracks
3-20	CF1	---	x				
3-27	BP-3	---	x				

in accordance with the requirements of AASHTO/AWS D1.5 ( ) Bridge Welding Code.
year

Inspector _____ Manufacturer _____

Signature _____

Virginia Test Method – 32

Depth Test of Asphalt Concrete Base Course – (Asphalt Lab)

November 1, 2000

A. Conventional Method

1. Scope

This method describes the tolerance in base course pavement thickness and frequency of pavement cores.

2. Procedure

For the purpose of establishing corrections to be made in asphalt concrete base courses found to be excessive or deficient, a core will be drilled at intervals of not more than 0.25 miles (0.4 km) for each 24 ft. (7 m) pavement width. When the measurement of any core indicates a deviation of more than plus or minus 0.5 in. (13 mm) from the plan thickness, additional borings shall be made 25 ft., (8 m) measured longitudinally on each side of the deficient core. If both of these additional borings are found to be within the 0.5 in. (13 mm) tolerance, no further borings will be made for this zone of deficiency or excess.

If either or both are deficient or excessive by more than the 0.5 in. (13 mm) tolerance, special borings will be made in each direction at 100 ft. (30 m) intervals measured longitudinally from the original boring until the thickness is found to be within the 0.5 (13 mm) tolerance, thus establishing the boundaries of the zone of deficiency or excess.

A separate boring will be taken for each intersection, entrance, crossover, storage lane, ramp, etc. having an area of 50 yd^2 (42 m^2) more. If this boring is found to be deficient or excessive by more than the 0.5 in. (13 mm) tolerance, 2 additional borings will be made in the area represented and the average thickness of the 3 borings will be considered the depth of the area.

Corrections or payment adjustment to be made will be in accordance with the Road and Bridge Specifications.

B. Statistical Method

1. Scope

This method described the procedures to be used in determining the base course pavement thickness and frequency of pavement cores taken in a stratified random manner. A lot of materials is defined as the quantity being tested for acceptance, except that the maximum lot size will be one mile (1.6 km) of 24 ft. (7 m) width base course. The randomization procedure used will be at the discretion of the Engineer.

2. Procedure

For the purpose of determining the thickness of asphalt concrete base course, samples will be taken from the lot in a stratified random manner at the following rate:

Lot Size	# Samples Required
0 - 1/2 Mile (0 – 0.8 km)	2
1/2 - 3/4 Mile (0.8 – 1.2 km)	3
3/4 - 1 Mile (1.2 – 1.6)	4

A separate boring will be taken from each intersection entrance, crossover, storage lane, ramp having an area of 50 yd^2 (42 m^2) or more. The boring will not be taken at random; however, care is to be taken not to set up a uniform pattern of testing. The tolerance for an individual test result shall apply.

It is not the intent of this test procedure to prohibit the sampling and testing of the material at any location visually determined to be out of specification tolerance for an individual test.

Corrections or payment adjustments to be made will be in accordance with Road and Bridge Specifications.

Suggested Randomization Procedures

Longitudinal Distance Number Drawn – 72 72% of 1320 = 950 Transverse Location Number Drawn – 3 Third Quarter	1. Lot Size - 1 Mile (1.6 km) Lot Size to be stratified to 1320 ft. (402 m) per depth check. 2. Number of depth checks per lot – 4. 3. To determine longitudinal distance, use one can. Place in can numbers 0 through 9 inclusive.
Longitudinal Distance Number Drawn – 98 98% of 1320 – 1294 Transverse location Number Drawn - 1 First Quarter	Draw one number and record. Place number back in can. Shake can, draw second number, and record. The 2-digit number drawn would represent the percentage of distance to be traveled from the beginning station number. (Number 00 would be 100%).
Longitudinal Distance Number Drawn – 00 100% of 1320 – 1320 Transverse Location Number Drawn – 4 Fourth Quarter	4.To determine the transverse location of a 24 ft. (7 m) pavement: Use one can, place in it Numbers1 through 4 inclusive. Draw number, then visually quarter the Roadway width beginning at the right edge of the pavement facing in the direction of station numbering. Perform depth check at the approximate center of the quarter selected by drawing Number 1, 2, 3, 4.
Longitudinal Distance Number Drawn – 42 42% of 1320 = 554 Transverse Location Number Drawn – 2 Second Quarter	5. Location to be tested using example shown at left and assuming a beginning Station 50+00:

1st Test - Sta. 50+00 + 9+50 = Sta. 59+50
Third Quarter

2nd Test - Sta. 50+00 + 13+20 = 63+20 + 12+94 = Sta. 76+14
First Quarter

3rd Test - Sta. 63+20 + 13+20 = 76+40 + 13+20 = Sta. 89+60
Fourth Quarter

4th Test - Sta. 76+40 +12+20 = 89+60 + 5+54 = Sta. 95+04
Second Quarter

The suggested procedure is for a one mile pavement 24 ft. (7 m) width. For other lengths, the 2-digit number would be the percentage of that length. The above procedure is a suggested procedure. Other approved randomization procedures may be used.

Virginia Test Method – 33

Visual Inspection of Fabricated Steel – (Structures)

September 12, 2006

1.0 Scope

1.1 This method outlines the procedures to be used for visual inspection of fabricated steel.

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

1.3 QA Inspectors shall adhere to all safety regulations and wear typical safety equipment Specified by the fabricator.

1.4 QC Inspector shall be in the fabrication shop at all times when work is being done for VDOT projects.

2.0 Specifications and Documents

2.1 Inspectors shall have the specifications and reviewed shop drawings available for reference.

3.0 Inspector - Definition

3.1 The quality control (QC) Inspector is the duly designated person who acts for and in behalf of the contractor on inspection, testing, and quality matters within the scope of the contract documents. The Inspector shall be a currently registered AWS Certified Welder Inspector (CWI), or previously certified as a welding inspector under the provisions of AWS QC1 provided there is acceptable documentation that the Inspector has remained active as an Inspector of welded steel fabrication since last being certified, there is no reason to question the Inspector's ability and shall be approved by the State Material Engineer

3.2 The quality assurance (QA) Inspector is the duly designated person who acts for and in behalf of the Engineer and owner on all manners within the scope of the contract documents and the limit of authority delegated by the owner.

3.3 When the term *Inspector* is used without further qualification, it applies equally to QC and QA as defined in 3.1 and 3.2.

4.0 Equipment

4.1 Inspectors shall have the necessary equipment to perform inspection.

5.0 Procedures

5.1 The inspector shall verify with shop management that there is an understanding as to the methods and procedures to be followed in all details of fabrication and that shop equipment is capable of producing work equal to that of accepted industry standards. The inspector shall give careful attention to the quality of workmanship, accuracy of punching, care in assembly alignment, and torquing of high-strength bolts. Frequent attention to details shall be made during fabrication so that errors and defects may be detected as soon as possible.

5.2 The inspector shall insure that members are fabricated from the designated type of steel and shall examine the steel for surface and shape defects prior to fabrication. Each piece

of steel, other than AASHTO M270-36 non-primary stress members, shall be identified with the heat number legibly marked. Steel, other than AASHTO M270-36, shall be marked with the AASHTO M160 color code or material designation.

5.3 The inspector shall insure that proper preparation is made of material to be welded, that surfaces to transmit bearing are in proper contact, that proper welding procedures are followed, that electrodes meet the specification and verify that only qualified welders, with current certification covering the type of welding involved, are employed in the work. Welds shall be checked for accuracy and proper functions. Shear studs shall be checked for alignment and fusion. Watch for unauthorized flame cutting, re-entrant cuts and other stress risers.

5.4 Check connections for clearance, matching of holes and that no chips or drillings remain between contact surface. See that reamed holes are cylindrical and free of burrs. See that splices are properly fitted and that camber blocking or corresponding equipment is used in assembling girders before reaming. Check splice members and other assembled members for matchmarks. See that all loose pieces are bolted in place for shipment.

5.5 The inspector shall check each paint container to determine if the paint has been pre-tested or is on the VDOT approved list. A letter of certification from the manufacturer shall be submitted to the State Materials Engineer. See that weather conditions are satisfactory for painting and the paint is applied to dry and properly cleaned surfaces. Check surface profile prior to paint application as well as quality and thickness of paint after curing. See that no material is loaded until the paint has dried or cured sufficiently to resist damage from handling and shipping.

5.6 Check for "rights" and "lefts" and for number of parts. Inspect for twists, bends and kinks in finished members. Check sole plates for flatness and contact with flanges. Verify that camber has been measured and pieces have erection marks. See that small parts are properly boxed or prepared for shipment. Check all fasteners for proper identification.

5.7 Bearing plates and bearing assemblies shall be checked for flatness and surface finish. Verify application of epoxy and grit or protective coatings to specified surfaces.

5.8 Material, including boxes or containers of small parts shall be marked with the inspector's stamp which shall be a company seal or VDOT stamp as appropriate.

6.0 Mill Analysis and Certifications

6.1 Unless otherwise directed by the State Materials Engineer, the inspector shall maintain on file for a period of seven (7) years from the last day of shipment one (1) copy of mill analysis and certification for material shipped form the fabricating plant. The inspector shall designate on each qualified mill analysis the piece number of flanges, webs, rolled beams and cover plates. A detailed summary of mill analyses for each structure shall be filed with the mill analysis. In addition, one (1) copy of the summary shall be submitted to the State Materials Engineer, (see Figure 1).

6.2 The inspector’s files will be audited at random by the State Materials Engineer.

Summary of Mill Analysis

Project: 0095-076-F14,C505, B645, B646, B658 **Bridge No:** B646

Piece Mark	Description	Heat No.	Reference #
120A1	WEB	C6193	31
	TF	C6235	21
	BF	C6235	21
121A2	WEB	C6217	30
	TF	C6235	21
	BF	C6235	21
122A3	WEB	C6094	32
	TF	C6235	21
	BF	C6235	21
123A4	WEB	C6217	30
	TF	C6235	21
	BF	C6235	21
124D1	WEB	C6269	14
		C6264	15
	TF	C6270	6
		C6264	13
	BF	C5963	51
		C6420	19
127D2	WEB	C6269	14
		C6214	24
	TF	C6270	6
		C6264	13
	BF	C5963	51
		C6420	19
130D3	WEB	C6269	14
		C6217	23
	TF	C6270	6
		C6264	13
	BF	C5963	51
		C6420	19
133D4	WEB	C6269	14
		C6094	22
	TF	C6270	6
		C6264	13
	BF	C5963	51
		C6420	19
125DE1	WEB	C6214	29
	TF	C6420	18
		C6541	4
		C6420	17
	BF	C6420	18
		C6541	7
		C6420	17

Figure 1

7.0 Reports

7.1 The QA inspector shall furnish reports for material shipped, showing the project number, description and amount of material. Reports shall be standard forms and shall indicate that the material has been inspected. The report must be signed by an Inspecting Agency Official or when applicable the State Employee Inspector. Separate reports shall be submitted for each bridge structure, (see Figure 2).

Reports shall carry forward a successive report number.

7.2 Distribution of reports:

3 copies to VDOT Materials Division

ABC INSPECTION SERVICE
123 FAR STREET
ANYWHERE, USA 09876

Report No: 1
Fabricator No:9334H
Date:1/21/05

REPORT OF SHOP INSPECTION OF STRUCTURAL STEEL

Fabricator: Carolina Steel Corporation, Colfax, NC

Project No: 0064-122-114, C507, B612, B613, C509
0064-134-104, C505

Consigned To: Archer-Western Contractors, Limited

Reported To: Virginia Department of Transportation

Member	Piece Mark	Number Pieces	Member	Piece Mark	Number Pieces
Anchor Bolts/Nuts	100A1	12			
Elastomeric Pads	101P1	2	Beam	5A1	1
Elastomeric Pad	101P2	1			
Bearing Assembly	102P1	3	Beam	6B1	1
Plate Washers	102W1	12			
No. 1 Paint	103FP14	1Gal.	Beam	5C1	1
Canvas Pads	103P1	9			
Diaphragms	106D1	3			
Diaphragms	106D2	4			
Diaphragms	106D3	3			
7/8X21/2 HSBT	106FP40	165			
7/8 HWASH	106FP41	330			
Beam	104A1	1			
Beam	105B1	1			
Beam	104C1	1			

Bill of Lading No. A

Date Shipped: 1/20/05
Weight This Report: 14,728 lbs.*

Shop Inspector: J. H. Martin

To Be Used On Bridge No: B613

Paint: Davis P-139 Primer

cc: 3 VDOT

Respectfully Submitted,

Joe D. Doe
President

Note: Metric projects shall use metric units in all reports.

Figure 2

Virginia Test Method – 34

Deleted - *Joint Sealers*
(Two-Component - Cold Applied)

June 1, 1991

Virginia Test Method – 35

Deleted - (See AASHTO T 164)

Virginia Test Method – 36

Quantitative Extraction of Bitumen
From Asphalt Paving Mixtures
By the Reflux Method – (Asphalt Lab)

November 1, 2000

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

l. 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 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	(4.75 mm)	400 g
⅜	(9.5 mm)	500 g
½ in.	(12.5 mm)	1000 g
¾ in.	(19.0 mm)	1200 g
1 in.	(25 mm)	1400 g
1 ½ 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-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 Method – 37

Determining Insoluble Residue Content of Carbonate Aggregates – (Chemistry Lab)

November 1, 2000

1. Scope

This method outlines the laboratory procedure for determining the percent of insoluble residue contained in a sample of carbonate aggregate.

2. Apparatus

a. Sieves - One – 0.5. in. (12.5 mm) and One – No. 8 (2.36 mm) standard laboratory sieve.
b. Scales - Accurate to 0.1 gram and a capacity of at least 500 grams.
c. Acid - Concentrated hydrochloric (37%) - Technical Grade.
d. Oven - Capable of maintaining a temperature of 230 ± 9 °F (110 ± 5° C).
e. Containers - One 0.5 gallon (1.9 L) jar for each sample.

3. Procedure

a. Existing quarries - From a stockpile sample of approximately 50 lbs. (23 kg), remove the plus 0.5 in. (12.5 mm) and minus #8 material by sieving. The remainder is processed through a sample splitter to obtain a test sample of approximately 200 grams.

b. Prospective Quarries - Collect approximately 500 grams of rock from each rock type to be quarried, crush to minus 0.5 in.(12.5 mm) and remove minus No. 8 (2.36 mm) material. Split sample as in 3a.

c. Dry the sample to constant weight at a temperature of 230 ± 9° F (110 ± 5° C) . Weigh to the nearest 0.1 gram and transfer to a 0.5 gallon (1.9 L) jar. Then add 400 ml of tap water.

d. Introduce into the jar 2 ml of concentrated hydrochloric (HCL) acid (37%) for each gram of rock. CAUTION: Proper precautions should be taken in the handling of concentrated acids. Work under a laboratory hood, wear eye protection, gloves, and suitable laboratory clothing. The laboratory should be equipped with an emergency shower.

e. Stir, periodically, until all reaction (Bubbling) ceases. This normally takes 24 to 48 hours.

f. After all reaction ceases, wash insolubles free of acid by filling the jar with tap water, allow the material to settle for 24 hours, and pour off the clear liquid. Repeat this procedure two (2) more times.

g. After the third cycle, wash the insolubles into an evaporating dish, dry to constant weight at a temperature of 230 ± 9° F (110 ± 5° C) and weigh to the nearest 0.1 gram.

4. Calculation

The percent insolubles is determined as follows:

$$\%\text{insolubles} = \frac{Weight\ of\ \text{Re}sidue}{Weight\ of\ Original\ sample} x100$$

Virginia Test Method – 38

Depth Test of Cement or Lime Stabilized Subgrade, Aggregate Bases, Subbase, Select Materials and Aggregate Shoulder Materials – (Soils Lab)

October 7, 2014

A. Conventional Method

This method describes the depth test for cement or lime stabilized subgrade, consisting of material-in-place or imported material other than aggregate base, subbase, or select material.

For the purpose of measuring the thickness of the layer in question, a slit trench shall be made to the bottom of the layer, a straightedge laid across the top of the trench, and the depth of layer measured in the center of the trench at right angles to straightedge from bottom of layer to bottom of straightedge. The measurement shall be made to the nearest 0.1 inch.

In cases in which the depth determined is deficient or excessive beyond the allowable specification tolerances, it will be necessary to define or bracket this area with additional depth tests. It will be necessary in this case to make additional depth measurements 25 ft, measured longitudinally, on each side of the test point found to be deficient or excessive. If the additional measurements are found to be within specification tolerances, further testing will not be necessary in this particular zone or area. If either or both of the additional tests are deficient or excessive, then it will be necessary to make additional depth measurements at intervals of 100 ft, measured longitudinally from the location of the original test point found to be deficient or excessive, until the depth is found to be within specification tolerances in both directions.

B. Statistical Method

This method describes the depth test for aggregate bases, subbase, and select materials, whether treated with cement or lime or untreated, and aggregate shoulder material.

A suggested randomization procedure is as follows. Other approved randomization procedures, such as a random number generator, may be used.

1. Lot Size – Refer to the Materials Division Manual of Instructions (MOI), Sec. 309.02 Depth Control, for lot sizes that shall be used.

2. Number of depth checks per lot – Refer again to MOI, Sec. 309.02, for number of depth checks that shall be made.

3. To determine longitudinal distance, use one can. Place in can numbers 0 through 9, inclusive. Draw one number and record it. Place number back in can. Shake can, draw second number, and record it. The 2-digit number drawn represents the percentage of distance to be traveled from the beginning station number. (Number 00 would be 100%).

4. To determine transverse location, use one can. Place in it numbers 1 through 4, inclusive. Draw number, then visually quarter the roadway width beginning at the right edge of the pavement facing in the direction of station numbering. Perform depth check at the approximate center of the quarter selected by having drawn Number 1, 2, 3, or 4.

Example, assuming a beginning Station 50+00:

1st Sublot Test

Longitudinal Distance	Transverse Location
Numbers Drawn – 4 and 9	Number Drawn – 4
49% of 2640 ft (805 m) = 1294 ft	Fourth Quarter

2nd Sublot Test

Longitudinal Distance	Transverse location
Numbers Drawn – 8 and 9	Number Drawn - 1
89% of 2640 ft (805 m) = 2350 ft	First Quarter

3rd Sublot

Longitudinal Distance	Transverse Location
Numbers Drawn – 0 and 0	Number Drawn – 1
100% of 2640 ft (805 m) = 2640 ft	First Quarter

4th Sublot

Longitudinal Distance	Transverse Location
Numbers Drawn – 3 and 0	Number Drawn – 2
30% of 2640 ft (805 m) = 792 ft	Second Quarter

lst Test - Sta. 50+00 + (*12+94*) = Sta. 62+94
Fourth Quarter

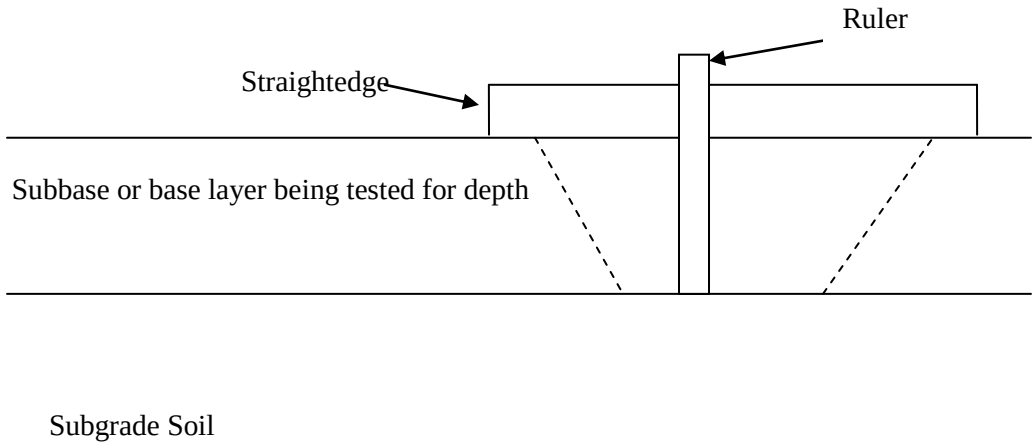
2nd Test - Sta. (50+00 + *26+40*) + (*23+50*) = Sta. 76+40 + (*23+50*) = Sta. 99+90
First Quarter

3rd Test - Sta. (76+40 + *26+40*) + *26+40* = Sta.102+80 + (*26+40*) = Sta. 129+20
First Quarter

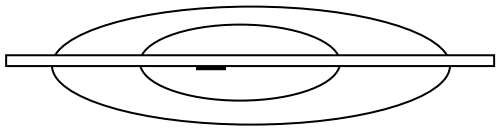
4th Test - Sta. (102+80 + *26+40*) + *7+92* = Sta. 129+20 + (*7+92*) = Sta. 137+12
Second Quarter

This suggested procedure is for 2 miles of material. For any other length, the 2-digit number would be the percentage of that number. On shoulder material, use the same procedure as described above, except alternate sides of the road. The above is a suggested procedure.

For the purpose of measuring the thickness of the layer in question, a slit trench shall be made to the bottom of the layer, a straightedge laid across the top of the trench, and the depth of layer measured in the center of the trench at right angles to straightedge from bottom of layer to bottom of straightedge. The measurement shall be made to the nearest 0.1 inch. For specification compliance, all the individual thickness measurements in the lot shall be averaged and rounded to the nearest 0.05 inch.



Sketch of Test Method – Sectional View



Sketch of Test Method – Plan View

Virginia Test Method – 39

Measuring Waterproofing Effectiveness of Membrane-Pavement Systems – (Physical Lab)

November 1, 2000

1. Scope

1.1 This method describes the procedure for determining the waterproofing effectiveness of membrane-pavement systems as applied to bridge decks. The tests are to be performed on the asphalt pavement overlay surface covering the waterproofing membrane.

2. Apparatus

2.1 Ohmmeter, 20,000 ohms per volt rating.

2.2 No. 18 insulated wire, Belden test probe wire or equivalent, two spools, 125 ft. (38 m) each, with connectors.

2.3 Copper plate, 12 x 12 x l/8 in. (300 mm x 300 mm x 3 mm), with clips for connecting the ohmmeter and means to connect a 36 in. wooden handle.

2.4 Polyurethane sponge, 12 x 12 in. to be attached to the copper plate by rubber bands.

2.5 Pressure spray can, 3 gallon (11 liter) capacity.

2.6 Stone cutters chisel, 3/4 in. (19 mm) face.

2.7 Hammer.

3. Reagent

3.1 Wetting agent, Aerosol OT manufactured by the American Cyanamid Company.

4. Procedure

4.1 Prepare surface to be tested by removing all foreign material by sweeping and/or scraping. Do not use water to clean. Surface must be dry and clean before testing.

4.2 Divide bridge deck into workable sub-areas similar to that illustrated in Figure 1. If the bridge is to be kept open to traffic, it is advisable to mark and test one lane at a time. Locate a reinforcing bar or other connection to the reinforcing steel in the bridge deck. A positive connection to the top mat of the reinforcing steel is desirable; however, if this is not feasible, the bridge railing, expansion joints, light standards, draining scuppers, or other exposed steel may provide a positive connection to the reinforcing steel.

4.2.1 A check of the resistance level at various distances along an exposed portion of the concrete must show a constant resistance level, thus indicating a positive connection to the reinforcing steel.

4.3 Uncoil an ample length of wire to reach all areas to be tested, attach the minus (-) jack of the ohmmeter to the reinforcing steel and the plus (+) jack to the 12 x 12 x 1/8 in. (300 mm x 300 mm x 3 mm) copper plate. Then wet the sponge.

4.3.1 Check ohmmeter battery for satisfactory charge, then zero ohmmeter dial indicator.

4.3.2 In order to check for proper overall equipment operation, place copper plate on exposed concrete deck curbing and observe resistance readings on the ohmmeter. These readings will normally vary from 1000 to 3000 ohms per sq. ft. (10, 800 to 32, 300 ohms per m^2).

4.4.3 Using water containing 1 oz. per gallon (7.5 grams per liter) of wetting agent, wet a spot thoroughly and repeatedly at each grid intersection large enough to accommodate the 1 ft^2 (300 mm) test plate; taking care that free surface moisture areas (puddles) do not connect with each other.

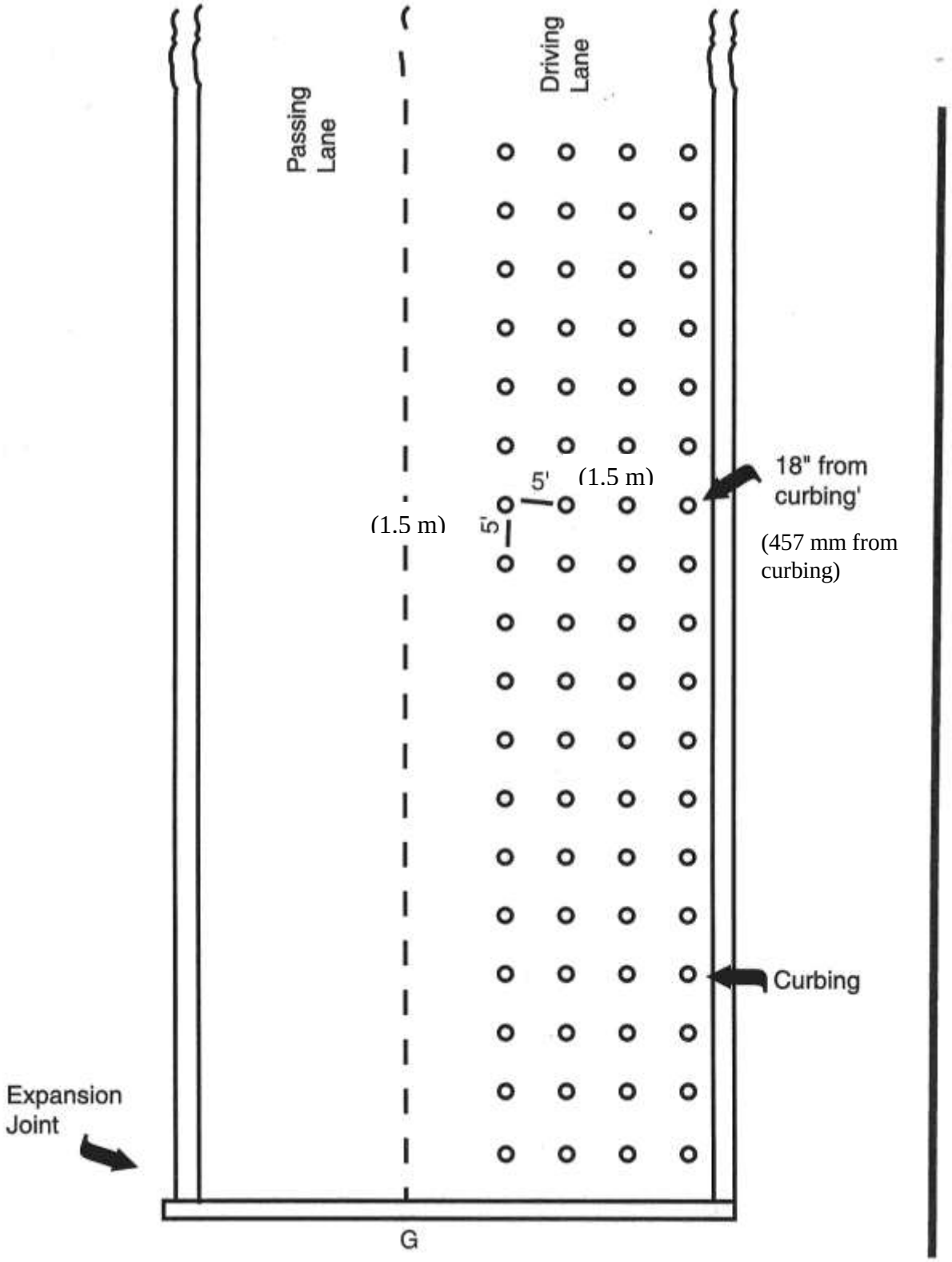
4.3.4 In order to assure proper moisture penetration through the asphalt pavement to the membrane, select one grid intersection for a check point that is dense-graded and well-compacted. Apply water to this point and all other test points on the grid pattern. Allow several minutes for moisture penetration. Then take a resistance reading with the ohmmeter at the check point. Repeat the procedure until it is determined that the resistance has stabilized at its lowest point. The wetting process should not require more than 15 to 20 minutes to complete.

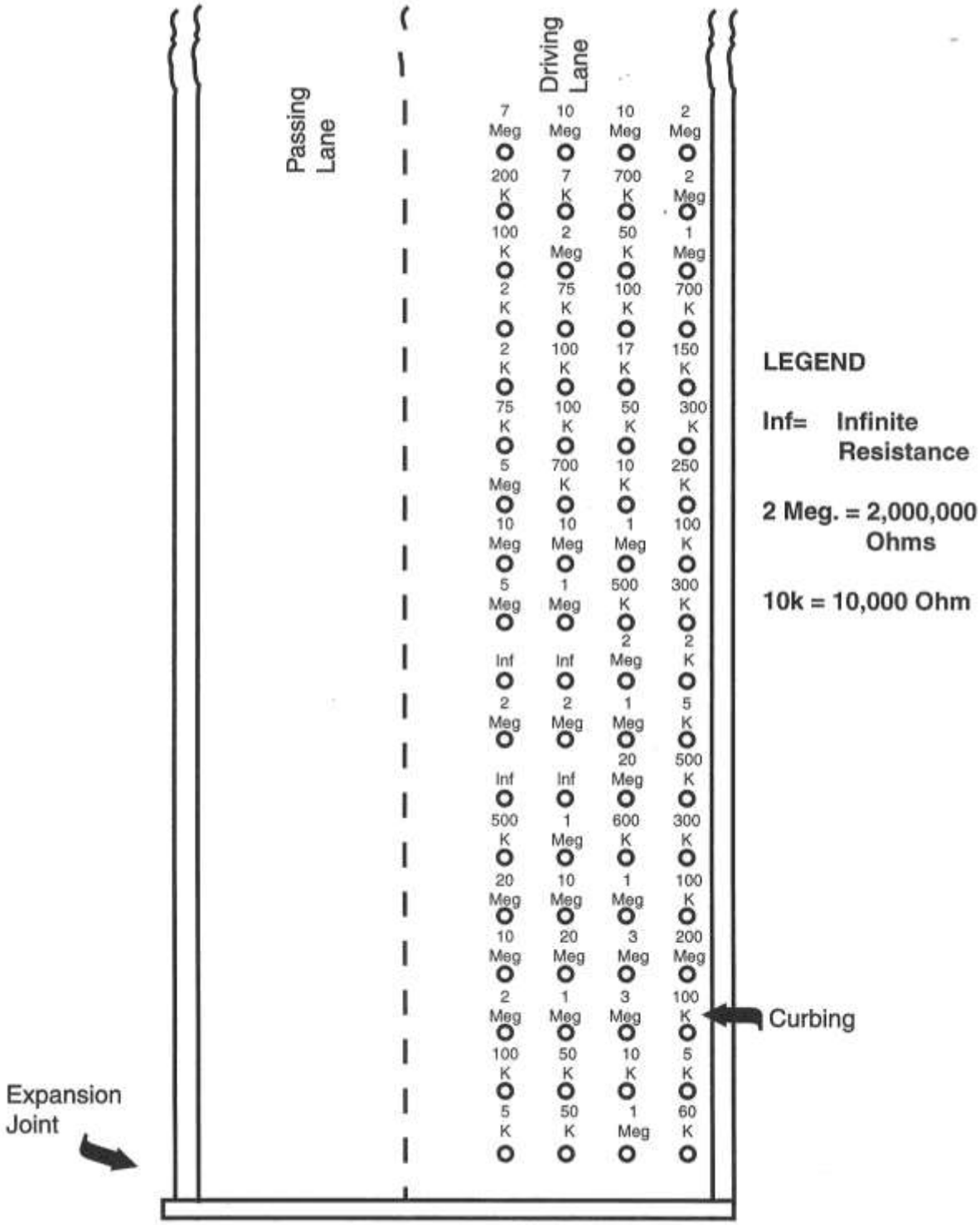
4.5 Proceed to test and record resistance values at each grid intersection. (See Figure 2)

4.6 If it is desired to further define areas for which the electrical resistance is lower than that required by the specifications, a grid pattern to cover grid intersections not previously examined may be made and tested. Before this is done, sufficient time must be allowed for the moisture from the previous testing to dissipate. This length of time will depend on the density and thickness of the pavement as well as the ambient and pavement temperatures.

5. Reporting

5.1 Report resistance values on a grid sheet similar to that shown on Figure 2. Outline on this grid sheet any defective areas that fail to meet the minimum requirements of the specifications. Calculate and report the percentage of deck area that fails to meet specification requirements. Outline these same areas on the bridge deck. Make notations on the grid sheet for repairs or corrections to be made.


Passing Lane
Driving Lane
5'
(1.5 m)
(1.5 m)
5'
18" from curbing'
(457 mm from curbing)
Curbing
Expansion Joint
G


Passing Lane
Driving Lane
7 Meg
10 Meg
10 Meg
2 Meg
200 K
7 K
700 K
2 Meg
100 K
2 Meg
50 K
1 Meg
2 K
75 K
100 K
700 K
2 K
100 K
17 K
150 K
75 K
100 K
50 K
300 K
5 Meg
700 K
10 K
250 K
10 Meg
10 Meg
1 Meg
100 K
5 Meg
1 Meg
500 K
300 K
Inf
Inf
2 Meg
2 K
2 Meg
2 Meg
1 Meg
5 K
Inf
Inf
20 Meg
500 K
500 K
1 Meg
600 K
300 K
20 Meg
10 Meg
1 Meg
100 K
10 Meg
20 Meg
3 Meg
200 Meg
2 Meg
1 Meg
3 Meg
100 K
100 K
50 K
10 K
5 K
5 K
50 K
1 Meg
60 K
Curbing
Expansion Joint
LEGEND
Inf= Infinite Resistance
2 Meg. = 2,000,000 Ohms
10k = 10,000 Ohm

Virginia Test Method – 40

Determining Cement Content of Freshly Mixed Cement-Aggregate Mixtures – (Chemistry Lab)

November 1, 2000

1. Scope

1.1 This method of test is intended for determining the cement content of cement-aggregate mixtures sampled at the central mix aggregate plant.

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 Balance - A balance having a capacity of at least 1,000 grams with a sensitivity of at least 0.1 gram.

2.2 Timer - A timer with a capacity of 10 minutes or more and a sensitivity of at least 0.1 second.

2.3 Glassware - 25 ml graduated cylinder, 1,000 ml cylinder, 2000 ml volumetric flask, 50 ml burettes, 10 ml volumetric pipettes, 250 ml Erlenmeyer flasks, medicine droppers.

2.4 Plasticware - 2 qt. (1.9 L) polyethylene containers with snap-on covers, 12 in. (305 mm) diameter plastic funnel, 5 gal. (19 L) polyethylene bottles for ammonium chloride, 5 gal. (19 L) polyethylene bottles for demineralized water.

2.5 Burette Stand for 50 ml burette.

2.6 Magnetic Stirrer and Stirring Bar.

2.7 Stirring Rods - Glass stirring rods approximately 12 in. (300 mm) long.

2.8 Indicator Paper - Supply of indicator paper, pH range from 10 to 14.

2.9 Pipette Filler.

2.10 Sample Splitter - Maximum size l l/2 in. (38 mm)

3. Reagents

3.1 Ammonium Chloride Solution (10%) - Transfer 1893 g of U. S. P. granular ammonium chloride (NH_4C1) to a 5-gal. (19 L.) plastic bottle.

Make up to 5 gallons (19 L.) with distilled or demineralized water and mix well.

3.2 EDTA Solution (0.1 M) - Dissolve 74.5 g of reagent grade disodium (ethylenedinitrilo) tetraacetate dehydrate ($Na_2C_{10}H_{14}N_2O_82H_2O$) powder in about one litre of warm, distilled or demineralized water in a beaker. Cool to room temperature, transfer quantitatively to a 2-liter volumetric flask and make to the mark with distilled or demineralized water. Store in polyethylene bottle.

3.3 Hydroxy Napthol Blue may be used as the indicator.

3.4 Sodium Hydroxide Solution (50%) - Add 500 g of reagent grade sodium hydroxide (NaOH) pellets in 600 ml of distilled or demineralized water and allow to cool to room temperature. Dilute to one litre with distilled or demineralized water. Store in plastic bottle. Dilute 1:1 with distilled or demineralized water for use. Caution: Solution shall be mixed in the order given to avoid spontaneous reaction.

3.5 Triethanolamine Solution (20%) - Dilute 100 ml of reagent grade triethanolamine ($HOCH_2CH_2$) 3 N to 500 ml with distilled or demineralized water.

4. Procedure for Preparing Calibration Curve

4.1 From the materials to be used for construction, prepare 3 sets of duplicate samples at the design moisture content and containing the following amounts of cement:

Set 1. Two (2) samples at 75 percent of the design cement content.

Set 2. Two (2) samples at 100 percent of the design cement content.

Set 3. Two (2) samples at 125 percent of the design cement content.

Using a sample size of 600 grams for each sample, compute the quantities of aggregate, cement and water as follows:

$$W_a \text{ (total weight of aggregate, g)} = \frac{\text{Sample Size}}{(1 + M/100)\,(1 + C/100)}$$

$$W_r \text{ (weight of material retained on No. 4 (4.75 mm sieve)} = \frac{R}{100} \times W_a$$

$$W_f \text{ (weight of material passing No. 4 sieve, (4.75 mm) g)} = W_a - W_r$$

$$W_c \text{ (weight of cement, g)} = \frac{C}{100} \times W_a$$

$$V_w \text{ (volume of water, ml)} = \frac{M}{100}\,(W_a + W_c)$$

Where:

M = design moisture content, percent by dry weight
C = cement content, percent by dry weight of aggregate, and
R = percent material retained on No. 4 (4.75 mm) sieve.

For each sample, mix the aggregate and cement thoroughly to a uniform color. Add the water and mix thoroughly.

Titrate each 600 g sample as described under Procedure for Titration. After titrating the 6 samples, construct a graph showing ml of EDTA solution vs. per cent cement by weight using average figures from Sets 1, 2, and 3.

A separate calibration curve shall be prepared for each brand, type and source of cement. When Type I-P is used, a separate calibration curve shall be prepared for each shipment in which the percent of fly ash varies by more than ±3.0 per cent from the quantity for which a curve has been established.

5. Procedure for Test Samples

5.1 At the central mix aggregate plant, samples of the cement-aggregate mixture shall be taken at the completion of mixing. The samples are to be tested immediately or placed in covered plastic containers and tested within one hour of the completion of mixing.

For testing, weigh a 600 g portion and titrate as described under Procedure for Titration.

Note 1 - If a correction is to be made for variations in moisture content, determine the moisture content (M') of a separate portion of the material passing a No. 4 (4.75 mm) sieve. Computation for the correction are given under Calculations, Note 4.

6. Procedure for Titration

6.1 Place each 600 g sample in a 2-qt. (1.9 L) polyethylene container and add 1,200 ml ammonium chloride solution. Place cover on the container and shake the mixture for 2 minutes (±2 seconds). Allow the mixture to settle for 4 minutes (±2 seconds). Pipette a 10 ml aliquot of the supernatant solution into a 250 ml Erlenmeyer flask and add 100 ml of distilled or demineralized water. While thoroughly mixing on a magnetic stirrer, add drops of sodium hydroxide solution until a pH between 13.0 to 13.5 is obtained as measured by the indicator paper. Use stirring rod to transfer drops of solution to indicator paper, add 4 drops of triethanolamine solution and then add about 0.2 g of the indicator powder. While the solution is being stirred on the magnetic stirrer, titrate with EDTA and record the quantity in ml to a pure blue endpoint.

Note 2 - A sharper endpoint may sometimes be obtained by adding approximately half of the anticipated quantity of EDTA solution before the addition of sodium hydroxide.

Note 3 - All equipment must be kept scrupulously clean by thorough rinsing with distilled or demineralized water. All reagents must be stored in polyethylene containers.

7. Calculations

Read the cement content by dry weight directly from the calibration curve corresponding to the titration results in ml of EDTA for the test sample.

Note 4 - Variations of moisture content (above 2%) will have a slight effect on the accuracy of test. Correction for moisture variation may be computed as follows:

$$C' = \frac{1 + M'/100\ C}{1 + M/100}$$

Where: C' = percent cement corrected for moisture variation,

C = percent cement determined from test sample,

M' = percent moisture of test sample as determined in Paragraph 5, Note 1, and

M = design moisture content.

GENERAL INFORMATION

8. Miscellaneous

8.1 Size of sample - Obtain a 10 lb. (4.5 kg) sample. Split this sample over a splitter until about a 600 g sample is obtained. Weigh exactly 600 g as sample size for testing.

8.2 Sampling

8.2.1 In all cases, samples shall be taken in a stratified random manner.

8.2.2 When sampling from a truck, the truck should be divided into quadrants and the 4 samples shall be taken from randomized quadrants.

Virginia Test Method – 41

Bond Strength of Epoxy Resin Systems or Grouts Used With Concrete – (Physical Lab)

March 2, 2006

ASTM C 882 shall be followed, except as modified below:

7.2 Add - A laboratory external vibrator may be used in lieu of rodding to consolidate mortar.

Sections 10 thru 14 are completely replaced by the following:

10. Test Specimens for Bond Strength

10.1 Make one or more composite bond strength test specimen for each test condition; i.e. bonding hardened mortar to hardened mortar or bonding freshly-mixed mortar to hardened mortar. Sandblast, acid etch, or wire-brush the elliptical bonding surfaces. Then remove all loose surface materials by dry-brushing.

10.2 Specimens for epoxy bonding of hardened mortar to air dry hardened mortar for moisture sensitive bonding systems shall be dried for at least 4 to 7 days. All other moisture insensitive systems will be bonded with moist surfaces. Two mortar sections will be needed for each test specimen. Thoroughly mix the components of the bond system in the proportions recommended by the formulator. A mixing time of three minutes should suffice. The hardened mortar sections are supported by a specially fabricated metal holder to enable the placing of the specimens in a firm horizontal position. Brush the bonding system on the prepared mortar surface. Place the two halves of the specimen together, squeezing out the excess resin and keeping the joint horizontal. For L.V. epoxy, wrap masking tape around the periphery of the specimen joint close to each end to prevent the epoxy from flowing out of bonded joint. Place additional masking tape along the joint. Keep the bonded joint horizontal for 24 hrs., then after 24 hrs. remove all masking tape. Cure the test specimen for a total of 7 days in the moist room and then test for bond strength. (ASTM C 192).

10.3 Specimens for epoxy bonding of hardened mortar to freshly-mixed mortar. One hardened mortar section will be needed for each test specimen. Prepare the bonding specimen as described in Section 10.1. Then mix the components of the bonding system as described in Section 10.2. Brush the bonding system on the prepared moist surface. Place the primed moist specimen in the cylinder mold that has previously been lined with 3 or 4 mil polyethylene sheet. Support the mold so that the bonding surface of the mortar specimen is horizontal. Place a layer of freshly-mixed portland cement mortar over the primed surface to a depth of approximately 1/2 in (13 mm). Rod the layer with 15 strokes of the tamping rod, gently so as to disturb the layer of resin as little as possible. Place the mold in its normal position, and place additional mortar into the mold in two layers of approximately equal volume. Rod each layer with 15 strokes of the tamping rod. Distribute the strokes over the cross-section and make them deep enough to penetrate into the underlying layer. A laboratory external vibrator may be used in lieu of rodding to consolidate mortar. Strike off the surface of the top layer with a trowel and cover it with a glass or metal plate. Demold the test specimen after one day and cure as specified in Section 10.2 or ASTM C 192 for 7 days in the moist room.

10.4 Specimens for bonding hardened mortar to freshly-mixed grout. One hardened mortar section will be needed for each test specimen. Prepare the bonding specimen as described in Section 10.1. Then mix the grout according to the manufacturer's instructions. Place the moist specimen in the cylinder mold. Place a layer of freshly-mixed grout over the surface

to a depth of approximately 2/3 of the open volume. Rod the layer with 15 strokes of the tamping rod. Fill the rest of the mold and rod with 15 strokes of the tamping rod. Distribute the strokes over the cross-section and make them deep enough to penetrate into the underlying layer. A laboratory external vibrator may be used in lieu of rodding to consolidate the grout in one layer. Strike off the surface of the top layer with a trowel and cover it with a glass or metal plate. De-mold the test specimen after one day and cure as specified in Section 10.2 or ASTM C 192 for 7 days in the moist room.

10.5 Cap all test specimens as described in ASTM C 617.

11. Testing Procedure

11.1 Test all prepared specimens in compression as described in Section 4 of ASTM C 39, except that the specimen shall be loaded at a rate of approximately 20,000 lb_f /min (1.48 kN/s). The loading rate should be adjusted to break the cylinder within an approximate time limit of one to two minutes.

12. Calculation

12.1 Calculate the bond strength of the epoxy resin bonding system by dividing the load carried by the specimen at failure by the horizontal surface area of the 3" x 6" (75 mm x 150 mm) cylinder. Repeat or correct the compressive psi if any voids are found in the bond on inspection after test. The results shall meet the bond strength requirements of Table II – 21 for epoxy systems or Sec. 218.03(d) (1000 psi) (6.9MPa) for high strength grouts.

Virginia Test Method – 42

Thermal Shear or Shrinkage Test
of an Epoxy Overlay Mortar Applied to Concrete – (Physical Lab)

November 1, 2000

1. Scope

1.1 This method covers the bond of an epoxy resin overlay system to portland cement concrete when subjected to temperature cycles of 5° - 110° F (-15° - 43° C).

2. Procedure

2.1 Blocks of A3 concrete are cast in pans and the edges sawed at right angles to the top to make a block 11 x 8 x 1.5 in (280 x 200 x 38 mm). The top circumference of the block is taped so that 0.375 to 0.500 in (10 to 13 mm). extends above the top level surface. A mortar mixed with ASTM C 109 sand and the epoxy proportioned as per the manufacturer's recommendations is placed on the block and consolidated with a laboratory vibrator and struck off smooth with a straight edge. The concrete overlay is allowed to cure in air for 3 days and in the moisture room 4 days, after which it is subjected to 10 cycles 17 hours in freezer at 5° F (-15° C) and 7 hours at 110° F (40° C). The surface of the epoxy overlay is measured before and after cycling to a tolerance of l/l6 in (1.6 mm).

3. Significance

3.1 Shearing, shrinkage, or expansion of the epoxy mortar is an indication of probable incompatability of the epoxy system applied to a concrete surface or pothole and shall be cause for rejection. Also, evidence of scaling of the epoxy is cause for rejection.

Virginia Test Method – 43

Filler Content of Epoxy Resins
With Epoxide Equivalent Correction Factor – (Chemistry Lab)

January 2003

1. Scope

1.1 To establish a consistent method in which to analyze epoxy samples for filler content and to correct the Epoxide Equivalent value due to the filler.

1.2 The values stated in English 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. Summary of Test

The filler content of Component A is determined. The filler is removed from the epoxy resin in Component A before the epoxide equivalent is determined. Epoxide equivalent is corrected for the filler.

3. Apparatus and Chemicals

3.1 Apparatus

3.1.1 Laboratory Hood
3.1.2 Centrifuge tubes, stainless steel 50 ml with lid
3.1.3 Glass stirring rod.
3.1.4 Erlenmeyer flask, 50ml.
3.1.5 Centrifuge
3.1.6 Analytical balance capable of weighing 0.1 mg.
3.1.7 Evaporating dish, 75 mm
3.1.8 Disposable syringe, 10 ml
3.1.9 Muffle furnace

3.2 Reagents
3.2.1 Chlorobenzene

4. Procedure

4.1 Filler Content

4.1.1 Weigh the evaporating dish on an analytical balance to the nearest 0.1 mg and record the weight.

4.1.2 Tare the dish on the balance

4.1.3 Using a 10 ml disposable syringe, transfer 10g or more of Component A to the dish. Record the weight.

Ignite the dish and contents over a flame until the flames die out. Place the sample in a muffle furnace (550° C overnight).

Cool to room temperature in a desiccator.

Reweigh the dish + ash and record the weight.

Epoxy Equivalent

4.2.1 Transfer 0.4g of Component A into the bottom of a tared stainless steel centrifuge tube.

4.2.2 Record the weight to 0.1mg.

4.2.3 Add 10 ml Chlorobenzene and mix well with a glass stirring rod.

4.2.4 Add a lid to the tube and centrifuge the sample until a firm pellet is formed and the supernatant is clear.

4.2.5 After centrifuge has stopped, transfer the clear liquid to a 50 ml Erlenmeyer flask.

4.2.6 Determine epoxy content in this extract according to ASTM D1652 Method A.

Calculations:

Calculate weight of filler ash as:

(weight of dish + ash obtained in 4.1.6) – (weight of dish obtained in 4.1.1)

Calculate Filler correction factor as:

$$correction\ \ factor\,(F) = \frac{wt\ of\ \text{filler}\ ash}{wt\ of\ Comp\ A}$$

Calculate WPE with correction factor

$$WPE = (1 - F)\frac{1000(wt\ of\ sample)}{(Normality\ of\ HBr)(ml\ of\ HBr\ used)}$$

Virginia Test Method – 44

Radiographic and Ultrasonic Inspection of Groove Welds of Railroad Structures and Fracture Critical Members – (Structures)

November 1, 2000

1. Scope

1.1 Radiographic and ultrasonic inspection of groove welds shall conform to the requirements of the latest Virginia Department of Transportation Road and Bridge Specifications, AASHTO/AWS D1.5 and AASHTO Guide Specifications for Fracture Critical Non-Redundant Steel Bridge Members with additional requirements noted in the following procedures.

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. Welds to be Examined

2.1 Radiographic and Ultrasonic, Groove Welds:

1. Flange and web splices in girders.
2. Longitudinal stiffener splices in beams and girders.
3. Splices of rolled beams and cover plates.
4. Horizontal web splices in beams and girders.
5. Other splices with groove welds.

2.2 Ultrasonic only, Groove Welds:

1. Flange to web welds in girders.
2. Stiffener to web or flange welds in beams and girders.

3. Procedures

3.1 Welds requiring repairs shall be retested after the repairs are made.

3.2 Other requirements as noted in VTM-29 and VTM-30 shall be considered a part of this test method.

Virginia Test Method – 45

Deleted - ***Bituminous-Fiber Pipe***
Has Been Discontinued by AASHTO

Virginia Test Method – 46

Water Holding Capacity of Fiber Mulch – (Soils Lab)

November 1, 2000

1. Scope

This method covers the procedure to be used in determining the water holding capacity of fiber mulch.

2. Apparatus

a. Scale, capable of weighing to nearest 0.1 gram.
b. No. 200 mesh sieve, 8 x 2 in (203 – 51 mm).
c. Cover for sieve - may be aluminum foil.
d. Two 1000 ml graduated glass beakers.
e. Pan - used to partly submerge sieve.
f. Sink and/or area free of drafts to drain sample.

3. Procedure

NOTE: Demineralized or distilled water shall be used in this test procedure.

a. Determine the total percent moisture (m%) of fiber according to the following formula:

$$\text{Percent Moisture} = \frac{Wt_w - Wt_d}{Wt_w - Wt_c} \times 100$$

Wt_w = Wet weight of sample
Wt_c = Container weight
Wt_d = [1]Dry weight of sample

[1] *See VTM-47 for procedure on the determination of percent moisture in the fiber mulch samples.*

b. Weigh out samples from each of the bags received and determine the wet weight equivalent (Wt_{eq}) to 12 grams of oven dry fiber. Weigh to nearest 0.1 gram and place into a 1000 ml graduated cylinder. The wet equivalent weight is determined by the following formula:

$$Wt_{eq} = \frac{12}{1 - (m\%/100)}$$

c. Add 800 ml demineralized or distilled water to sample, stir and/or shake until thoroughly mixed. Allow to stand for 30 minutes.

d. Wet No. 200 (0.075 mm) sieve. Cover top of sieve with aluminum foil to retard evaporation. Prop sieve up at an angle of 30°- 45° and drain for 10 minutes. Remove cover and wipe excess water from outside surface of sieve, weigh immediately, and record weight (Wt_s) for use in step f.

e. Place sieve in pan and pour fiber onto screen. Add sufficient demineralized or distilled water to float fiber mulch inside of sieve. Stir, so that the fiber will form a uniform mat over the screen area. Carefully lift sieve and mat from the water. Cover top with aluminum foil to retard evaporation. Prop sieve up at an angle of 30° - 45° and drain for

10 minutes. Remove foil and wipe the excess water from outside surface of sieve and weigh immediately.

f. After thoroughly draining the specimen, obtain a net weight of wet fiber mulch mat by subtracting the wet sieve weight (Wt_s) determined in step d from the total wet weight of fiber mulch and sieve. Use the following to determine the net weight of wet fiber mulch mat (N_{wt}).

$$\text{Net weight } (N_{wt}) \text{ of wet fiber mulch } = T_{wt} - Wt_s$$

where:

T_{wt} = total weight of wet specimen and sieve
Wt_s = weight of wet sieve

g. Calculate and report the percent of Water Holding Capacity (WHC) by use of the following formula:

$$WHC\% = \frac{N_{wt} - 12}{N_{wt}} \times 100$$

Virginia Test Method – 47

Dry Weight of Fiber Mulch – (Soils Lab)

November 1, 2000

1. Scope

This method covers the procedure to be used in determining the moisture content and dry weight of fiber mulch as packaged.

2. Apparatus

a. Scale, capable of weighing 100 lb (45.4 kg). (to nearest 0.1 pound (0.045 kg))
b. Scale, capable of weighing to nearest 0.1 gram.
c. Oven, capable of maintaining 212 ± 4° F (100 ± 2° C)
d. (3) one gallon (3.8 L) containers
e. (3) No. 200 mesh (0.075 mm) screens to cover the containers

3. Procedure

a. Weigh bag of mulch as received. (Use this weight in step h.)
b. The percent moisture (%m) should be determined from the average results of three separate samples. Take one sample each from the top, center, and bottom portions of the bag.
c. For each sample, loosely fill a one gallon container of known weight with mulch to approximately one inch from the top of the container.
d. Weigh immediately and cover with the 200 mesh (0.075 mm) screen.
e. Dry in oven for 24 hours at 212° F (100° C) .
f. Cool to room temperature. Remove screen and weigh can and mulch.
g. Percent moisture (%m) is determined by the following formula:

$$\%m = \frac{A - B}{A - C} \times 100$$

Where: A = Original weight of container and mulch, in gm.

B = Weight of container and dry mulch, in gm.

C = Weight of container, in gm.

h. The total dry weight of the packaged fiber mulch is determined from the following formula:

$$\text{Dry Wt. of Packaged Product} = X - [(X)(Y)]$$

Where: X = Actual Wt. of mulch as packaged in lbs (kg) as determined in Step a. of this procedure.

$$Y = \frac{\text{Average \% m for 3 Samples}}{100}$$

The resulting calculated weight is compared with the weight printed on the bag. The resultant weight must be within ± 1.0 lb. (0.45 kg) of the printed bag weight to be approved.

Virginia Test Method – 48

Sampling Asphalt Paving Mixtures – (Asphalt Lab)

November 1, 2000

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" (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.

Virginia Test Method – 49

Deleted - Moisture in Asphalt Paving Mixtures

(use AASHTO T-164 8.2.3 Note 5.)

June 1, 1991

Virginia Test Method – 50

Deleted - (See AASHTO T 209)

Virginia Test Method – 51

Filtering Efficiency And Flow Rate Of A Filter Fabric – (Soils Lab)

May 16, 2012

1. Scope

This method covers the procedure to be used in determining the filtering efficiency and flow rate of a commercial filter fabric.

2. Apparatus

a. A flume 48 inches long and 32 inches wide by 12 inches high with a gutter attached to one side. (See Figure 1.)

b. Two 20-gallon mixing containers.

c. A stirrer on a 0.25-inch portable drill.

d. Stopwatch.

e. A DH-48 integrated water sampler or equivalent with 1-pint or 500-ml bottles.

3. Procedure

a. Stretch a sample of the fabric 39 inches long by 12 inches wide across the flume opening 32 inches wide and fasten securely in place to assure that all the sediment-laden water passes through the sample. Ensure that water is not able to pass under the fabric. Note: The flume opening is the standard length of a straw bale.

b. Elevate the flume to an 8 percent slope.

c. Pre-wet the fabric by passing 13 gallons of untreated, fairly sediment-free water through it (for example, tap or well water). If the fabric is not able to pass this quantity of water in 1 hour, pre-wetting may be ended. Pre-wetting may alternatively be accomplished by soaking the fabric in a container of the same fairly sediment-free water for approximately 10 seconds.

d. Mix 150 grams of a silt or clay soil in 13 gallons of the untreated water placed in one of the 20-gallon containers. The soil may be from a representative sample of project site soil if known at time of testing, or the soil may fit within the bands shown on the gradation curve in Figure 2, or it may meet the following gradation requirements:

Sieve Size (opening size)	Percent Passing
No. 10 (2.0 mm)	100
No. 40 (0.420 mm)	80-100
No. 100 (0.149 mm)	70-90
No. 200 (0.075 mm)	50-70

e. After uniformly mixing the solution, quickly dump the solution behind the fabric sample in the flume. Start the timer at dumping.

f. Rinse the mixing container with 1 or 2 quarts of the tap or well water and dump into the flume.

g. Time the flow of water through the fabric until the water level drops to a point 10.5 inches behind the fabric. At this point the flow rate has essentially ceased.

h. Collect all filtrate in the second 20-gallon mixing container.

i. At the completion of the test, agitate the collected filtrate until the mixture is uniformly mixed. Obtain a depth-integrated suspended solids sample from the mixture during agitation.

j. Process the suspended solids samples by the "nonfilterable residue" procedure described in the 14th edition of Standard Methods for the Examination of Water and Wastewater (APHA, AWWA, WPCH).

k. Calculate the flow rate of the fabric as follows:

$$\text{Flow rate (gal/ft}^2\text{/min.)} = 14.85/\text{time (min.)}$$

Time in minutes shall be recorded to the nearest 0.1 minute (6 seconds). Flow rate shall be recorded to 2 significant figures after the decimal point. Flow rate shall be rounded up if the 3rd figure after the decimal point is 5 or greater. For example, if time is recorded as 30.0 minutes, flow rate shall be calculated as 14.85/30.0 = 0.495 gal/ft^2/min, and shall be recorded as 0.50 gal/ft^2/min.

l. Calculate the filtering efficiency (F.E.) of the fabric as follows:

$$\text{F. E.} = \frac{3000 - \text{S.S.}_{\text{After}}}{3000} \times 100$$

where $\text{S.S.}_{\text{After}}$ is the suspended solids value after filtration.

Weights shall be recorded in grams to 4 decimal places (read from an electronic scale). F. E. shall be recorded to 1 significant figure after the decimal point. F. E. shall be rounded up if the 2nd figure after the decimal point is 5 or greater.

m. Repeat steps e through m for the same piece of fabric twice more.

4. General Notes

a. This test method is conducted to approve or provide quality assurance for silt fence for use on VDOT projects. VDOT uses the criteria in the 1992 Virginia Department of Conservation and Recreation's "Virginia Erosion and Sediment Control Handbook" (the Green Book), Table 3.05-B, to determine pass/fail. In Table 3.05-B, the flow rate requirement is 0.2 gpm/sq ft. and the filtering efficiency requirement is 75%. VDOT tests the flow rate first, and if the fabric fails, the filtering efficiency is not tested.

fig 1 flume - side view and top view

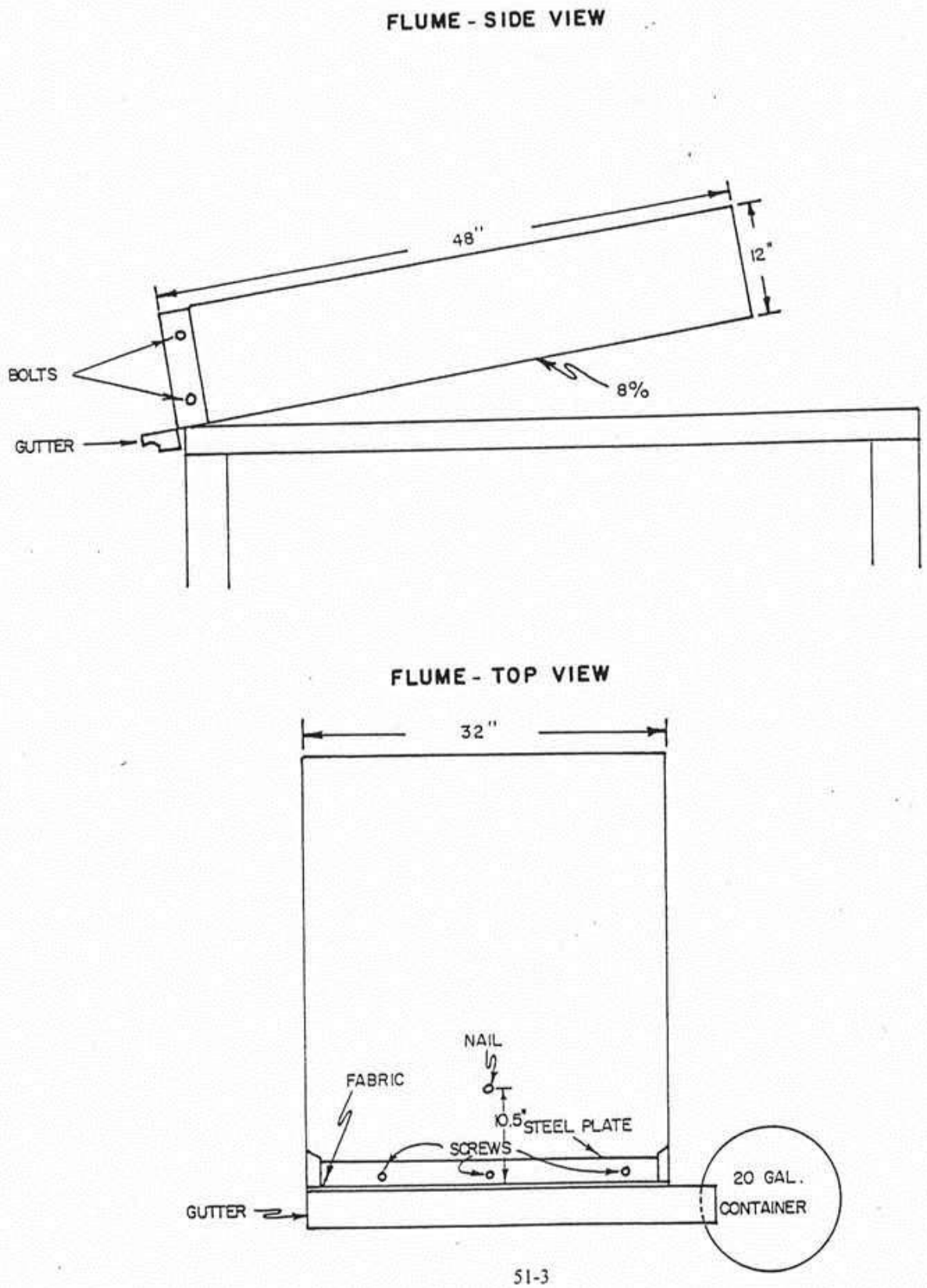
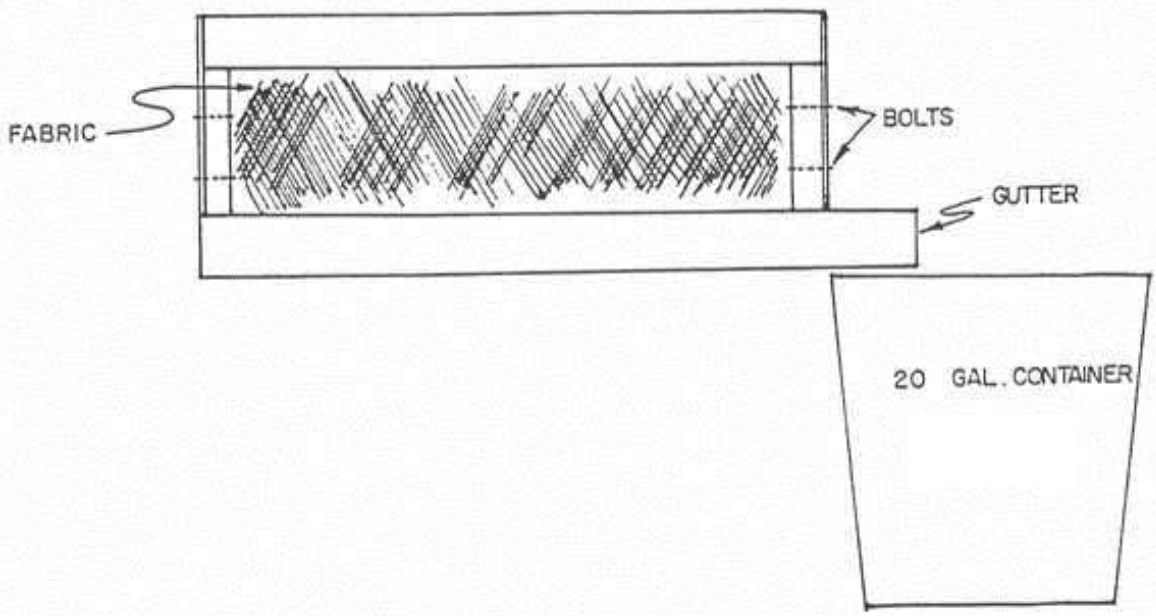


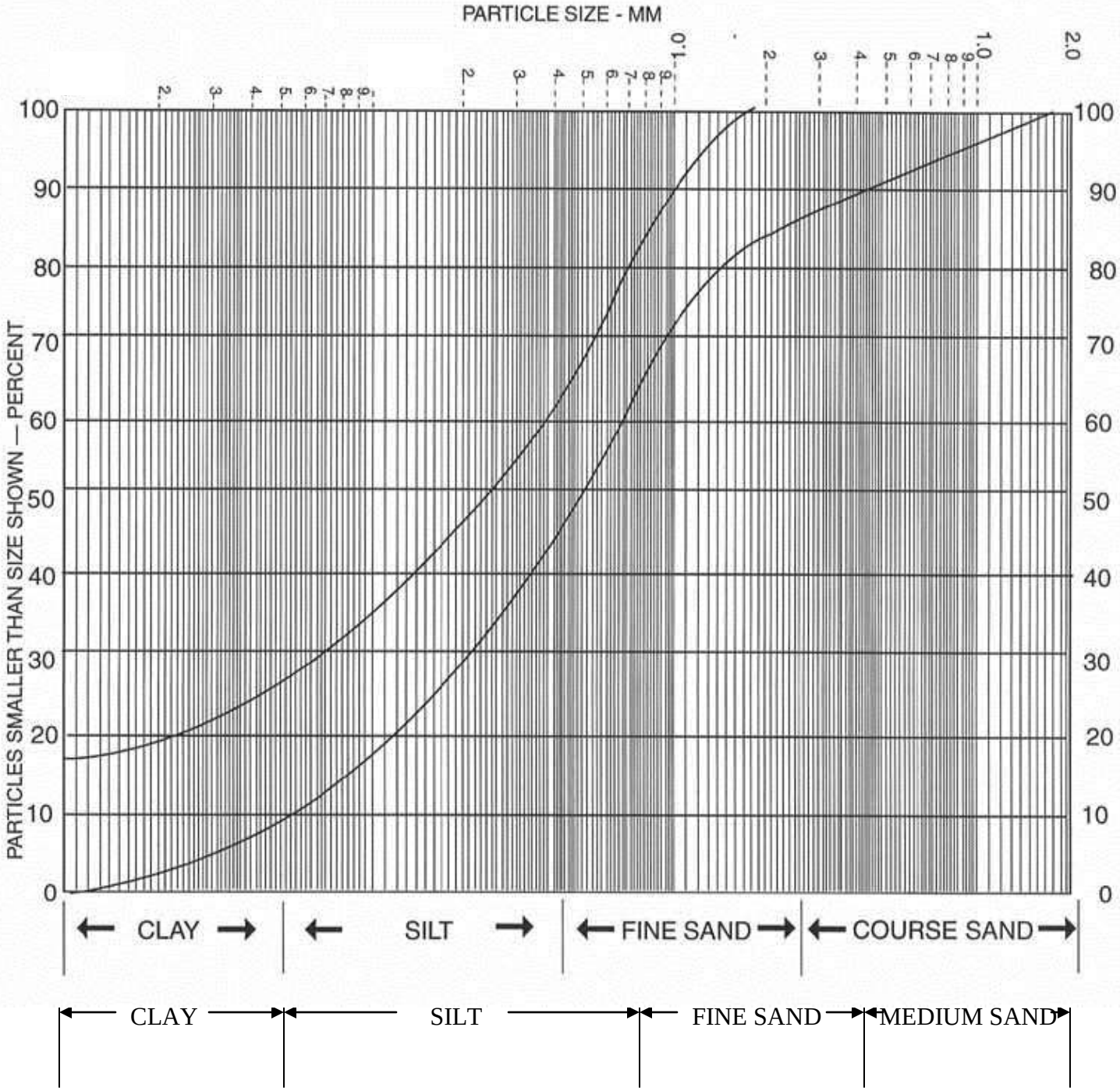
fig 1 cont flume - end view

FLUME - END VIEW



NOTE...(1) ALL FLUME DIMENSIONS ARE INSIDE MEASUREMENTS
(2) 2 SIDE PLATES AND A BOTTOM PLATE ARE USED TO FASTEN THE SAMPLE OF FABRIC IN PLACE

figure 2 particle size



Virginia Test Method – 52

Grab Strength and Elongation of Geotextiles – *(Soils Lab)*

May 16, 2012

1. Scope

This method of test is intended to the grab strength and corresponding elongation of geotextiles.

2. Apparatus

A tensile testing device with a capacity of approximately 2500 pounds equipped with a dial that can be read in increments of 10 pounds or less. The test shall be performed at a rate of travel of 12 ± 0.5 in./min.

3. Procedure

a. Cut three samples of the fabric in the direction perpendicular to the axis of the roll. The samples shall be 8.0 inches long by 4.0 inches wide.

b. Securely fasten a sample of the fabric in the clamps of the tensile testing device so the length of the fabric between the clamps is 3.0 inches long.

c. Take load and elongation readings until failure has occurred.

d. Plot the load on the vertical axis versus its corresponding elongation on the horizontal axis.

e. Determine the maximum load value (grab strength).

f. Repeat Steps b through e for the other two samples.

g. Average the maximum load values determined in Step e and report it as the grab strength.

h. Average the elongations corresponding to peak loads and report it as elongation at grab strength.

Virginia Test Method – 53

Asphalt Release Agents – (Asphalt Lab)

June 1, 2004

1. Scope

1.1 This Method is used to determine the effects of asphalt release agents on the binder used in asphalt plant mix. An asphalt release agent must eliminate sticking of asphalt plant mixes in truck bodies without altering the properties of the binder when in contact with such release agents.

1.2 This standard may involve hazardous material, 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 PG 64-22 and/or PG 70-22 Binder

2.2 Release Agent with the following information: (a) manufacturer's name, (b) dilution rate, (c) whether the agent is the puddling type or non-puddling type and (d) safety data sheet.

2.3 Container to mix Release Agent and Binder.

2.4 Balance (precision 0.1), stirring sticks, heating oven.

2.5 Equipment to perform penetration test AASHTO T 49.

3. Procedure

3.1 The test shall be run using the dilution ratio as furnished by the manufacturer.

3.2 The amount of release agent to be added to the binder will be calculated by using 6% bindertimes the manufacturer's dilution ratio. (example: Ratio = 1:20; 1/20 x 6% = 0.05 x 6% = 0.3 = % agent to be added to binder)

3.3 Release agent will be added to the binder.

3.4 Binder temperature shall be between 320° F and 330° F (160˚ C - 165˚ C).

3.5 The size of the test samples shall be 500 ± 5 grams.

3.6 The sample shall be stirred using a stirring stick until thoroughly mixed not less than one minute nor more than five minutes.

3.7 A control sample shall be made at the same time as the sample containing the Release Agent. It shall be treated the same as mentioned herein, above and below, except it shall not contain any release agent.

3.8 A test sample containing the release agent and a test sample containing only the control binder(s) shall be taken and tested in accordance with AASHTO T 49.

3.9 The average penetration of the test sample containing the Release Agent shall be within three penetration points of the test sample containing the control binder(s).

4. Example

Manufacturers Dilution Ratio = 1 part Agent to 20 parts water
Binder Standard = 6%
Test Specimen Size = 500 ± 5 grams

1/20 of 6% = 0.05 x 6% = 0.003 = > 0.3 % of agent to add.

500 x 0.003 = 1.5 grams = additive to add.

500 + 1.5 = 501.5 grams = weight of sample containing agent

5. Report

5.1 Pass or Fail.

5.2 The results obtained should not harden the binder so as to decrease the pavement life nor soften the binder so that stripping may occur. Changes in binder properties may also be measured by viscosity at 140° F (60° C) softening point and ductility.

Virginia Test Method – 54

Deleted - *Industrial Wiping Towels*

June 1, 1991

Virginia Test Method – 55

Detection Of Antistripping Additives In Asphalt Cements
(Quick Bottle Test) – (Asphalt Lab)

November 1, 2000

1. Scope

This method covers the procedure to be used in determining rapidly the presence of an antistripping additive in asphalt cements.

2. Apparatus

a. 4 oz. (120 ml) glass bottle with a screw cap.

b. Glass or wood stirring rod.

c. Medicine dropper.

d. Paper towels.

e. Clean 1 qt. (1 L.) test can.

f. Balance with a capacity of at least 100 grams, sensitive to 0.1 gram.

g. Standard Ottawa sand (ASTM C-190 sand, 20-30 mesh).

h. Distilled or demineralized water.

i. Solvent Naphtha (VM & P).

3. Procedure

a. Place 20 ± 1.0 gram of the standard Ottawa sand in the 4 oz. (120 oz.) bottle, and add enough distilled or demineralized water at room temperature to cover the sand 1/2 in. (12.5 mm).

b. Heat the asphalt to be tested until thoroughly liquid. Weigh 100 ± 1 gram and cool to 175° to 200° F (79° C - 93° C). Slowly add 36 ± 1 gram of the solvent naphtha. The solvent will vaporize rapidly at this temperature, so this step would be done where there is good ventilation and no open flames. Some reheating of the mixture may be required on a hot plate. This results in a cutback. Check the weight of the solvent-asphalt mixture when blending is finished to insure proper amount of solvent. Add any amount of solvent needed to attain the 36 ± 1 gram required. Normally, reheating will not be required at this point.

c. When the mixture has cooled to 140° F to 150° F (60° C - 65° C) add 1 ± 0.2 gram the prepared cutback material onto the surface of the water.

d. Place cap on bottle and shake vigorously for 30 seconds.

e. Remove cap and pour off excess water.

f. Tap wet sand out onto a paper towel.

4. Results

If the wet sand and asphalt are intimately combined in a homogeneous mixture having a uniform color, the test result shall be reported as positive. If the wet sand and asphalt do not mix or the sand contains globules of asphalt on the surface but the mass is not uniform in appearance, the test result shall be reported as negative.

Virginia Test Method – 56

Deleted - Abrasion Resistance of Thermoplastic Traffic Marking Material

April 1, 1996

Virginia Test Method – 57

Design of Asphalt Mixtures by the Marshall Method – (Asphalt Lab)

November 1, 2000

1. Scope

1.1 AASHTO T 245 and ASTM D 5581 shall be followed, except it may be modified as listed below:

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 Specimen Mold Assembly Three mold cylinders are recommended.

2.2 Deleted

2.3 Mechanical Compactor and Compaction Hammer, A mechanically operated hammer shall be used on all marshall designs.

The mechanical compactor must be designed for a stationary base for all marshall designs.

NOTE 1: A washed gradation will be used in accordance with T-11, unless otherwise authorized by the Engineer.

2.4 A minimum 4 in. (100 mm) solid concrete slab is required when anchored to a concrete floor. When placed on ground, a solid concrete slab of minimum 12 in. (300 mm) depth is required.

2.6 Deleted

2.7 Hand jack may be used on 6 in. (150 mm) molds.

2.8 Deleted

2.12 Water Bath, For 6 in. (150 mm) Marshall Specimens, the water bath shall be at least 8 1/2 in. (216 mm) deep and shall be the thermostatically controlled so as to maintain the bath at 140 ± 1.8 ° F (60 ± 1° C). . The tank shall have perforated false bottom or be equipped with a shelf for supporting specimens 2 in. (50 mm) above the bottom of the bath.

2.13 Deleted

2.13.6 Deleted

3. Specimens

3.2 Optional

3.3.3 - Delete

3.3.4 - Delete

3.4.1 Blend a sufficient amount of aggregate using a percentage of each material to form a composite sample of 5000 g. after mixing. A minimum of four asphalt contents shall be used. Individual samples may be blended as stated above to form a composite sample of approximately 1200 g. Place the aggregate batches and the asphalt cement in the oven and heat to the mixing temperature as established by the viscosity temperature chart. Weigh the required amount of asphalt cement into the aggregate and charge the mixing bowl. Care must be exercised to prevent loss of the mix during mixing and subsequent handling. Mix the aggregate and asphalt cement rapidly until thoroughly coated.

NOTE 2: Two asphalt contents shall be 0.2 percent higher and lower than the proposed JMF and the remaining two at 0.6 percent higher and lower than the proposed asphalt content. The range between the highest and lowest asphalt contents shall not exceed 1.2 percent.

3.4.1.2 On 6 in. (150 mm) mold, blend a sufficient amount of aggregate using a percentage of each material to form a composite sample of 4100 ± 300 g. after mixing. Place approximately one half of the batch in the mold, spade the mixture vigorously with a heated spatula or trowel 15 times around the perimeter and 10 times over the interior. Place the second half of the batch in the mold and repeat the foregoing procedure.

3.4.2 Place batch in a large pan of sufficient size to allow a maximum height of 2 in. (50 mm) and return to the oven. When the material reaches the molding temperature established by the viscosity temperature chart, begin molding specimens. Thoroughly mix the material in the pan using a large spoon. Cut the material for each test specimen with a flat bottom scoop. Place the pan back in the oven while each specimen is being molded. (In no case, should the material for the specimens remain at the molding temperature for more than 30 minutes before molding). Each test specimen shall be 2.5 ± 0.05 in. (63.5 ±1.3 mm) in height.

NOTE 3: The dry bulk sp. gr. of each material must be run for each marshall design (AASHTO T-84 and T-85). When rap is used, the asphalt shall be removed from a sample of rap and dry bulk specific gravities run on the +4 (4.75 mm) and the -4 (4.75 mm) portion of the sample. The percentage of +4 (4.75 mm)and -4 (4.75 mm) material shall be multiplied by the total percentage of rap in the design, and that number divided by the dry bulk specific gravity of the +4 (4.75 mm) and -4 (4.75 mm) material and then added into the B.S.G.A. formula.

NOTE 4: For 6 in (150 mm) molds spade the second layer no more than 2 in (50 mm) into the first layer.

B.S.G.A.- Bulk Dry Sp.Gr. of Aggregate to be calculated at time of design.

$$\text{B.S.G.A.} = \frac{100}{\underline{\%\ \text{Agg.\#1}} + \underline{\%\ \text{Agg.\#2}} + \underline{\%\ \text{Agg.\#3}}}$$

Sp.Gr.Agg. Sp.Gr.Agg. Sp.Gr.Agg.

Effective Sp.Gr. of Aggregate to be determined at time of design

$$\text{Eff.Sp.Gr.} = \frac{\%\text{Aggregate}}{\frac{100}{\text{AC}} - \frac{\%\ \text{AC.}}{\text{Sp.Gr.}}}$$

(max.sp.gr) Rice

Examples:

AC 6.96
55% #8=2.606
35% #10=2.711
10% sand=2.697

$$\text{B.S.G.A. \#1} \quad \frac{100}{\frac{55}{2.606} + \frac{35}{2.711} + \frac{10}{2.697}} = \frac{100}{21.105 + 12.910 + 3.708} = \frac{100}{37.723} = 2.651$$

B.S.G.A. #2
AC 5.50
50% #8=2.645
30% #10=2.720
20% rap +4=2.620 55%
-4=2.630 45%

$$\text{B.S.G.A.} = \frac{100}{\frac{50}{2.645} + \frac{30}{2.720} + \frac{(.20 \times 55)}{2.620} + \frac{(.20 \times 45)}{2.630}}$$

$$= \frac{100}{18.904 + 11.029 + 4.198 + 3.422} = \frac{100}{37.553} = 2.663$$

$$\text{Effective Sp. Gr.} = \frac{93.04}{\frac{100}{2.438} - \frac{6.96}{1.025}} = \frac{93.04}{41.017 - 6.790}$$

$$= \frac{93.04}{34.227} = 2.718$$

For Correction Factor = Subtract BSGA from Effective Sp.Gr.

2.718 -2.651 = .067

Note 5: On all designs, the producer must submit B.S.G.A., Ef.Sp.Gr., Correction Factor and a copy of the completed laboratory work sheet. (Copy of laboratory work sheets attached.)

Note 6: Select the unit weight from the Marshall Design chart at the asphalt content selected. As a check, perform the following calculation:

Unit Weight = Rice T.M.D. x 62.4 x .955
Rice T.M.D. = Rice value calculated at asphalt content picked at design voids.

Tester: _____

Date: _____

Coarse Aggregate

Specific Gravity

Sample ID:	_____	_____	_____	_____
SSD "B"	_____	_____	_____	_____
Under Water "C"	_____	_____	_____	_____
Pan and Aggr.	_____	_____	_____	_____
Pan Tare	_____	_____	_____	_____
Oven Dry "A"	_____	_____	_____	_____
B - C	_____	_____	_____	_____
A - C	_____	_____	_____	_____
B - A	_____	_____	_____	_____
Bulk Dry SpGr.				
A/(B-C)	_____	_____	_____	_____
Bulk SSD SpGr.				
B/(B-C)	_____	_____	_____	_____
Apparent SpGr.				
A/(A-C)	_____	_____	_____	_____
Absorption,%				
(B-A)/A x 100	_____	_____	_____	_____

Tester: _____

Date: _____

Fine Aggregate

Specific Gravity

Sample ID:	_____	_____	_____	_____
Flask No.:	_____	_____	_____	_____
Flask & SSD(1)	_____	_____	_____	_____
Flask (2)	_____	_____	_____	_____
SSD (1)-(2), "B"	_____	_____	_____	_____
Flask,SSD,H_2O(3)	_____	_____	_____	_____
Flask & H_2O (4)	_____	_____	_____	_____
(3) - (4) = "C"	_____	_____	_____	_____
Aggr. & Pan	_____	_____	_____	_____
Pan Tare	_____	_____	_____	_____
Oven Dry "A"	_____	_____	_____	_____
B - C	_____	_____	_____	_____
A - C	_____	_____	_____	_____
B - A	_____	_____	_____	_____
Bulk Dry SpGr.				
A/(B-C)	_____	_____	_____	_____
Bulk SSD SpGr.				
B/(B-C)	_____	_____	_____	_____
Apparent SpGr.				
A/(A-C)	_____	_____	_____	_____
Absorption,%				
(B-A)/A x 100	_____	_____	_____	_____
(with or without minus 200 (75μm))	_____	_____	_____	_____

Virginia Test Method – 58

Determining the Marshall Stability Volumetric Properties, and Flow of an Asphalt Concrete Mixture – (Asphalt Lab)

November 1, 2000

1. Scope

1.1 This method covers the procedure to be used in determining the Marshall Stability, Volumetric Properties, and flow of an asphalt concrete mixture, using 4 in. (100 mm) and 6 in. (150 mm) Marshall Specimens.

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 All testing equipment shall be in accordance with VTM-57, except the oven shall be a forced air type.

3. Material

3.1 Samples shall be taken in accordance with the Materials Division Manual of Instructions for the Marshall Stability Test.

4. Procedure

4.1 The sample when cooled, shall be heated in a forced air oven to a temperature not to exceed the molding temperature specified by the job mix formula sufficient to allow uniform mixing of the sample. If necessary, quarter the sample to reduce to approximately 20 lbs. (9 kg). Obtain samples from the uniformly mixed material for testing in accordance with VTM-36 or VTM 102 and AASHTO-T209. Return the remainder of the sample to the oven and heat to a molding temperature specified by the job mix formula. Do not allow the material to remain at the molding temperature for more than 30 minutes. Mold three specimens using number of blows specified per side. Handle and test the completed specimens for stability and flow in accordance with AASHTO T 245.

4.2 The volumetric properties shall be determined as follows:

a. The specific gravities of the asphalt mixture shall be determined by AASHTO T-209, (Max. sp. gr.) and AASHTO T-166 Method A (Bulk sp. gr.).

b. Calculations:

(1) Voids in Total Mix (VTM)

VTM = 100 (1 - Bulk sp. gr./Max. sp. gr.)
report to nearest 0.1%

(2) Effective sp. = $\frac{\%\ \text{Aggregate}}{\frac{\text{gr. agg.}\ 100}{\text{Max. sp. gr.}} - \frac{\%\ \text{Asphalt}}{\text{Asphalt sp. gr.}}}$

(3) Voids in Mineral Aggregate (VMA)

$$\text{VMA} = 100 - \frac{\text{Bulk sp. gr. X \% agg.}}{\text{Bulk sp. gr. agg.}}$$

report to nearest 0.1%

where:

% agg. = aggregate, percent by total weight of mixture.

Bulk sp. gr. = Bulk specific gravity, determined by AASHTO T-166 Method A.

(4) Voids Filled with Asphalt (VFA)

$$\text{VFA} = \frac{\text{VMA - VTM}}{\text{VMA}} \text{ X } 100$$

report to nearest 1.0%

(5) To obtain Bulk Sp.Gr. of aggregate of field marshall, calculate Effective Sp. Gr. and subtract Correction Factor from design. (Correction Factor = Eff. Sp. Gr. of Aggr. - (minus) B.S.G.A. from design.

5. Reporting

5.1 The reported results for stability, flow, V.T.M., V.F.A. and V.M.A. shall be the average of the three specimens.

Virginia Test Method – 59

Monitoring Program for Central-Mix Aggregates and Asphalt Concrete – (Computer Technology)

March 1, 2006 (Corrected August 9, 2007)

1. SCOPE

The Monitoring Program is to be used for Central Mix Aggregates (CMA) and Asphalt Concrete that are accepted using the Contractor's test results. The program uses a series of statistical comparisons between the Contractor's acceptance tests and the Department's monitor test results to verify that both sets of test results are comparable, and thus allow the use of the Contractor's test results in the acceptance decision for the material.

These comparisons are performed using the CMA and Asphalt Concrete materials databases. The purpose of this VTM is to describe and explain the statistical assumptions and methods used to conduct these comparisons.

This monitoring program methodology can also potentially be applied to the acceptance of other materials, but would require some modifications.

2. REFERENCED DOCUMENTS

AASHTO Standard R 9 Acceptance Sampling Plans for Highway Construction

ASTM E 456 Standard Terminology for relating to Quality and Statistics

3. TERMS AND DEFINITIONS

Statistics – It is the analysis of data and whose practice includes the measuring, summarizing, and interpreting of observations using mathematical models. There are two major branches of statistics, descriptive statistics and inferential statistics. Descriptive statistics describe or summarize the observed measurements of a system. Inferential statistics are used to infer or predict future outcomes, tendencies, and behaviors of a system. Statistics is a branch of applied mathematics which uses probability theory in the design mathematical models. Since statistics is based on probability theory, statistical results can not provide definitive cause and effect relationships but can only provide correlations. For this reason, statistical terms are very carefully defined and the interpretation of the analysis must be weighed in light of the assumptions of the theory. Attempts to extrapolate the results of statistical analysis are a common error since the theory usually attempts to infer or characterize the population within the range of the observations.

The basic tenet of statistics is that some collection of entities or objects usually referred to as the "population" can be represented by a sample of that population, given that the sample is sufficiently large and that the sample was selected at random from the population.

Population - A statistical population is a set of entities or members, which are to be described, or from which statistical inferences are to be drawn. These analyses are usually based on a random sample taken from the population.

Random Sample - A sample is that part of a population which is actually observed. Every member of the population should have an equal chance of being included in the sample. Though simple in concept, this goal is usually difficult to achieve. Because of the difficulty to insure the randomness in sampling, statistics also examines the samples for precision and bias.

Bias – When some entities are more likely to be chosen in the sample than others, then the analysis will be higher or lower than the true value thus presenting a "biased" view of the population. So when estimating a

quantity about a population, bias is the error which arises due to incorrect sampling. In general, errors from chance will cancel each other out in the long run, those from bias will not.

Precision - Precision is a measure of how close a statistical measurement is expected to be to the true value of the actual quantity or parameter. Precision is usually expressed in terms of imprecision and related to the standard error of the estimator. Less precision is reflected by a larger standard error.

Split Sample – A sample that has been divided into two or more portions representing the same material. This sample is used to verify acceptability of an operator's test equipment and procedure.

Independent Sample – A sample taken separate from any other sample used to represent the material. This sample is used to verify an acceptance decision or the process. In this VTM, the Department's monitor sample is used as the independent sample when the Contractor's companion sample is eliminated from the analysis. This adjustment is made to maintain the sample's independence. This will be explained in more detail.

Monitor Sample – The sample the Department takes as a companion sample to one of the Contractor's acceptance samples. This is a split sample. The monitor sample in this VTM fulfills both the functions of the split sample and independent sample as described above.

Acceptance Sample – The sample that is used to determine if the product meets the desired specifications, and upon which the acceptance decision is made. Often the acceptance decision is based on multiple acceptance samples. In this VTM, the Contractor takes this sample and the averages of these samples are used in the acceptance decision.

Hypothesis – A statement of an assumption or claim about two sets of data. In this VTM, the hypothesis claimed is that there is no difference between the Contractor's test results and the Department's test result. That is to say the two sets of data compare. This is typically called the "null" hypothesis because the assumption made is that there is "no difference" or zero change between the two populations. The statistical notation used to represent the null hypothesis is "$\mathbf{H_0}$" pronounced H sub zero and the claim is represented by the equation $\mathbf{H_0 = 0}$ **.** When the hypothesis is rejected, it can then be said with some level of confidence that the two populations do not compare statistically. A statistical test can be conducted for the opposite assertion namely that the two populations are not equal this is called the "alternative hypothesis" symbolized by "$\mathbf{H_1}$**" or** "$\mathbf{H_a}$**"**.

Level of Significance (α) - The probability of wrongly rejecting the null hypothesis $\mathbf{H_0}$. This can be restated such as two samples actually compare, and were rejected. In this VTM, the level of significance is the probability of the database indicating the Contractor's results do not compare to VDOT's results when they may actually compare. This is often referred to as the seller's risk or a type I Error. Typical levels of significance are 0.10, 0.05 and 0.01. For example if the level of significance is 0.01 and the samples did not compare, there is only a one chance in one hundred that the samples did indeed compare and were incorrectly rejected. The level of significance (Contractor's risk) that is used in this VTM is 0.01or stated as 1%.

Level of Confidence, 1-α - The probability of rejecting a hypothesis that is indeed the correct decision. It is directly correlated to the level of significance. In this VTM, the level of confidence that is used is 99% when assessing if the contractors tests should be rejected. In other words, there is a 99% confidence level that when the contractor's tests are rejected, the correct decision has been made.

β - The probability of accepting a hypothesis, such as two samples compare, when in fact it is false. This may be restated as the probability of the database indicating the Contractor's result do not compare to the Department's results when they may actually compare. In statistics this is often referred to as the buyer's risk or a type II Error. For example if the β risk is 0.01 and the samples did not compare, there is only a one chance in one hundred that the samples did indeed not compare and were incorrectly accepted. In this VTM, the β risk (the Department's risk) is a function of the number of samples compared, since the α risk remains fixed. As the number of samples in the comparison increases, the β risk is reduced.

Standard Deviation - The standard deviation measures the spread of the data from the mean value. A large standard deviation indicates that the data points are far from the mean and a small standard deviation indicates that they are clustered closely around the mean. Standard deviation is also defined as the square root of the variance.

Variance - Variance like the standard deviation is a measure of spread for a set of data. It is computed by squaring the differences of the data points from the mean and then averaging the result. For example, if our data set contained the numbers 1, 2, and 3, the mean is 2 and the variance is computed: $((1-2)^2 + (2-2)^2 + (3-2)^2) / 3 = .667$.

n_m - The number of Department's monitor tests

n_c - The number of Contractor's acceptance tests

$\overline{X}_m$ - Mean of the Department's monitor test results

$\overline{X}_c$ - Mean of the Contractor's acceptance test

s_m - Standard deviation of the Department's monitor test results

s_c - Standard deviation of the Contractor's acceptance test results

s_m^2 - Variance of the Department's monitor test results

s_c^2 - Variance of the Contractor's acceptance test results

df* or *ν – Degrees of freedom, the number of values that are freely determined. This concept is best illustrated by the following: when a series of values are averaged together, it is a fact that the sum of the differences between the individual values and the average value is 0. Thus if $n_m = 4$ and $x_1 - x_{\underline{m}} = 8$, $x_2 - x_{\underline{m}} = -6$, $x_4 - x_{\underline{m}} = -4$, then it must be concluded that $x_3 - x_{\underline{m}} = 2$, so the sum of the differences equals 0. Since the forth value is automatically determined by the first three values, it can then be said that only 3 of the values are freely determined, or that 3 degrees of freedom are present.

V_m - Calculated value of the variance for the Department's monitor samples divided by the number of the Department's monitor samples, used for ease of calculations

V_c - Calculated value of the variance for the Contractor's samples divided by the number of Contractor's samples, used for ease of calculations.

4. STATISTICAL TESTS

Difference "Two"-Standard-Deviation Limit (D2S Limit) – The D2S method compares the Contractor and Department results from a single split sample. This is the simplest procedure that can be used for verification, however it is the least powerful, and thus is not the only one used. The procedure uses the difference between only two test results and applies only to split samples. The D2S limit is the maximum acceptable difference between the two test results and has a level of significance of 0.05. This level of significance means that the chance of the D2S limit being exceeded if the tests are actually from the same population is 5%. Mathematically the D2S is calculated as ($1.96\sqrt{2}$) times one standard deviation, or about 2.8s.

Paired *t*-test – Used to compare more than one pair of split-sample test results. This test uses the difference between pairs of test and determines whether the average difference is statistically different from 0. A two-tailed test is used in this procedure.

***F*-test** – Provides a method for comparing the variances (standard deviations squared) of two sets of data. Upon completing this test, one of the following can be concluded:

1) The two sets of data are from different populations, since the difference between the two variances is greater than is likely to occur from chance if they were equal.
2) The two sets of data are from the same population, since the difference between the two variances is not so great so as to expect them to be from different populations.

A two-tailed test is used in this procedure.

***t*-test** – Provides a method for comparing the means of the two sets of data. Upon completing this test, one of the following can be concluded:

1) The two sets of data have different means because the difference in the sample means is greater than is likely to occur from chance it their means are actually equal.
2) The two sets of data have the same means because the difference in the sample means is not so great as to be unlikely to have occurred from chance if the means are actually equal.

There are two approaches that can be taken to perform the *t*-test. One, if the sample variances are assumed to be equal or two, if the sample variances are assumed to be not equal. This VTM assumes that the sample variances are not equal. A two-tailed test is used in this procedure.

5. PROCEDURE

Samples for testing by the Department shall be taken in accordance with The Materials Division's Manual of Instructions Section 311.05 for Central-Mix Aggregates and Section 502.04 for Asphalt Concrete respectively. Test results shall be input into the Materials Database for analysis. The analyses that will then be performed in the Materials Database is the Paired *t*-test, *F*-test and *t*-test. These analyses are executed using the Report Options button and then selecting the Comparison Reports tab. The reports shall then be generated to identify if any of the Department's tests are not in agreement with the Contractor's tests. Test results that do not compare will be flagged on the computer generated output using *** under the test results that do not compare. If differences cannot be explained or reconciled, the Department may call for the referee system as outlined in the Manual of Instructions to determine the final disposition of the material. Also, in the event either statistical test indicates a significant difference exists, data accumulated and used in the comparison tests will not be used in future comparison tests.

The D2S procedure is performed only on split samples comparing the Contractor and Department test results against one another, and should be done when the sample testing is completed. This procedure is not a part of the database applications and the comparison must be done manually. This is a component of the Independent Assurance, IA.

The Paired *t*-test is performed on the difference in means between the Contractor's and the Department's split sample test results. These results can be found on the Matched Comparison Analysis Report. This is a component of IA.

The *F*-test is performed on all the Contractor's acceptance tests (except for the test from the sample that is split with the Department) and Departments monitor test results from the split sample. The results of this analysis procedure can be found on the Matched Comparison Analysis Report and the Non-Matched Comparison Analysis Report. This is a component of both IA and Quality Assurance, QA.

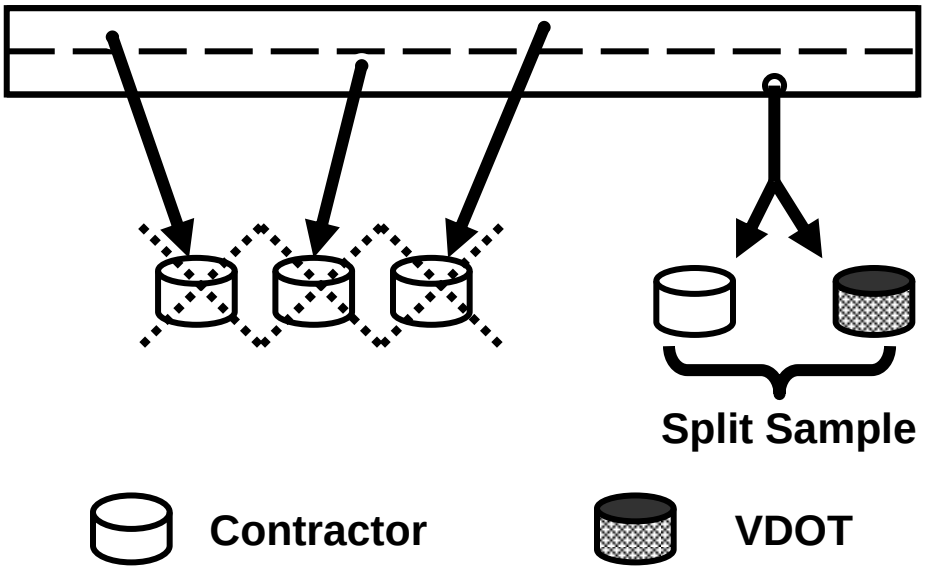
The *t*-test is performed on all the Contractor's acceptance tests (except for the test from the sample that is split with the Department) and Department's monitor test results from the split sample. The results of this analysis procedure can be found on the Non-Matched Comparison Analysis Report. This is a component of QA.

The Department uses the same sample, the monitor sample, to verify the acceptability of an operator and test procedure as well as to verify the acceptance decision. In other words, the split sample and independent sample are the same sample. To ensure that this is a statistically valid approach, the results obtained by the contractor from the split sample are not used when conducting the *F*-test and *t*-test. Such an approach is demonstrated in the details that follow.

The Department may periodically take more than one monitor sample per lot, however only one of these monitor samples will be used in the *F*-test and *t*-test. The program randomly chooses the sample that is used in the evaluation. All of the Department's monitor samples, however are used in the Paired *t*-test.

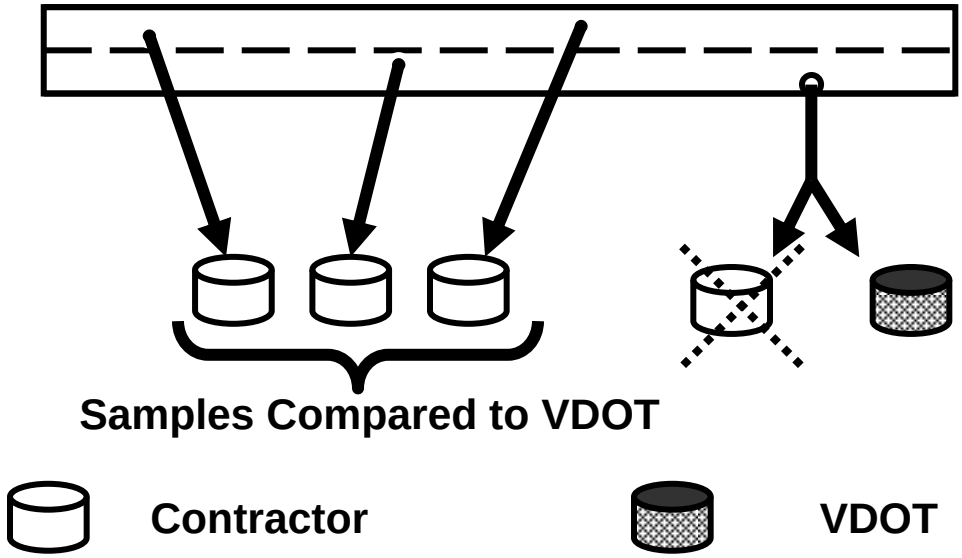
Split Sample Evaluation

The Contractor performs the acceptance testing during production. The figure below represents a typical sampling rate by the Contractor for a lot. The Department will randomly select one of these samples to be split for testing by both the Contractor and the Department. The two results of the split sample are first compared against one another using the D2S procedure. Then a comparison is made for multiple lots using both the Paired *t*-test and F-test. In this case only the results of the split samples are used as part of the evaluation. This is done to verify acceptability of an operator's test equipment and procedure as part of IA. The Paired *t*-test and F-test results are found on the "Matched Comparison Analysis" Report.



Acceptance Evaluation

To verify the acceptance decision, independent samples are taken and their results compared against the acceptance samples results. The *t*-test is used to compare the test result means and the F-test is used to compare the sample variability. This comparison is made with all of the Department's split samples and does not include the results obtained by the Contractor on his portion of the split sample. The remaining tests performed by the Contractor are then compared to the Department's test as shown below as shown below.



If either of the statistical comparisons indicates the Department's monitor test results are not in agreement with the Contractor's acceptance test results, action will be taken to determine the source of differences.
The mathematical computations of the various analysis procedures are shown below:

5. a. D2S

Test procedure to determine if the individual split sample result from the Department's monitor test differs significantly from those of the Contractor's acceptance test.

1. Determine the D2S tolerance from the precision statement in the test procedure or multiply 2.8 times the standard deviation. If the D2S tolerance is an absolute value, determine the absolute difference between the two values and go to step 3, if the D2S is listed as a percent difference, go to step 2.
2. For each test, determine the percent difference between the Department's and the Contractor's test results.
   Percent Difference = 100* (difference between test results)/(average of the two test results)
3. Compare calculated difference, percent or absolute value to the D2S tolerance, if the D2S tolerance is greater than the calculated difference, the two tests are said to compare with a 5% level of significance.

Calculations based on the example data in Table 1A are contained in the table itself.

5. b. Paired *t*-test

Test procedure to determine if the split sample test result averages from the Department's monitor samples, $\overline{X}_m$, significantly differ from those of the Contractor's acceptance samples, $\overline{X}_c$.

Listed below are the procedural steps to determine if $\overline{X}_m$ differs from $\overline{X}_c$ at a 1% significance level.

1. Determine *n*, the number of split samples

2. Determine $\overline{X}_d$, the average of the differences between the split sample test results

3. Determine, s_d, the standard deviation of the differences between the split sample tests results

4. Calculate $t = \dfrac{\left|\overline{X}_d\right|}{\dfrac{s_d}{\sqrt{n}}}$, which is the test statistic

5. Look up $t_{\alpha/2,\, n-1}$, or $t_{0.995,\, n-1}$, (in Table 5) since testing is done at a 1% significance level (α= 0.01). Since this is a two-tailed test, $\alpha/2$ or 0.005 must be used.

6. If $t \geq t_{\alpha/2,\, n-1}$, then conclude that $\overline{X}_m$ differs from $\overline{X}_c$, otherwise conclude that there is no reason to believe $\overline{X}_m$ differs from $\overline{X}_c$.

Calculations based on the example data in Table 1A are contained in the Appendix, step 3.

5.c. F-test

Test Procedure to determine if s_m is statistically different than s_c using the *F*-test for the Department's monitor tests and the Contractor's acceptance tests

The procedural steps to determine if s_m differs from s_c at a significance level of 1% are listed below.

1. Determine n_m and n_c, where n_m = the number of the Department's monitor tests to be used in the comparison, and n_c = the number of Contractor tests that are to be used in the comparison. Note: n_c only includes the number of tests that are not split samples. This can be determined by finding the total number of contractor tests and subtracting out the number of split samples.

2. Square the standard deviations determined from the Department's monitor tests and the Contractor's acceptance test data; i.e., compute s_m^2 and s_c^2. Note: s_c^2 is based on only those Contractor tests that are not split samples.

3. Compute *F*, where the larger of the two standard deviations squared is divided by the smaller of the two standard deviations squared, as in $F = \left(\dfrac{s_m^{\ 2}}{s_c^{\ 2}}\right)$ or $F = \left(\dfrac{s_c^{\ 2}}{s_m^{\ 2}}\right)$.

4. Determine the degrees of freedom, ν_1 and ν_2, where ν_1 = Number of samples associated with the larger of the two standard deviations squared minus 1 and ν_2= Number of samples associated with the smaller of the two standard deviations squared minus 1.

5. Look up $F_{.99}$, the F value that would be exceeded only with a 99% level of confidence (α= 0.01) in Table 2 (note: This is for a two-tailed test)

6. If $F > F_{.99}$, conclude that s_m is different from s_c; otherwise conclude that s_m is not different than s_c.

Computations of F values for the example data in Table 1B are shown in Table 3. All of the comparisons made indicated that there is no reason to believe that the distributions are different at a 1% significance level.

5.d. *t*-test

Test Procedure to determine if $\overline{X}_m$ differs from $\overline{X}_c$ significantly using the *t*-test for the Department's monitor tests and the Contractor's acceptance tests.

Listed below are the procedural steps to determine if $\overline{X}_m$ differs from $\overline{X}_c$ at a 1% significance level. Calculations based on the example data in Table 1B are contained in Table 4.

1. Determine n_m and n_c, where n_m = the number of monitor tests used in the comparison, and n_c = the number of contractor tests that are to be used in the comparison. Note: The n_c only includes the number of tests that are not apart of the split samples. This can be determined by finding the total number of contractor tests and subtracting out the number of split samples.

2. Square the standard deviations determined from the Department's monitor test and the Contractor's acceptance test data; i.e., compute s_m^2 and s_c^2. Note: s_c^2 is based only on those Contractor tests that are split samples.

3. Compute V_m and V_c,

   where $V_m = \left(\frac{s_m^{\ 2}}{n_m}\right)$, and $V_c = \left(\frac{s_c^{\ 2}}{n_c}\right)$

4. Compute *df*, where $df = \left(\frac{(V_m + V_c)^2}{\left(\frac{V_m^{\ 2}}{n_m + 1}\right) + \left(\frac{V_c^{\ 2}}{n_c + 1}\right)}\right) - 2$

   and round *df* to the nearest integer value.

5. Look up $t_{\alpha/2,\, df}$, or $t_{0.995,df}$ since testing is done at a 1% significance level (α= 0.01), in Table 5 for the rounded value of *df* computed in Step 4. Since this is a two-tailed test, $\alpha/2$ or 0.005 must be used.

6. Compute $\mu = t_{0.995}\sqrt{(V_c + V_m)}$

7. If $|\overline{X}_m - \overline{X}_c| > \mu$, conclude that $\overline{X}_m$ differs from $\overline{X}_c$, otherwise conclude that there is no reason to believe $\overline{X}_m$ differs from $\overline{X}_c$.

Note: Steps 6 and 7 above are a derivation to the traditional *t*-test, where the *t*-statistic is compared with t_{crit}. And is derived as follows:

$$t = \frac{\left|\overline{\boldsymbol{X}}_m - \overline{\boldsymbol{X}}_c\right|}{\sqrt{\frac{s_c^2}{n_c} + \frac{s_m^2}{n_m}}}$$ which is the test statistic and t_{crit} is based on $t_{\alpha/2,\, df}$

and if $t > t_{crit,}$ then the conclusion is that the means are different.

Substituting $\frac{\left|\overline{\boldsymbol{X}}_m - \overline{\boldsymbol{X}}_c\right|}{\sqrt{\frac{s_c^2}{n_c} + \frac{s_m^2}{n_m}}}$ for t gives $\frac{\left|\overline{\boldsymbol{X}}_m - \overline{\boldsymbol{X}}_c\right|}{\sqrt{\frac{s_c^2}{n_c} + \frac{s_m^2}{n_m}}} > t_{crit}$

$$\frac{\left|\overline{\boldsymbol{X}}_m - \overline{\boldsymbol{X}}_c\right|}{\sqrt{V_c + V_m}} > t_{crit}$$

$$\left|\overline{\boldsymbol{X}}_m - \overline{\boldsymbol{X}}_c\right| > t_{crit}\ \sqrt{V_c + V_m}$$

Substituting μ for $t_{crit}\ \sqrt{V_c + V_m}$ gives the test in step 7 of $\left|\ \overline{X}_m - \overline{X}_c\ \right| > \mu$

Based on the calculation shown in Table 4, the means differ for example data set two after one week. (Calculations for this case also are shown in the Appendix.) Thus, some determination of the cause for the difference must be made. For instance, the acceptance sampling procedures may not be random. Instead, an attempt is being made to select the most homogeneous samples, which will yield less variable results than would truly random samples. For the second, and second and third weeks (second example data set) it was found that $\overline{X}_m$ did not differ significantly from $\overline{X}_c$.

6. DATA ANALYSIS

To illustrate the methodology involved in the four comparison analysis procedures (D2S, Paired *t*-test, *t*-test and F-test), consider the three example sets of data shown in Tables 1A and 1B. Table 1A shows the split samples for the Contractor's and Department's test results with the accompanying D2S comparison. Table 1B shows two data sets of the Contractors results that would be used for acceptance purposes along with the Department's monitor sample test results. Table 1B shows the Contractor's acceptance sample that is split with the Department, as being lined out. These sample are not used in the comparison analysis, but are used in the acceptance decision.

Table 1A – Results for percent passing ½" Sieve, Split Samples

Lot Number	Sample Number	Contractor's Test	Department's Test	Difference	Within D2S (3.5%) ***
1	1	90.5%	93.7%	-3.2%	Yes
1	4	91.6%	93.5%	-1.9%	Yes
2	3	91.1%	93.6%	-2.5%	Yes
3	2	94.4%	95.5%	-1.1%	Yes
3	3	93.1%	92.6%	0.5%	Yes
4	3	93.1%	95.1%	-2.0%	Yes
5	1	92.3%	93.2%	-0.9%	Yes
5	4	92.7%	94.4%	-1.7%	Yes
6	4	92.4%	92.2%	0.2%	Yes
7	3	92.0%	91.7%	0.3%	Yes
8	4	92.0%	92.8%	-0.8%	Yes
9	2	93.1%	94.1%	-1.0%	Yes
10	1	90.6%	93.4%	-2.8%	Yes
10	3	93.2%	91.6%	1.6%	Yes
11	2	89.8%	93.0%	-3.2%	Yes
12	1	89.1%	93.4%	-4.3%	No
14	2	92.4%	94.1%	-1.7%	Yes
15	2	90.7%	93.1%	-2.4%	Yes
16	4	90.5%	91.4%	-0.9%	Yes
18	2	91.7%	91.8%	-0.1%	Yes
Number of Samples	$n = 20$	$n_c = 20$	$n_m = 20$		
Mean	$\overline{X}_d = -1.4$	$\overline{X}_c = 91.8$	$\overline{X}_m = 93.2$		
Standard Deviation	$s_d = 1.46$	$s_c = 1.33$	$s_m = 1.13$		

*** From Precision Statement in AASHTO T30 for Multi lab Precision

Table 1B - Results for percent passing #200 Sieve

Example Data Set 1

Week	Contractor Test Results			Department Test Results		
	Lot	Sample	% Passing	Lot	Sample	% Passing
1	1	1	8.8	1		
		2	~~8.9~~		2	8.3
		3	9.4			
		4	10.3			
	2	1	~~10.9~~	2	1	11.3
		2	9.8			
		3	10.6			
		4	8.9			
	3	1	9.7	3		
		2	10.8			
		3	~~8.9~~		3	8.4
		4	11.0			
	4	1	10.4	4		
		2	9.3			
		3	~~10.5~~		3	10.7
Note: n_c is the number of contractor tests that are not a part of the split sample, n_c=Total number of test - n_m, as in 15 total tests – 4 split tests = 11			n_c = 11 $\overline{X}_c$ = 9.91 s_c = 0.76			n_m = 4 $\overline{X}_m$ = 9.67 s_m = 1.55
2	4	4	9.5	4		
	5	1	10.2	5		
		2	11.1			
		3	9.3			
		4	~~9.8~~		4	9.6
	6	1	9.5	6		
		2	9.1			
		3	10.4			
		4	8.9			
	7	1	10.2	7		
		2	~~10.9~~		2	11.7
		3	10.7			
		4	9.8			
			n_c = 22 $\overline{X}_c$ =9.90 s_c = 0.71			n_m = 6 $\overline{X}_m$ = 10.0 s_m= 1.46
3	8	1	~~10.9~~	8	1	10.7
		2	8.3			
		3	10.4			
		4	9.7			
	9	1	11.4	9		
		2	~~11.0~~		2	11.0
		3	8.7			
		4	9.8			
	10	1	10.9	10		
		2	8.8			
		3	8.5			
		4	~~9.8~~		4	9.2
	11	1	~~8.9~~	11	1	8.5
		2	11.3			
			n_c = 10[(b)] $\overline{X}_c$ =9.78 s_c = 1.18			n_m = 4[(b)] $\overline{X}_m$ = 9.85 s_m= 1.20

[(b)] 3rd week only

Table 1B continued – Results for percent passing #200 Sieve

Example Data Set 2

Week	Contractor Test Results			Department Test Results		
	Lot	Sample	% Passing	Lot	Sample	% Passing
1	1	1	~~7.2~~	1	1	6.5
		2	8.3			
		3	10.5			
		4	9.6			
	2	1	~~7.5~~	2	1	8.2
		2	11.3			
		3	8.6			
		4	9.9			
	3	1	10.8	3		
		2	9.3			
		3	~~6.4~~		3	5.9
		4	11.3			
	4	1	9.1	4		
		2	11.3			
		3	~~8.6~~		3	7.8
Note: n_c is the number of contractor tests that are not a part of the split sample, n_c=Total number of test - n_m, as in 15 total tests – 4 split tests = 11			n_c = 11 $\overline{X}_c$ =10.0 s_c = 1.11			n_m = 4 $\overline{X}_m$ = 7.10 s_m= 1.08
2	4	4	6.5	4		
	5	1	9.4	5		
		2	8.2			
		3	10.3			
		4	~~9.0~~		4	8.8
	6	1	~~9.8~~	6	1	10.1
		2	8.2			
		3	8.0			
		4	8.3			
	7	1	9.4	7		
		2	7.6			
		3	~~7.8~~		3	7.7
		4	6.9			
	8	1	8.8	8		
		2	~~7.9~~		2	7.1
			n_c = 11[a] $\overline{X}_c$ =8.83 s_c = 1.12			n_m = 4[a] $\overline{X}_m$ = 8.43 s_m= 1.32
3	8	3	8.2			
		4	9.3			
	9	1	~~8.9~~	9	1	8.2
		2	7.1			
		3	6.4			
		4	9.4			
	10	1	10.3	10		
		2	9.7			
		3	7.6			
		4	~~7.0~~		4	7.6
	11	1	8.8			
		2	8.2			
			n_c = 21[c] $\overline{X}_c$ =8.41 s_c = 1.14			n_m = 6[c] $\overline{X}_m$ = 8.25 s_m= 1.07

[a] 2nd week only [c] 2nd and 3rd week

Table 2 Percentiles of the ***F*** distribution

ν_1, Degrees of freedom, numerator (two-tailed) $\alpha = 1\%$

V_2, Degrees of Freedom, Denominator

$\nu_2 \backslash \nu_1$	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	inf
1	16210.72	19999.50	21614.74	22499.58	23055.80	23437.11	23714.57	23925.41	24091.00	24224.49	24426.37	24630.21	24835.97	24939.57	25043.63	25148.15	25253.14	25358.57	25464.46
2	198.50	199.00	199.17	199.25	199.30	199.33	199.36	199.37	199.39	199.40	199.42	199.43	199.45	199.46	199.47	199.47	199.48	199.49	199.50
3	55.55	49.80	47.47	46.19	45.39	44.84	44.43	44.13	43.88	43.69	43.39	43.08	42.78	42.62	42.47	42.31	42.15	41.99	41.83
4	31.33	26.28	24.26	23.15	22.46	21.97	21.62	21.35	21.14	20.97	20.70	20.44	20.17	20.03	19.89	19.75	19.61	19.47	19.32
5	22.78	18.31	16.53	15.56	14.94	14.51	14.20	13.96	13.77	13.62	13.38	13.15	12.90	12.78	12.66	12.53	12.40	12.27	12.14
6	18.63	14.54	12.92	12.03	11.46	11.07	10.79	10.57	10.39	1tt0.25	10.03	9.81	9.59	9.47	9.36	9.24	9.12	9.00	8.88
7	16.24	12.40	10.88	10.05	9.52	9.16	8.89	8.68	8.51	8.38	8.18	7.97	7.75	7.64	7.53	7.42	7.31	7.19	7.08
8	14.69	11.04	9.60	8.81	8.30	7.95	7.69	7.50	7.34	7.21	7.01	6.81	6.61	6.50	6.40	6.29	6.18	6.06	5.95
9	13.61	10.11	8.72	7.96	7.47	7.13	6.88	6.69	6.54	6.42	6.23	6.03	5.83	5.73	5.62	5.52	5.41	5..30	5.19
10	12.83	9.43	8.08	7.34	6.87	6.54	6.30	6.12	5.97	5.85	5.66	5.47	5.27	5.17	5.07	4.97	4.86	4.75	4.64
11	12.23	8.91	7.60	6.88	6.42	6.10	5.86	5.68	5.54	5.42	5.24	5.05	4.86	4.76	4.65	4.55	4.45	4.34	4.23
12	11.75	8.51	7.23	6.52	6.07	5.76	5.52	5.35	5.20	5.09	4.91	4.72	4.53	4.43	4.33	4.23	4.12	4.01	3.90
13	11.37	8.19	6.93	6.23	5.79	5.48	5.25	5.08	4.94	4.82	4.64	4.46	4.27	4.17	4.07	3.97	3.87	3.76	3.65
14	11.06	7.92	6.68	6.00	5.56	5.26	5.03	4.86	4.72	4.60	4.43	4.25	4.06	3.96	3.86	3.76	3.66	3.55	3.44
15	10.80	7.70	6.48	5.80	5.37	5.07	4.85	4.67	4.54	4.42	4.25	4.07	3.88	3.79	3.69	3.58	3.48	3.37	3.26
16	10.58	7.51	6.30	5.64	5.21	4.91	4.69	4.52	4.38	4.27	4.10	3.92	3.73	3.64	3.54	3.44	3.33	3.22	3.11
17	10.38	7.35	6.16	5.50	5.07	4.78	4.56	4.39	4.25	4.14	3.97	3.79	3.61	3.51	3.41	3.31	3.21	3.10	2.98
18	10.22	7.21	6.03	5.37	4.96	4.66	4.44	4.28	4.14	4.03	3.86	3.68	3.50	3.40	3.30	3.20	3.10	2.99	2.87
19	10.07	7.09	5.92	5.27	4.85	4.56	4.34	4.18	4.04	3.93	3.76	3.59	3.40	3.31	3.21	3.11	3.00	2.89	2.78
20	9.94	6.99	5.82	5.17	4.76	4.47	4.26	4.09	3.96	3.85	3.68	3.50	3.32	3.22	3.12	3.02	2.92	2.81	2.69
21	9.83	6.89	5.73	5.09	4.68	4.39	4.18	4.01	3.88	3.77	3.60	3.43	3.24	3.15	3.05	2.95	2.84	2.73	2.61
22	9.73	6.81	5.65	5.02	4.61	4.32	4.11	3.94	3.81	3.70	3.54	3.36	3.18	3.08	2.98	2.88	2.77	2.66	2.55
23	9.63	6.73	5.58	4.95	4.54	4.26	4.05	3.88	3.75	3.64	3.47	3.30	3.12	3.02	2.92	2.82	2.71	2.60	2.48
24	9.55	6.66	5.52	4.89	4.49	4.20	3.99	3.83	3.69	3.59	3.42	3.25	3.06	2.97	2.87	2.77	2.66	2.55	2.43
25	9.48	6.60	5.46	4.84	4.43	4.15	3.94	3.78	3.64	3.54	3.37	3.20	3.01	2.92	2.82	2.72	2.61	2.50	2.38
26	9.41	6.54	5.41	4.79	4.38	4.10	3.89	3.73	3.60	3.49	3.33	3.15	2.97	2.87	2.77	2.67	2.56	2.45	2.33
27	9.34	6.49	5.36	4.74	4.34	4.06	3.85	3.69	3.56	3.45	3.28	3.11	2.93	2.83	2.73	2.63	2.52	2.41	2.29
28	9.28	6.44	5.32	4.70	4.30	4.02	3.81	3.65	3.52	3.41	3.25	3.07	2.89	2.79	2.69	2.59	2.48	2.37	2.25
29	9.23	6.40	5.28	4.66	4.26	3.98	3.77	3.61	3.48	3.38	3.21	3.04	2.86	2.76	2.66	2.56	2.45	2.33	2.21
30	9.18	6.35	5.24	4.62	4.23	3.95	3.74	3.58	3.45	3.34	3.18	3.01	2.82	2.73	2.63	2.52	2.42	2.30	2.18
40	8.83	6.07	4.98	4.37	3.99	3.71	3.51	3.35	3.22	3.12	2.95	2.78	2.60	2.50	2.40	2.30	2.18	2.06	1.93
60	8.49	5.79	4.73	4.14	3.76	3.49	3.29	3.13	3.01	2.90	2.74	2.57	2.39	2.29	2.19	2.08	1.96	1.83	1.69
120	8.18	5.54	4.50	3.92	3.55	3.28	3.09	2.93	2.81	2.71	2.54	2.37	2.19	2.09	1.98	1.87	1.75	1.61	1.43

TABLE 3

Computations to determine if s_m is different from s_c

at 1% Significance Level (Two-tailed)

Example Data Set (Table 1B)	Period Analyzed	n_{m-1}	n_{c-1}	$F_{.99}$ (Table 2)	s_m^2	s_c^2	$F = \frac{s_m^2}{s_c^2}$ or $F = \frac{s_c^2}{s_m^2}$ so $F \geq 1$	$F > F_{.99}$
1	1st Week	3	10	8.08	2.40	0.58	4.13	No
	1st 2 Weeks	5	21	4.68	2.13	0.50	4.26	No
	3rd Week	3	9	8.72	1.44	1.39	1.04	No
2	1st Week	3	10	43.69	1.17	1.23	1.05	No
	2nd Week	3	10	8.08	1.74	1.25	1.39	No
	2nd & 3rd Week	5	20	12.90	1.14	1.30	1.14	No

TABLE 4

Calculations to determine if x_m differs from x_c at 1% level of significance

								A	B	C						
Example Data Set	Period Analyzed	n_m	n_c	s_m^2	s_c^2	$v_m = \frac{s_m^2}{n_m}$	$v_c = \frac{s_c^2}{n_c}$	$(v_m + v_c)^2$	$\frac{v_m^2}{n_{m+1}}$	$\frac{v_c^2}{n_{c+1}}$	$df = \frac{A}{B+C} - 2$	df round	$t_{.995}$	$\mu = t_{.995}\sqrt{V_c + V_m}$	$\lvert \bar{X}_m - \bar{X}_c \rvert$	$\lvert \bar{X}_m - \bar{X}_c \rvert > \mu,$
1	1st week	4	11	2.40	0.58	0.60	0.05	0.42	0.072	0.000	3.83	4	4.60	3.71	0.06	No
	1st 2 weeks	6	22	2.13	0.50	0.36	0.02	0.14	0.026	0.000	3.38	3	3.84	0.61	0.10	No
	3rd week	4	10	1.44	1.39	0.36	0.14	0.25	0.026	0.002	6.93	7	3.50	2.47	0.07	No
2	1st week	4	11	1.17	1.23	0.29	0.11	0.16	0.017	0.001	6.89	7	3.50	2.21	2.90	Yes
	2nd week	4	11	1.74	1.25	0.44	0.11	0.30	0.039	0.000	5.50	6	3.71	2.75	0.10	No
	2nd & 3rd week	6	21	1.14	1.30	0.19	0.06	0.06	0.005	0.000	10.00	10	3.17	1.58	0.16	No

TABLE 5 - PERCENTILES OF THE ***T*** DISTRIBUTION

t table with right tail probabilities								
df\p	0.40	0.25	0.10	0.05	0.025	0.01	0.005	0.0005
1	0.324920	1.000000	3.077684	6.313752	12.70620	31.82052	63.65674	636.6192
2	0.288675	0.816497	1.885618	2.919986	4.30265	6.96456	9.92484	31.5991
3	0.276671	0.764892	1.637744	2.353363	3.18245	4.54070	5.84091	12.9240
4	0.270722	0.740697	1.533206	2.131847	2.77645	3.74695	4.60409	8.6103
5	0.267181	0.726687	1.475884	2.015048	2.57058	3.36493	4.03214	6.8688
6	0.264835	0.717558	1.439756	1.943180	2.44691	3.14267	3.70743	5.9588
7	0.263167	0.711142	1.414924	1.894579	2.36462	2.99795	3.49948	5.4079
8	0.261921	0.706387	1.396815	1.859548	2.30600	2.89646	3.35539	5.0413
9	0.260955	0.702722	1.383029	1.833113	2.26216	2.82144	3.24984	4.7809
10	0.260185	0.699812	1.372184	1.812461	2.22814	2.76377	3.16927	4.5869
11	0.259556	0.697445	1.363430	1.795885	2.20099	2.71808	3.10581	4.4370
12	0.259033	0.695483	1.356217	1.782288	2.17881	2.68100	3.05454	4.3178
13	0.258591	0.693829	1.350171	1.770933	2.16037	2.65031	3.01228	4.2208
14	0.258213	0.692417	1.345030	1.761310	2.14479	2.62449	2.97684	4.1405
15	0.257885	0.691197	1.340606	1.753050	2.13145	2.60248	2.94671	4.0728
16	0.257599	0.690132	1.336757	1.745884	2.11991	2.58349	2.92078	4.0150
17	0.257347	0.689195	1.333379	1.739607	2.10982	2.56693	2.89823	3.9651
18	0.257123	0.688364	1.330391	1.734064	2.10092	2.55238	2.87844	3.9216
19	0.256923	0.687621	1.327728	1.729133	2.09302	2.53948	2.86093	3.8834
20	0.256743	0.686954	1.325341	1.724718	2.08596	2.52798	2.84534	3.8495
21	0.256580	0.686352	1.323188	1.720743	2.07961	2.51765	2.83136	3.8193
22	0.256432	0.685805	1.321237	1.717144	2.07387	2.50832	2.81876	3.7921
23	0.256297	0.685306	1.319460	1.713872	2.06866	2.49987	2.80734	3.7676
24	0.256173	0.684850	1.317836	1.710882	2.06390	2.49216	2.79694	3.7454
25	0.256060	0.684430	1.316345	1.708141	2.05954	2.48511	2.78744	3.7251
26	0.255955	0.684043	1.314972	1.705618	2.05553	2.47863	2.77871	3.7066
27	0.255858	0.683685	1.313703	1.703288	2.05183	2.47266	2.77068	3.6896
28	0.255768	0.683353	1.312527	1.701131	2.04841	2.46714	2.76326	3.6739
29	0.255684	0.683044	1.311434	1.699127	2.04523	2.46202	2.75639	3.6594
30	0.255605	0.682756	1.310415	1.697261	2.04227	2.45726	2.75000	3.6460

APPENDIX

1. Calculations to determine if s_m differs significantly from s_c for data set one after 2 weeks (Table 1B).

$n_m = 6, \quad n_m - 1 = 5$

$n_c = 22, \quad n_c - 1 = 21$

$F_{.99} = 4.68$ (Table 2)

$s_m = 1.46, \quad s_m^2 = 2.13$

$s_c = 0.71, \quad s_c^2 = 0.50$

$$F = \left(\frac{s_m^{\ 2}}{s_c^{\ 2}}\right) = \frac{2.13}{0.50} = 4.26$$

$F < F_{.99}$ or $4.26 < 4.68$, therefore $s_m = s_c$ at 1% significance level

2. Calculations to determine if $\overline{X}_m$ differs significantly from $\overline{X}_c$ for data set two after 1 week (Table 1B).

$n_m = 4$

$n_c = 11$

$\overline{X}_m = 7.10$

$\overline{X}_c = 10.00$

$s_m = 1.08, \quad s_m^2 = 1.17$

$s_c = 1.11, \quad s_c^2 = 1.23$

$$V_m = \left(\frac{s_m^{\ 2}}{n_m}\right) = \frac{1.17}{4} = 0.29$$

$$V_c = \left(\frac{s_c^{\ 2}}{n_c}\right) = \frac{1.23}{11} = 0.11$$

$$df = \left(\frac{(V_m + V_c)^2}{\left(\frac{V_m^{\ 2}}{n_m + 1}\right) + \left(\frac{V_c^{\ 2}}{n_c + 1}\right)}\right) - 2$$

$$= \left(\frac{(0.29 + 0.11)^2}{\left(\frac{0.29^2}{4+1}\right) + \left(\frac{0.11^2}{11+1}\right)} \right) - 2 = \left(\frac{(.40)^2}{\left(\frac{0.084}{5}\right) + \left(\frac{0.012}{12}\right)} \right) - 2$$

$$= \frac{0.16}{.017+.001} - 2 = \frac{0.16}{.018} - 2 = 8.89 - 2$$

$$= 6.89$$

df round to = 7

$t_{.995}$ = 3.50, for *df* = 7 (Table 5)

$\mu = t_{.995} \sqrt{(V_m + V_c)}$ $\mu = 3.50\sqrt{(0.29 + 0.11)}$ $\mu = 3.50\sqrt{0.40}$ $\mu = 3.50\ (0.63)$ $\mu = 2.21$

$|\bar{X}_m - \bar{X}_c| = |7.10 - 10.00| = 2.90$

$|\bar{X}_m - \bar{X}_c| > \mu$ or (2.90 > 2.21), $\bar{X}_m$ differs from $\bar{X}_c$ at a 1% significance level.

3. Calculations to determine if the test results from the Department's split samples, $\bar{X}_m$, differ significantly from those of the Contractor's, $\bar{X}_c$, for data represented in Table1A using the paired *t*-test.

n=20, $\bar{X}_d$ = -1.4, s_d = 1.46, $t = \frac{|\bar{X}_d|}{\frac{s_d}{\sqrt{n}}} = \frac{|-1.4|}{\frac{1.46}{\sqrt{20}}} = 4.29$

Look up $t_{\alpha/2, n-1}$, or $t_{0.995, 19}$, since testing is done at a 1% significance level (α= 0.01) from Table 5 (which is single-tail), $t_{0.995, 19}$ = 2.86, $t \geq t_{0.995, 19}$ or 4.29 $\geq$ 2.86 then conclude the Department's monitor sample results, $\bar{X}_m$ differ from the Contractor's acceptance sample results, $\bar{X}_c$.

Calculations to determine if s_m differs significantly from s_c for data represented in Table 1A.

n_m = 20, n_m - 1 = 19, n_c = 20, n_c - 1 = 19

$F_{.99}$ = 3.44 (Table 2, Note: had to interpolate)

s_m = 1.13, s_m^2 = 1.28, s_c = 1.33, s_c^2 = 1.77

$$F = \left(\frac{s_c^2}{s_m^2} \right) = \frac{1.77}{1.28} = 1.39$$

$F < F_{.99}$ or 1.39 < 3.44, therefore $s_m = s_c$ at 1% significance level

Virginia Test Method – 60

Compatibility Test of Slurry Seal Mixtures – (Asphalt Lab)

November 1, 2000

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. (100 mm) or more out of round bottom bowl during stirring.

d. Supply of 6 in. (152 mm) (approximately) squares cut from smooth (40-60 lb.) (18-27 kg.) 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) (20 – 27° C), 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. (6 mm) and cured for one hour at 68-80° F (20 - 27° C). 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 – 61

Deleted - ***Acid Resistance Of Glass Spheres In Preformed Tape***

April 1, 2000

Virginia Test Method - 62

Deleted - ***Stripping Test for Asphalt Concrete***

Virginia Test Method - 63

Deleted – ***Filtering Efficiency of Filter or Liquid Bags for use in Rest Areas***

April 1, 1996

Virginia Test Method – 64

Consistency of Emulsified Asphalt (Asphalt Lab)

November 1, 2000

AASHTO T 59 procedure shall be followed, except as modified below:

23. Procedure

23.2 Tests at 122° F (50° C) - Clean and dry the viscometer and insert the cork. Stir the sample thoroughly without incorporating bubbles, and then pour approximately 100 ml in to a 400 ml glass beaker. Immerse the bottom of the beaker containing the emulsion approximately 2 in. (50 mm) below the level of a 160 ± 5° F (71 ± 5° C) water bath. Hold the beaker upright and stir the emulsion with a wide circular motion at a rate of 60 rpm with the thermometer to obtain uniform temperature distribution. Avoid incorporation of bubbles. Heat the emulsion in the water bath to 124.5 ± 0.5° F (51.4 ± 0.3° C). Immediately pour the emulsion through the No. 20 sieve or 20 mesh strainer into the viscometer until it is above the overflow rim. Stir the emulsion in the viscometer at 60 rpm with the thermometer until the test temperature is attained, avoiding bubble formation. Adjust the bath temperature until the emulsion temperature remains constant for 1 min. at 122 ± 0.1° F (50 ± 0.05° C). Withdraw the thermometer. Quickly remove the excess emulsion from the gallery with a suction pipette. Determine the viscosity as described in AASHTO T 72. Report the results to the nearest full second.

NOTE 11 - While the Saybolt Furol viscometer is not used for petroleum products and lubricants when the time of flow is less than 25 s, this instrument is satisfactory for testing emulsified asphalt when the time of flow is not less than 20 s.

Virginia Test Method – 65

Aggregate-Asphalt Compatibility Test for Surface Treatment – (Asphalt Lab)

November 1, 2000

1. Scope

1.1 The Compatibility Test is used to determine the stripping of emulsified asphalt from aggregate.

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 Scale, capable of weighing 1000 grams accurate to within ± 1.0 gram.

2.2 Suitable heavy gauge steel round bottom bowl to contain the sample during mixing.

2.3 Long-handle spoon of sufficient length to project 100 mm or more out of round bottom bowl during stirring.

2.4 Supply of 150 mm (appr.) squares cut from smooth (14-27 kg) roofing felt.

2.5 Quart (0.95 L) can with 18 holes (3 mm) in lid for sprinkling water.

3. Procedure

3.1 To a total of 200 grams of minimum SSD (Saturated Surface Dry) condition aggregate add 30 grams (15%) of emulsion. Stir until completely coated. (Max. 30 sec.). Place on roofing felt and spread to uniform thickness (Approx. depth of top size aggregate) and immediately sprinkle water over sample until water running off sample is clear, very nearly clear, or when 3/4 of a quart 700 ml) of water is used, observe coating after sprinkling with water (within 5 minutes). To pass a sample must have a glossy black and tacky surface. Also, the sample shall show no signs of stripping. If aggregate is not fully coated it fails this test.

In case there is a question of a very small amount of 5% or less aggregate not coated a reference test shall be run to determine if this is due to not being fully coated during mixing. The reference test shall be run on 400 grams of aggregate of 20 percent emulsion. On half of the sample after mixing shall be placed on the roofing felt and not sprinkled. The other half shall be sprinkled as described in Section 3.1. If the sprinkled portion looks like the unsprinkled portion the test will be considered fully coated.

4. Report

4.1 Pass or Fail

VTM-65
AGGREGATE ASPHALT COMPATABILITY TEST
FOR SURFACE TREATMENT

SAMPLE NO.	**DATE**	
TERMINAL	**LOCATION**	
AGGREGATE SOURCE	**AGGREGATE GRAMS**	
TYPE EMULSION	**% EMULSION**	
SAMPLED FROM:	**TERMINAL TANK π**	**PROJECT π**
% RESIDUAL ASPHALT		
SAMPLE GLOSSY BLACK	**YES π PASS**	**NO π FAIL**
SAMPLE TACKY WHEN CHECKED BY HAND CONTACT:	**YES π PASS**	**NO π FAIL**
COATING:	**100% π PASS**	**LESS THAN 100% π FAIL**
RUN BY	**TELEPHONE NO.**	

Virginia Test Method – 66

Surface Treatment Design – (Asphalt Lab)

November 1, 2000

1. Scope

1.1 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. Procedures

2.1 Method MS-19 as published by The Asphalt Institute - procedure shall be followed, except as modified below:

PART 1 - SIEVE ANALYSIS

Delete the following sieve: 1/4" - 0 .250 (6.3 mm – 6.4 mm)

PART 2 - FLAKINESS INDEX

Sizes of slots for each aggregate fraction MS-19, Appendix D, Figure D-2.

Delete the following slot sixes:

Sieve Size	Slot Width, in./mm.
1" - 3/4" (25 mm – 19 mm)	0.525 (13.3 mm)
3/4" - 1/2" (19 mm – 12.5 mm)	0.375 (9.5 mm)
1/4" - No. 4 (6.3 mm – 4.75 mm)	0.131 (3.33 mm)

Change slot from -3/8" + 1/4" (0.184) to -3/8" + #4 (0.184)
(- 9.5 mm + 6 .3 mm (4.67 mm)

C. 6.13

W = Rodded weight of cover aggregate lb/ft^3 (kg/m^3). (AASHTO Method T19).

<u>Virginia Test Method – 67</u>

Deleted - *MEK Solvent Rub Test*

See ASTM D-4752

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Virginia Test Method – 68

Nondestructive Pavement Deflection Testing
With a Falling-Weight-Type-Impulse Load Device – (Pavement Design)

July 1, 2001

1. Scope

a. This method covers the measurement of deflections of paved and unpaved surfaces with a Falling-Weight-Type impulse load device.

b. The test shall be run using a Falling Weight Deflectometer (FWD) and in accordance with ASTM 4694-96, Test Method for Deflections with a Falling – Weight – Type Impulse Load Device and VDOT's "Project Evaluation and Pavement Design – Appendix A."

2. Flexible Pavements

General - For flexible pavements, falling weight deflectometer (FWD) testing is used to assess the structural capacity of the pavement and estimate the strength of subgrade soils. In addition to the structural capacity, the elastic modulus for the surface, base and subbase layers can be determined.

a. General – For flexible pavements, falling weight deflectometer (FWD) testing is used to access the structural capacity of the pavement and estimate the strength of subgrade soils. In addition to the structural capacity, the elastic modulus for the surface, base and subbase layers can be determined.

b. FWD Testing Pattern - The FWD testing pattern selected for a project should be related to the project's size and layout. The Pavement Designer should consider the number of lanes to be tested, total length of the project, and any unusual circumstances that would require a change in the testing pattern.

c. Project Layout - The project layout will influence the FWD testing pattern. For projects where the pavement is to be repaired in each direction, then travel lanes in each direction should be tested. Typically, this should be the outside travel lane. For projects where only one direction will be repaired and more than two lanes exist, then testing should be conducted on the outside lane and possibly inside lane. The inside lane should be tested if:
    i. Pavement structure is different than the outside lane,
    ii. More load related distress is present as compared to the outside lane, or
    iii. Heavy truck traffic uses the lane (lane is prior to a left exit).

d. Project Size - The size of a project will influence the test spacing. The project size is determined by the directional length of pavement to be repaired, not necessarily the centerline length. For example, a project that has a centerline distance of 1 mile (1.6 km) and will be repaired in two directions has a directional length of 2 miles (3.2 km). Therefore, the test spacing should be based on two miles (3.2 km). Table 1 contains guidelines based on project size, test spacing, and estimated testing days. More detailed

testing guidelines are provided at the end of this appendix. A testing day is defined as 200 locations tested.

Project Size (miles/ km)	Test Spacing (ft / m)	Approximate Number of Tests	Testing Days
0 – 0.5 (0-0.8 km)	25 (8 m)	75	Less than ½ day
0.5 – 1.0 (0.8-1.6 km)	50 (15 m)	90	½ Day
1.0 – 2.0 (1.6-3.2 km)	50 (15 m)	175	½ to 1 Day
2.0 – 4.0 (3.2-6.4 km)	100 (30 m)	175	½ to 1 Day
4.0 – 8.0 (6.4-12.8 km)	150 (45 m)	200	½ to 1 ½ Days
> 8.0 (12.8 km)	200 (60 m)	>200	> 1 Day

e. Basin Testing Location - For flexible pavements, FWD testing should be conducted in the wheel path closest to the nearest shoulder. For the outside lanes, testing should be conducted in the right wheel path. For inside lanes, testing should be conducted in the left wheel path.

f. FWD Drop Sequence - When collecting pavement structure data, the correct drop sequence is required. Drop sequences vary based on pavement type and the type of information being gathered. Drop sequence is defined as the order in which impulse loads are applied to the pavement. This includes the "seating drops" and the recorded impulse loads. Below is the recommended drop sequence for basin testing on flexible pavements:

   i. Two Seating Drops at 12,000 pounds (5,443 kg)
   ii. Three Recorded Drops at 6,000 pounds (2,722 kg)
   iii. Three Recorded Drops at 9,000 pounds (4,082 kg)
   iv. Three Recorded Drops at 16,000 pounds (7,257 kg)

g. FWD Sensor Spacing - FWD sensor spacing to record pavement deflection data is dependent on the pavement type as well as the testing purpose (load transfer testing vs. basin testing). For basin testing on flexible pavements, the recommended spacing is 0 in., 8 in., 12 in., 18 in., 24 in., 36 in., 48 in., 60 in., and 72 in. (203 mm, 305 mm, 457 mm, 610 mm, 915 mm, 1220 mm, 1525 mm, 1830 mm) If the FWD is only equipped with seven sensors, then the sensors at 48 in. and 72 in. (1220 mm and 1830 mm) can be removed.

h. Pavement Temperature Readings - For flexible pavements, the asphalt material strength is dependent on its temperature. For higher temperatures (above 80 degrees Fahrenheit (27 degrees Celcius)), the material is softer and has a lower elastic modulus. Conversely, at lower temperatures (less than 60 degrees Fahrenheit (16 degrees Celcius)) the material is harder and has a higher elastic modulus. In order to determine the strength of an asphalt layer for project level analysis, its strength must be corrected to a standard reference temperature. This temperature is typically between 68 and 75 degrees Fahrenheit (20 and 24 degrees Celcius). Therefore, the pavement temperature must be known. When conducting FWD testing, it is important to properly measure and record the pavement temperature. The temperature should be measured at the mid-depth point of the AC layer and on the AC surface.

   i. Mid-Depth Temperature Measurement - In order to measure the temperature at the mid-depth point of the AC layer(s), a hole must be drilled into the pavement. The depth of this hole should be approximately one half the thickness of the AC

layer(s). Therefore, to drill this hole either the AC layer(s) thickness must be known or trial holes must be drilled to estimate the layer thickness. Once the temperature hole is drilled, the hole should be filled within one inch (25 mm) of the AC surface with mineral oil. Mineral oil helps dissipate the heat introduced to the pavement from the drill bit as well as become the same temperature as the surrounding asphalt. Then, place a piece of gray duct tape over the hole, this keeps the sun from warming the mineral oil. By inserting a temperature probe into the hole, the mid-depth pavement temperature can be recorded. It is important to allow the pavement temperature to stabilize before recording the measurement. This generally takes 5 to 10 minutes after pouring in the mineral oil. Once stabilized, record the temperature to the nearest degree. At a minimum, the temperature should be recorded twice during the FWD testing. The temperature should be recorded prior to testing and once testing has been completed for the day. If testing will take more than four hours, then a temperature should recorded in the middle of the testing. If applicable, the same temperature holes can be used for all measurements. However, if the AC layer thickness changes or if the FWD operator determines the initial hole should not be reused (due to distance, traffic control, etc.), then new hole(s) must be drilled and the temperature recorded.

ii. Surface Temperature Measurement - Since asphalt strength is dependent on the material temperature, it is important to know the mid-depth temperature during deflection analysis. By knowing the mid-depth temperature, the AC modulus determined from back calculation can be adjusted to a reference temperature (typically between 68 and 75 degrees Fahrenheit (20 and 24 Celsius)) for each test location. This will aid the Pavement Designer in assessing weak sections of a pavement as well as design an appropriate rehabilitation option. Ideally, the pavement temperature will be recorded directly from temperature holes at each test location as the FWD test is being performed. While this is the preferred approach for research projects, it is not practical for production level testing (network level or maintenance and rehabilitation projects). Therefore, for production level testing the economic and practical approach to determine the mid-depth pavement temperature is by measuring the surface temperature at each test location. This can be easily done using an infrared thermometer. The FWD can automatically measure and record the pavement surface temperature to the FWD file. If the FWD is not equipped with an Infrared thermometer, then the FWD operator can use a hand held thermometer and record the temperature to a file. Using temperature correlation models such as the BELLS2 equation, the mid-depth AC material temperature can be estimated.

3. Jointed Concrete Pavement

a. General - For rigid pavements, falling weight deflectometer (FWD) testing is used to assess the structural capacity of the pavement and estimate the strength of subgrade soils. In addition to the structural capacity, the elastic modulus for the surface, base and sub-base layers can be determined.
b. FWD Testing Pattern - The FWD testing pattern selected for a jointed concrete pavement project should be related to the project's layout, project size, and slab length. The Pavement Designer should consider the number of lanes to be tested, total number of slabs, length of the project, and any unusual circumstances that would require a change in the testing pattern.
c. Project Layout - The project layout will influence the FWD testing pattern. For projects where the pavement is to be repaired in each direction, then travel lanes in each direction

should be tested. Typically, this should be the outside travel lane. For projects where only one direction will be repaired and more than two lanes exist, then testing should be conducted on the outside lane and possibly inside lane. The inside lane should be tested if:

i. Pavement structure is different than the outside lane,
ii. More load related distress is present as compared to the outside lane, or
iii. Heavy truck traffic uses the lane (lane is prior to a left exit).

d. Slab Length and Project Size - The number of jointed concrete slabs in a project will determine test spacing. For projects with short slab lengths, it may not be practical to test every slab (basin and joint testing). For projects with longer slab lengths, every slab may be tested. In addition to slab length, the size of a project will influence the test spacing. The project size is determined by the directional length of pavement to be repaired, not necessarily the centerline length. For example, a project that has a centerline distance of 1 mile (1.61 km) and will be repaired in two directions has a directional length of 2 miles (3.22 km). Therefore, the test spacing should be based on two miles (3.22 km). Table 2 contains guidelines based on project size, approximate slab length, test spacing, and estimated testing days. More detailed testing guidelines are provided at the end of this appendix. A testing day is defined as 175 locations tested (joints, corners and basins).

Project Size (miles)	Slab Length	Basin Test Spacing (no. of slabs)	Joint/Corner Spacing (no. of slabs)	Approximate Number of Tests	Testing Days
0 - 0.5 (0-0.8 km)	< 20' (6 m)	Every 6th Slab	Every 2nd J/C	115	½ to 1 Day
	20' – 45' (6-14 km)	Every Slab	Every J/C	175	1 Day
	> 45' (14 m)	Every Slab	Every J/C	120	½ to 1 Day
0.5 – 1.0 (0.8–1.6 km)	< 20' (6 m)	Every 9th Slab	Every 3rd J/C	180	1 Day
	20' – 45' (6-14 m)	Every 2nd Slab	Every 2nd J/C	175	1 Day
	> 45' (14 m)	Every Slab	Every J/C	300	1 ½ - 2 Days
1.0 – 2.0 (1.6– 3.2 km)	< 20' (6 m)	Every 12th Slab	Every 4th J/C	250	1 – 2 Days
	20' – 45' (6-14 m)	Every 4th Slab	Every 2nd J/C	300	1 ½ - 2 Days
	> 45' (14 m)	Every 2nd Slab	Every 2nd J/C	270	1 ½ - 2 Days
2.0 – 4.0 (3.2– 6.4 km)	< 20' (6 m)	Every 15th Slab	Every 5th J/C	380	1 ½ - 3 Days
	20' – 45' (6-14 m)	Every 6th Slab	Every 4th J/C	380	1 ½ - 3 Days
	> 45' (14 m)	Every 4th Slab	Every 2nd J/C	450	2 – 3 ½ Days
4.0 – 8.0 (6.4-12.8 km)	< 20' (6 m)	Every 20th Slab	Every 10th J/C	220	1 ½ - 3 Days
	20' – 45' (6-14 m)	Every 8th Slab	Every 4th J/C	470	2 ½ - 4 ½ Days
	> 45' (14 m)	Every 6th Slab	Every 3rd J/C	590	2 ½ - 4 ½ Days
> 8.0 (12.8 km)	<20' (6 m)	Every 20th Slab	Every 10th J/C	450	3 Days
	20' – 45' (6-14 m)	Every 10th Slab	Every 5th J/C	650	3 ½ - 4 Days
	> 45' (14 m)	Every 8th Slab	Every 4th Slab	500	3 Days

e. Testing Location - For jointed concrete pavements, three types of FWD testing are generally conducted – basin, joint, and slab corner testing. Each test provides information on the structural integrity of the pavement.

i. Basin Testing - For jointed concrete pavements, basin testing should be conducted near the center of the slab (See Diagram 2). This testing provides information on the elastic modulus of the PCC and strength of base materials and subgrade soils.

ii. Joint Testing - For jointed concrete pavements, joint testing should be conducted in the wheel path closest to the free edge of the slab. Typically, for the outside lanes, testing will be conducted in the right wheel path. For inside lanes, testing should be conducted in the left wheel path. If more than two lanes exist and the middle lanes are to be tested, then the nearest free edge must be determined. This testing provides information on joint load transfer – how well a joint, either through aggregate interlock and/or dowel bars, can transfer a wheel load from one slab to an adjacent slab.

iii. Corner Testing - For jointed concrete pavements, corner testing should be conducted at the slab's free edge corner. Typically, for the outside lanes, testing will be conducted in the right corner edge of the slab. For inside lanes, testing should be conducted in the left corner edge of the slab. If more than two lanes exist, then the middle lanes should only be tested if pumping is suspected in the middle lanes. The Pavement Designer will determine if pumping is present and if testing should be conducted. This testing provides information on the possibility for the presence of voids under a slab corner.

f. FWD Drop Sequence - When collecting pavement structure data, the correct drop sequence is required. Drop sequences vary based on pavement type and the type of information being gathered. Drop sequence is defined as the order in which impulse loads are applied to the pavement. This includes the "seating drops" and the recorded impulse loads.

i. Basin Testing - Below is the recommended drop sequence for basin testing on jointed concrete pavements:
   1. Two Seating Drops at 12,000 pounds (5,443 kg)
   2. Three Recorded Drops at 6,000 pounds (2,722 kg)
   3. Three Recorded Drops at 9,000 pounds (4,082 kg)
   4. Three Recorded Drops at 16,000 pounds (7,257 kg)

ii. Joint Testing - Below is the recommended drop sequence for joint testing on jointed concrete pavements:
   1. Two Seating Drops at 12,000 pounds (5,443 kg)
   2. One Seating Drop at 9,000 pounds (4,082 kg)
   3. One Recorded Drop at 9,000 pounds (4,082 kg)
   4. One Seating Drop at 16,000 pounds (7,257 kg)
   5. One Recorded Drop at 16,000 pounds (7,257 kg)

iii. Corner Testing - Below is the recommended drop sequence for corner testing on jointed concrete pavements:
   1. Two Seating Drops at 12,000 pounds (5,443 kg)
   2. One Seating Drop at 9,000 pounds (4,082 kg)
   3. One Recorded Drop at 9,000 pounds (4,082 kg)
   4. One Seating Drop at 12,000 pounds (5,443 kg)
   5. One Recorded Drop at 12,000 pounds (5,443 kg)
   6. One Seating Drop at 16,000 pounds (7,257 kg)
   7. One Recorded Drop at 16,000 pounds (7,257 kg)

g. FWD Sensor Spacing - FWD sensor spacing to record pavement deflection data is dependent on the pavement type as well as the type of testing. For jointed concrete pavements, three types of testing are performed – joint, corner and basing.

i. Basin Testing - For basin testing on jointed concrete pavements, the following is the recommended spacing: 0 in., 8 in., 12 in., 18 in., 24 in., 36 in., 48 in., 60 in., and 72 in (203 mm, 305 mm, 457 mm, 610 mm, 915 mm, 1220, 1525 mm, 1830 mm).

ii. Joint Testing - For joint testing on jointed concrete pavements, only two sensors are required. The required spacing 0 in. and 12 in (0 – 305 mm). The sensors are to be placed on each side of the joint and are to be 6 inches (152 mm) from the joint.

h. Pavement Temperature Readings - For rigid pavements, the concrete material strength is not highly dependent of its temperature; however, load transfer and pavement layer strength below the PCC slab are affected. At higher temperatures (typically above 70 degrees Fahrenheit (21 degrees Celcius)), PCC slabs tend to curl concave down and expand in length. Therefore, at the center of the slab the PCC and base layer are not in contact. At the transverse joints, slabs are pressed together and testing may indicate load transfer is good even though at lower temperatures this is not the case. Please note, when incompressibles are present in the joint, then the joint tends to spall or even buckle. For lower temperatures (typically less than 50 degrees Fahrenheit (10 degrees Celcius)), PCC slabs tend to curl concave up and contract in length. Therefore, the edges of the slab are not in contact with the base layer and the joints are open. Because temperature effects the structural characteristics of jointed concrete pavement, the pavement temperature must be known. At temperatures above 70 degrees Fahrenheit (21 degrees Celcius), FWD joint and basin testing is not recommended. At temperatures below 50 degrees Fahrenheit (10 degrees Celcius), FWD corner testing is not recommended. Please note, the temperature effects on short slab lengths (less than 15 feet (5 m)) is minimal but must be considered prior to testing. When conducting FWD testing, it is important to properly measure and record the pavement temperature. The temperature should be measured at the mid-depth point of the PCC layer and on the PCC surface.

i. Mid-Depth Temperature Measurement - In order to measure the temperature at the mid-depth point of the PCC layer(s), a hole must be drilled into the pavement. The depth of this hole should be approximately one half the thickness of the PCC layer(s). Therefore, to drill this hole either the PCC layer(s) thickness must be known or trial holes must be drilled to estimate the layer thickness. Once the temperature hole is drilled, the hole should be filled within one inch of the PCC surface with mineral oil. Mineral oil helps dissipate the heat introduced to the pavement from the drill bit as well as become the same temperature as the surrounding PCC. Then, place a piece of gray duct tape over the hole this keeps the sun from warming the mineral oil. By inserting a temperature probe into the hole, the mid-depth pavement temperature can be recorded. It is important to allow the pavement temperature to stabilize before recording the measurement. This generally takes 5 to 10 minutes after pouring in the mineral oil. Once stabilized, record the temperature to the nearest degree. At a minimum, the temperature should be recorded twice during the FWD testing. The temperature should be recorded prior to testing and once testing has been completed for the day. If testing will take more than four hours, then a temperature should recorded in the middle of the testing. If applicable, the same temperature holes can be used for all measurements. However, if the PCC layer thickness changes or if the FWD operator determines the initial hole should not be reused (due to

distance, traffic control, etc.), then new hole(s) must be drilled and the temperature recorded.

ii. Surface Temperature Measurement - Ideally, the pavement temperature will be recorded directly from temperature holes at each test location as the FWD test is being performed. While this is the preferred approach for research projects, it is not practical for production level testing (network level or maintenance and rehabilitation projects). Therefore, for production level testing the economic and practical approach is by measuring the surface temperature at each test location. This can be easily done using an infrared thermometer. The FWD can automatically measure and record the pavement surface temperature to the FWD file. If the FWD is not equipped with an Infrared thermometer, then the FWD operator can use a hand held thermometer and record the temperature to a file. By measuring and monitoring the surface temperature during testing, the FWD operator can suspend testing if the pavement becomes too hot.

4. Composite Pavements

a. General - For composite pavements, falling weight deflectometer (FWD) testing is used to assess the structural capacity of the pavement and estimate the strength of subgrade soils as well as assess the load transfer at underlying joints. In addition to the structural capacity, the elastic modulus for the surface, base and subbase layers can be determined.

b. FWD Testing Pattern - The FWD testing pattern selected for a project should be related to the project's size and layout. The Pavement Designer should consider the number of lanes to be tested, total length of the project, and any unusual circumstances that would require a change in the testing pattern. In addition, the AC overlay thickness should be considered. If the thickness is less than four inches (102 mm), then the load transfer of the underlying PCC joints may be performed.

c. Project Layout - The project layout will influence the FWD testing pattern. For projects where the pavement is to be repaired in each direction, then travel lanes in each direction should be tested. Typically, this should be the outside travel lane. For projects where only one direction will be repaired and more than two lanes exist, then testing should be conducted on the outside lane and possibly inside lane. The inside lane should be tested if:
   i. Pavement structure is different than the outside lane,
   ii. More load related distress is present as compared to the outside lane, or
   iii. Heavy truck traffic uses the lane (lane is prior to a left exit).

d. Project Size - The size of a project will influence the test spacing. The project size is determined by the directional length of pavement to be repaired, not necessarily the centerline length. For example, a project that has a centerline distance of 1 mile (1.61 km) and will be repaired in two directions has a directional length of 2 miles (3.22 km). Therefore, the test spacing should be based on two miles (3.22 km). Table 3 contains guidelines based on project size, test spacing, and estimated testing days if load transfer testing is not performed. If load transfer testing is desired, then the appropriate spacing should be determined in the field. As a guideline, please refer to Joint/Corner Spacing column in Table 2. More detailed testing guidelines are provided at the end of this appendix. A testing day is defined as 200 locations tested.

Project Size (miles/ km)	**Test Spacing (ft / m)**	**Approximate Number of Tests**	**Testing Days**
0 – 0.5 (0-0.8 km)	25 (8 m)	75	Less than ½ day
0.5 – 1.0 (0.8-1.6 km)	50 (15 m)	90	½ Day

1.0 – 2.0 (1.6-3.2 km)	50 (15 m)	175	½ to 1 Day
2.0 – 4.0 (3.2-6.4 km)	100 (30 m)	175	½ to 1 Day
4.0 – 8.0 (6.4-12.8 km)	150 (45 m)	200	½ to 1 ½ Days
> 8.0 (12.8 km)	200 (60 m)	>200	> 1 Day

Table 1 Composite Pavement Test Spacing Guidelines

e. Testing Locations - For composite pavements, two types of FWD testing are generally conducted – basin and joint. Each test provides information on the structural integrity of the pavement.

   i. Basin Testing - For composite pavements, basin testing should be conducted in the middle of the lane or near the center of the slab. This testing provides information on the elastic modulus of the AC, PCC and strength of base materials and subgrade soils.

   ii. Joint Testing - For composite pavements, joint testing should be conducted in the wheel path closest to the free edge of the slab. Typically, for the outside lanes, testing will be conducted in the right wheel path. For inside lanes, testing should be conducted in the left wheel path. If more than two lanes exist and the middle lanes are to be tested, then the nearest free edge must be determined. This testing provides information on joint load transfer – how well a joint, either through aggregate interlock and/or dowel bars, can transfer a wheel load from one slab to an adjacent slab.

f. FWD Drop Sequence - When collecting pavement structure data, the correct drop sequence is required. Drop sequences vary based on pavement type and the type of information being gathered. Drop sequence is defined as the order in which impulse loads are applied to the pavement. This includes the "seating drops" and the recorded impulse loads.

   i. Basin Testing - Below is the recommended drop sequence for basin testing on composite pavements:

      1. Two Seating Drops at 12,000 pounds (5,443 kg)
      2. Three Recorded Drops at 6,000 pounds (2,722 kg)
      3. Three Recorded Drops at 9,000 pounds (4,082 kg)
      4. Three Recorded Drops at 16,000 pounds (7,257 kg)

   ii. Joint Testing - Below is the recommended drop sequence for joint testing on composite pavements:

      1. Two Seating Drops at 12,000 pounds (5,443 kg)
      2. One Seating Drop at 9,000 pounds (4,082 kg)
      3. One Recorded Drop at 9,000 pounds (4,082 kg
      4. One Seating Drop at 16,000 pounds (7,257 kg)
      5. One Recorded Drop at 16,000 pounds (7,257 kg)

g. FWD Sensor Spacing - FWD sensor spacing to record pavement deflection data is dependent on the pavement type as well as the type of testing. For composite pavements, three types of testing are performed – joint, and basin.

i. Basin Testing - For basin testing on composite pavements, the recommended spacing is 0 in., 8 in., 12 in., 18 in., 24 in., 36 in., 48 in., 60 in., and 72 in. (203 mm, 305 mm, 457 mm, 610 mm, 915 mm, 1220, 1525 mm, 1830 mm).

ii. Joint Testing - For joint testing on composite pavements, only two sensors are required. The required spacing is 0 in. and 12 in (0-305 mm).

h. Pavement Temperature Readings - For flexible and composite pavements, the asphalt material strength is dependent on its temperature. For higher temperatures (above 80 degrees Fahrenheit 27 degrees Celcius)), the material is softer and has a lower elastic modulus. Conversely, at lower temperatures (less than 60 degrees Fahrenheit (16 degrees Celcius)) the material is harder and has a higher elastic modulus. In order to determine the strength of an asphalt layer for project level analysis, its strength must be corrected to a standard reference temperature. This temperature is typically between 68 and 75 degrees Fahrenheit (20 and 24 degrees Celcius). Additionally, when estimating the strength of the underlying PCC layer, the compression in the asphalt layer during testing must be determined. This AC layer compression is dependent on material temperature. Therefore, the pavement temperature must be known. When conducting FWD testing, it is important to properly measure and record the pavement temperature. The temperature should be measured at the mid-depth point of the AC layer and on the AC surface.

i. Mid-Depth Temperature Measurement - In order to measure the temperature at the mid-depth point of the AC layer(s), a hole must be drilled into the pavement. The depth of this hole should be approximately one half the thickness of the AC layer(s). Therefore, to drill this hole either the AC layer(s) thickness must be known or trial holes must be drilled to estimate the layer thickness. Once the temperature hole is drilled, the hole should be filled within one inch of the AC surface with mineral oil. Mineral oil helps dissipate the heat introduced to the pavement from the drill bit as well as become the same temperature as the surrounding asphalt. Then, place a piece of gray duct tape over the hole, this keeps the sun from warming the mineral oil. By inserting a temperature probe into the hole, the mid-depth pavement temperature can be recorded. It is important to allow the pavement temperature to stabilize before recording the measurement. This generally takes 5 to 10 minutes after pouring in the mineral oil. Once stabilized, record the temperature to the nearest degree. At a minimum, the temperature should be recorded twice during the FWD testing. The temperature should be recorded prior to testing and once testing has been completed for the day. If testing will take more than four hours, then a temperature should recorded in the middle of the testing. If applicable, the same temperature holes can be used for all measurements. However, if the AC layer thickness changes or if the FWD operator determines the initial hole should not be reused (due to distance, traffic control, etc.), then new hole(s) must be drilled and the temperature recorded.

ii. Surface Temperature Measurement - Since asphalt strength is dependent on the material temperature, it is important to know the mid-depth temperature during deflection analysis. By knowing the mid-depth temperature, the AC modulus determined from back calculation can be adjusted to a reference temperature (typically between 68 and 75 degrees Fahrenheit) for each test location. This will aid the Pavement Designer in assessing weak sections of a pavement as well as design an appropriate rehabilitation option. Ideally, the pavement temperature

will be recorded directly from temperature holes at each test location as the FWD test is being performed. While this is the preferred approach for research projects, it is not practical for production level testing (network level or maintenance and rehabilitation projects). Therefore, for production level testing the economic and practical approach to determine the mid-depth pavement temperature is by measuring the surface temperature at each test location. This can be easily done using an infrared thermometer. The FWD can automatically measure and record the pavement surface temperature to the FWD file. If the FWD is not equipped with an Infrared thermometer, then the FWD operator can use a hand held thermometer and record the temperature to a file. Using temperature correlation models such as the BELLS2 equation, the mid-depth AC material temperature can be estimated.

5. Continuously Reinforced Concrete Pavement

a. General - For rigid pavements, falling weight deflectometer (FWD) testing is used to assess the structural capacity of the pavement and estimate the strength of subgrade soils. In addition to the structural capacity, the elastic modulus for the surface, base and sub-base layers can be determined.

b. FWD Testing Pattern - The FWD testing pattern selected for a continuously reinforced concrete pavement project should be related to the project's layout and project size. The Pavement Designer should consider the number of lanes to be tested, total number of slabs, length of the project, and any unusual circumstances that would require a change in the testing pattern.

c. Project Layout - The project layout will influence the FWD testing pattern. For projects where the pavement is to be repaired in each direction, then travel lanes in each direction should be tested. Typically, this should be the outside travel lane. For projects where only one direction will be repaired and more than two lanes exist, then testing should be conducted on the outside lan) and possibly inside lane. The inside lane should be tested if:
   i. Pavement structure is different than the outside lane,
   ii. More load related distress is present as compared to the outside lane, or
   iii. Heavy truck traffic uses the lane (lane is prior to a left exit).

d. Project Size - The size of a project will influence the test spacing. The project size is determined by the directional length of pavement to be repaired, not necessarily the centerline length. For example, a project that has a centerline distance of 1 mile (1.61 km) and will be repaired in two directions has a directional length of 2 miles (3.22 km). Therefore, the test spacing should be based on two miles. Table 4 contains guidelines based on project size, test spacing (basins and cracks), and estimated testing days. More detailed testing guidelines are provided at the end of this appendix. A testing day is defined as 175 locations tested (joints, corners and basins).

Project Size (miles/km)	**Basin Test Spacing (ft/m)**	**Crack Spacing (ft/m)**	**Approximate Number of Tests**	**Testing Days**
0 – 0.5 (0 – 0.8 km)	25 (8 m)	25 (8 m)	150	½ - 1 Days
0.5 – 1.0	50	25	270	1 ½ Days

(0.8 – 1.6 km)	(15 m)	(8 m)		
1.0 – 2.0 (1.6 – 3.5 km)	100 (30 m)	50 (15 m)	270	1 ½ - 2 Days
2.0 – 4.0 (3.2 – 6.4 km)	150 (45 m)	50 (15 m)	450	2 – 3 Days
3.0 – 8.0 (6.4 – 12.8 km)	150 (45 m)	75 (23 m)	650	2 ½ - 5 Days
> 8.0 (12.8 km)	200 (60 m)	150 (45 m)	680	4 Days

Table 2 Continuously Reinforced Concrete Pavement Test Spacing Guidelines

e. Testing Location - For continuously reinforced concrete pavements, two types of FWD testing are generally conducted – basin and crack. Each test provides information on the structural integrity of the pavement.

   i. Basin Testing - For continuously reinforced concrete pavements, basin testing should be conducted near the center of the panel (See Diagram 6). This testing provides information on the elastic modulus of the PCC and strength of base materials and subgrade soils.

   ii. Crack Testing - For continuously reinforced concrete pavements, crack testing should be conducted in the wheel path closest to the free edge of the slab (See Diagram 6). Typically, for the outside lanes, testing will be conducted in the right wheel path. For inside lanes, testing should be conducted in the left wheel path. If more than two lanes exist and the middle lanes are to be tested, then the nearest free edge must be determined. This testing provides information on crack load transfer – how well a crack, either through aggregate interlock and/or steel reinforcement, can transfer a wheel load from one CRC panel to an adjacent panel.

f. FWD Drop Sequence - When collecting pavement structure data, the correct drop sequence is required. Drop sequences vary based on pavement type and the type of information being gathered. Drop sequence is defined as the order in which impulse loads are applied to the pavement. This includes the "seating drops" and the recorded impulse loads.

   i. Basin Testing - Below is the recommended drop sequence for basin testing on continuously reinforced concrete pavements:

      1. Two Seating Drops at 12,000 pounds (5,443 kg)
      2. Three Recorded Drops at 6,000 pounds (2,722 kg)
      3. Three Recorded Drops at 9,000 pounds (4,082 kg)
      4. Three Recorded Drops at 16,000 pounds (7,257 kg)

   ii. Crack Testing - Below is the recommended drop sequence for crack testing on continuously reinforced concrete pavements:

      1. Two Seating Drops at 12,000 pounds (5,443 kg)
      2. One Seating Drop at 9,000 pounds (4,082 kg)
      3. One Recorded Drop at 9,000 pounds (4,082 kg)
      4. One Seating Drop at 16,000 pounds (7,257 kg)
      5. One Recorded Drop at 16,000 pounds (7,257 kg)

g. FWD Sensor Spacing - FWD sensor spacing to record pavement deflection data is dependent on the pavement type as well as the type of testing. For continuously reinforced concrete pavements, two types of testing are performed – basin and crack.

   i. Basin Testing - For basin testing on continuously reinforced concrete pavements, the recommended spacing is 0 in., 8 in., 12 in., 18 in., 24 in., 36 in., 48 in., 60 in., and 72 in. (203 mm, 305 mm, 457 mm, 610 mm, 915 mm, 1220, 1525 mm, 1830 mm).

   ii. Crack Testing - For crack testing on continuously reinforced concrete pavements, only two sensors are required. The required spacing 0 in. and 12 in (0-305 mm).

h. Pavement Temperature Readings - For rigid pavements, the concrete material strength is not highly dependent of its temperature. However, it is still important to properly measure and record the pavement temperature. The temperature should be measured at the mid-depth point of the PCC layer and on the PCC surface.

   i. Mid-Depth Temperature Measurement - In order to measure the temperature at the mid-depth point of the PCC layer, a hole must be drilled into the pavement. The depth of this hole should be approximately one half the thickness of the PCC layer(s). Therefore, to drill this hole either the PCC layer(s) thickness must be known or trial holes must be drilled to estimate the layer thickness. Once the temperature hole is drilled, the hole should be filled within one inch (25 mm) of the PCC surface with mineral oil. Mineral oil helps dissipate the heat introduced to the pavement from the drill bit as well as become the same temperature as the surrounding PCC. Then, place a piece of gray duct tape over the hole, this keeps the sun from warming the mineral oil. By inserting a temperature probe into the hole, the mid-depth pavement temperature can be recorded. It is important to allow the pavement temperature to stabilize before recording the measurement. This generally takes 5 to 10 minutes after pouring in the mineral oil. Once stabilized, record the temperature to the nearest degree. At a minimum, the temperature should be recorded twice during the FWD testing. The temperature should be recorded prior to testing and once testing has been completed for the day. If testing will take more than four hours, then a temperature should recorded in the middle of the testing. If applicable, the same temperature holes can be used for all measurements. However, if the PCC layer thickness changes or if the FWD operator determines the initial hole should not be reused (due to distance, traffic control, etc.), then new hole(s) must be drilled and the temperature recorded.

   ii. Surface Temperature Measurement - Ideally, the pavement temperature will be recorded directly from temperature holes at each test location as the FWD test is being performed. While this is the preferred approach for research projects, it is not practical for production level testing (network level or maintenance and rehabilitation projects). Therefore, for production level testing the economic and practical approach is by measuring the surface temperature at each test location. This can be easily done using an infrared thermometer. The FWD can automatically measure and record the pavement surface temperature to the FWD file. If the FWD is not equipped with an Infrared thermometer, then the FWD operator can use a hand held thermometer and record the temperature to a file.

By measuring and monitoring the surface temperature during testing, the FWD operator can suspend testing if the pavement becomes too hot.

6. Responsibilities of Personnel Requesting the FWD Test

   a. To provide the NDT Unit Manager with a completed request form.
   b. To coordinate the availability of traffic control during testing and coring.
   c. To arrange for drilling crew, obtaining, identifying, and transporting all cores and samples.
   d. To provide equipment operator (driver) if necessary.

7. Responsibilities of FWD Testing Crew

   a. Collect deflection data including the noting of visible distress and drainage features of the pavement.
   b. Collect and record ambient air and pavement temperatures.
   c. Forward the collected data to the NDT Unit Manager.

Virginia Test Method – 69

Deleted - ***Reclaiming Trichloroethane and Adjusting Alcohol Content***

April 1, 1996

Virginia Test Method – 70

Abrasion Resistance of Pavement Markers – (Chemistry Lab)

November 1, 2004

1. Scope

1.1 The purpose of this test is to evaluate the abrasion resistance of pavement markers.

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 ASTM D 4280 Section 9.5

3. Method

3.1 ASTM D 4280, Section 9.5, shall be followed.

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Virginia Test Method – 71

Crushing Strength of Pavement Markers – (Chemistry Lab)

November 1, 2000

4. Scope

4.1 The purpose of this test is to evaluate the abrasion resistance of pavement markers.

4.2 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 Compression Machine conforming to AASHTO T22

6. Method

6.1 Position marker base down at the center of a 0.5 inch (12.5 mm) thick flat steel plate. Apply a load to the top center of the marker by means of a 1.0 inch (25 mm) diameter solid steel plug at a rate of 0.03 in. per minute. Failure occurs when breakage or significant deformation occurs.

Virginia Test Method – 72

Soil Cement Stabilization – (Soils Lab)

November 1, 2000

1. Scope

1.1 This method covers the procedure to be used for determining the following:

1.2 For base or subbase design, soil cement molds are made, as below, and used to determine the soil/cement losses and moisture changes produced by both repeated wetting/drying and freezing/thawing cycles.

1.3 For subgrade design, soil cement molds are made, as below through procedure 4b., and broken on 7, 14, 21 and 28 days.

1.4 This standard may involve hazardous materials, operations, and equipment. This 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 1/30 ft^3 (0.000943 m^3) molds.

2.2 Hand held, or automatic, compactor with 5.5 lb. (2.5 kg) rammer.

2.3 Balance capacity of 25 lbs., accuracy of 0.01 lb. Also a balance capacity of 1,000 g, accuracy of 0.1 g.

2.4 Drying oven controlled to maintain a temperature of 230 ± 9º F (110 ± 5º C) .

2.5 Wire scratch brush made of 2 x 0.0625 inch (51 x 16 mm) flat No. 26 gage wire bristles assembled in 50 groups of 10 bristles each and mounted to form 5 longitudinal rows and 10 transverse rows of bristles on a 7.5 x 2.5 inch (190.5 x 63.5 mm) hardwood block.

2.6 Large containers with air-tight lids, and small cans with tight fitting lids for moisture content samples.

2.7 No. 4 (4.75 mm) sieve.

3. Molding Specimens

3.1 Air-dry or oven dry the sample at a temperature not over 140° F (60° C).

3.2 Screen the soil through a No. 4 (4.75 mm) sieve and store in the large containers (The lids should fit tightly in order to control the moisture content.)

3.3 Determine the moisture content of the canned soil.

3.4 In accordance with AASHTO T-99, Method A, determine the optimum moisture content and maximum density.

3.5 For each percent of cement to be tested, combine approximately 8000 grams of soil with the amount of cement by weight required to obtain the percent of cement. Mix the soil

and cement thoroughly. Mix the soil/cement mixture with sufficient water to obtain optimum moisture. The mixture can be calculated by using the formulas as in the following EXAMPLE:

Data: (1) 8.0% Cement by Volume required
(2) 8000 grams. of Dry soil desired
(3) 2.0% Moisture in Air-dried Soil
(4) 130.0 lbs /ft^3. (2243 kg/m^3) Maximum Density
(5) 14.0% Optimum Moisture

Step 1: Convert % cement by volume to % cement by weight

$$\frac{\text{\% Cement by Volume x 0.94}}{\text{Maximum density - (\% cement by volume x 0.94)}} \text{ x } 100$$

Example:

$$\frac{.0 \text{ x } 0.94}{130.0 - (8.0 \text{ x } 0.94)} \text{ x } 100 = 6.14 \text{ \% Cement by weight}$$

Step 2: Determine weight of CEMENT needed

$$\frac{\text{\% Cement by weight x Dry soil desired}}{100}$$

Example:

$$\frac{6.14 \text{ x } 8000}{100} = 491 \text{ Grams}$$

Step 3: Determine weight of AIR-DRIED SOIL needed

$$\text{Dry soil x } \left(1 + \frac{\text{\% Moisture in Air-dried soil}}{100}\right)$$

Example:

$$8000 \text{ x } \left(1 + \frac{2.0}{100}\right) = 8160 \text{ Grams}$$

Step 4: Determine the amount of WATER to be added

$$\left[(\text{Dry soil + cement}) \text{ x } \frac{\text{Opt. moist.}}{100}\right] - \text{Air-dried + dry soil}$$

Example:

$$\left[(8000 + 491) \text{ x } \frac{14.0}{100}\right] - 8160 + 8000 = 1029 \text{ Grams}$$

3.6 For each percent of cement to be tested, form 4 (four) specimens by compacting the prepared soil/cement mixture in the mold, with the collar attached, in 3 (three) equal layers so as to give a total compacted depth of about 5 (five) inches (127 mm). In addition, scarify the tops of the first and second layers to remove smooth compaction planes. Compact each layer by 25 blows from the rammer dropping free from a height of 12 inches (305 mm). The blows shall be uniformly distributed over the surface of layer being compacted. During compaction, the mold shall rest on a uniform, rigid foundation.

Following compaction, remove the extension collar, carefully trim the specimen even with the top of the mold with a straightedge.

During compaction, take from the batch a representative sample of the soil-cement mixture, weighing not less than 100 grams, weigh immediately and dry in the oven for at least 12 hours or to constant mass. Calculate the percentage of moisture to check against design moisture content.

3.7 Weigh the compacted specimen and mold, remove the specimen from mold and calculate the oven-dry mass of each specimen in pounds/cubic foot (kilograms /cubic meter) to check against design density.

3.8 Identify and label each specimen.

3.9 Form the other specimens as rapidly as possible using this same procedure.

4. Procedure

4.1 Place ALL specimens in the moisture room to cure for 7 (seven) days. (Temperature at 70° ± 3° F (21° ± 1.7° C) and humidity at 100%).

4.2 The 1ST SPECIMENS are to be used to determine the 7 (seven) day compressive strengths. Place in water and soak for 4 (four) hours, then break at a rate of application of load of 5 to 6 psi/sec (239 – 287 Pa/sec).

4.3 The 2ND SPECIMENS are to be used for the wetting/drying test as follows:

(1) Soak specimens in water for 5 (five) hours.
(2) Place in oven for 43 hours.
(3) Weigh specimens and record in the report.
(4) Brush with 20 strokes on the sides and 2 strokes on each end. --UP AND DOWN equals 1 (one) stroke --
(5) Reweigh specimen and record.

The above constitutes 1 (one) cycle.

4.4 The 3RD SPECIMENS will be used for the freeze/thaw test as follows:

(1) Place specimen on 3 inch (76 mm) thick blotters and place in the freezer (Temperature at -10° F (-23° C)) for 24 hours.
(2) Place specimens in the moisture room for 24 hours. The blotters should remain saturated at all times.
(3) Weigh specimen and record.
(4) Brush the specimen as in step 4.c.(4).
(5) Reweigh specimen and record.

The above constitutes 1 (one) cycle.

4.5 The 4TH SPECIMENS will be used for the 28 day strength. After curing in the moisture room for 28 days, the specimens will be broken as in step 4b.

4.6 After 12 cycles of wetting/drying and freeze/thaw, the specimens are placed in oven and allowed to dry for 5 (five) days.

4.7 Weigh the specimens and record.

5. Calculations

For each specimen, calculate PERCENT LOSS for wetting/drying test and freeze/thaw test as follows:

5.1 Original weight:

(1) Calculate the average weight of the 4 molds for each percent cement.
(2) Divide the average by 1+ moisture content to obtain the original weight. (For example: for a moisture content = 8%, divide by 1.08).

5.2 Final weight:

-for materials with optimum moistures up to 15%, divide final weight by 1%: (weight after oven drying)/(1.01)

-for materials with optimum moistures over 15%, divide final weight by 2%: (weight after oven drying)/(1.02)

5.3 (original weight - final weight)/(original weight) = PERCENT LOSS.

Virginia Test Method – 73

Method for Evaluating Qualified Paint Systems – (Chemistry Lab)

November 1, 2000

1. Scope

1.1 This method of test is used to approve paint systems submitted for a qualified systems test.

1.2 This standard may involve hazardous materials, operations, and equipment. This 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 Salt Fog Cabinet

2.2 Cleveland Condensing Cabinet

2.3 U. V. Cabinet

2.4 Sand Blasting Equipment

2.5 Paint Spray Equipment

2.6 Wet and Dry Film Thickness Gauges

2.7 Profilometer

2.8 Panels of Various Sizes (Provided by the Department)

3. Preparation of Sample

3.1 A complete set of panels will be sent to the manufacturer upon request.

3.2 Panels shall be cleaned and prepared in accordance with SSPC-SP l, 2 or 3, and then blasted to a nominal 2.0 mil (0.05 mm) profile in accordance with SSPC-SP 10.

3.3 The panels will be painted with the entire coating system following the manufacturer's recommendations.

3.4 Panels used for salt fog and Cleveland condensing testing will be scribed with an X with minimum 2 inch (51 mm) legs and at a 90° angle to each other.

3.5 The panels will be weathered and rated as described below.

4. Procedure

4.1 Salt Fog: After 5000 hours, the panels shall be graded for rust and staining at the scribe, blistering and overall stain and rust.

a. Rust and Stain at Scribe

Amount	Rating	Weighted Value
None	4	4
Staining	3	3
Minor or Moderate	2	2
Severe	1	1

b. Blister size/Frequency (per ASTM D714)

Rating	3.5	3.0	2.5	2.0	1.0
Weighted Value7	6	5	4	2	
Blister rating	8F	8M	8MD	8D	6D
	6F	6M	6MD	4D	
	4F	4M	4MD	2MD	
		2F	2M	2D	

c. Overall Rust and Rust Staining

Amount	Rating	Weighted Value
None	4	8
Staining	3	6
Minor or Moderate	2	4
Severe	1	2

4.2 Freeze Thaw

Prepared panels will be exposed to a 30 day freeze/thaw/immersion cycle. The cycle shall consist of 4 hours of immersion in deionized water at room temperature, 16 hours at approximately 5° F (-15° C) , followed by 4 hours at room temperature to complete one 24 hour cycle. This is done for 5 days with panels remaining in the freezer over weekends/holidays. Upon completion, cross hatch adhesion in general accordance with ASTM D3359 Method B (modified) will be performed using a 5 mm guide.

The results will be rated as:

	PAINT	WEIGHTED VALUE
Good - Minor coating removal adjoint to scribe line or no removal of coating	4	8
Marginal - A portion of each square disbanded from grid, but approximately 70% or more of the coating in the test area remain intact	3	6
Marginal to Poor - A portion of each squareremoved and in most cases entire squares disbonded from grid. Generally 30 – 70% of the coating in the test area remained intact.	2	4
Poor - Less Than 30% remained, but generally complete disbonding of coating within entire grid area.	1	2
Very Poor - Total disbondment without using tape	0	0

4.3 Cleveland Condensing: After 5000 hours in a Cleveland Condensing Cabinet (1 cycle is 20 hours of condensation at 104° F (40° C), 4 hours drying), the panels shall be rated for:

a. Rust at Scribe
Rated as in 4.1 (a) above

b. Blister size/Frequency
Rated as in 4.1 (b) above

c. Overall rust and stain
Rated as in 4.1 (c) above

d. Adhesion
Rated as in 4.2 above

4.4 Ultraviolet Exposure: After 2000 hours in a QUV Cabinet (1 cycle is 8 hours of UV exposure at 140° F (40° C), 4 hours of condensation at 113° F (45° C), color retention shall be acceptable and adhesion rating can not be less than "Marginal to Poor" when rated as in 4.2 above.

5.1 Any system which has a rating of severe rusting at scribe, any overall rust and staining, a poor adhesion rating due to freeze thaw, or Cleveland condensing or Ultraviolet exposure will be rejected. Otherwise, the points awarded on the weighted rating scale will be totaled and a percentage of the total calculated. Any system which receives a rating of less than 75% will be rejected. The systems will also be rejected if they are not capable of being easily applied in the laboratory.

Virginia Test Method – 74

Determining Lime Content of Freshly Mixed Lime-Aggregate Mixtures for Use in Asphalt Concrete – (Asphalt Lab)

November 1, 2000

1. Scope

1.1 This method of test is intended for determining the lime content of lime-aggregate mixtures sampled at the Asphalt Concrete plant.

1.2 This standard may involve hazardous materials, operations, and equipment. This 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 Balance - A balance having a capacity of at least 1,000 grams with a sensitivity of at least 0.1 gram.

2.2 Timer - A timer with a capacity of 10 minutes or more and a sensitivity of at least 0.1 second.

2.3 Glassware - 25 ml graduated cylinder, 1,000 ml cylinder, 2,000 ml volumetric flask, 50 ml burettes, 10 ml volumetric pipettes, 250 ml Erlenmeyer flasks, medicine droppers.

2.4 Plasticware - 2 qt. (1.89 L) polyethylene containers with snap-on covers, 12 in. (300 mm) diameter plastic funnel, 5 gal. (19 L) polyethylene bottles for ammonium chloride, 5 gal. (19 L) polyethylene bottles for demineralized water.

2.5 Burette Stand for 50 ml burette.

2.6 Magnetic Stirrer and Stirring Bar.

2.7 Stirring Rods - Glass stirring rods approximately 12 in. (300 mm) long.

2.8 Indicator Paper - Supply of indicator paper, pH range from 10 to 14.

2.9 Pipette Filler.

2.10 Sample Splitter - Maximum size 1 1/2 in (37.5 mm).

3. Reagents

3.1 Ammonium Chloride Solution (10%) - Transfer 1893 g of U. S. P. granular ammonium chloride (NH_4C1) to a 5-gal. (18.93 L) plastic bottle. Make up to 5-gal. (18.93 L) with distilled or demineralized water and mix well.

3.2 EDTA Solution (0.1 M) - Dissolve 74.5 g of reagent grade disodium (ethylenedinitrilo) tetraacetate dihydrate ($Na_2C_{10}H_{14}N_2O_82H_20$) powder in about one litre of warm, distilled or demineralized water in a beaker. Cool to room temperature, transfer quantitatively to a 2-litre volumetric flask and make to the mark with distilled or demineralized water. Store in polyethylene bottle.

3.3 Cal Red or Hydroxy Naphthol Blue may be used as the indicator.

3.4 Sodium Hydroxide Solution (50%) - Add 500 g of reagent grade sodium hydroxide (NaOH) pellets in 600 ml of distilled or demineralized water and allow to cool to room temperature. Dilute to one litre with distilled or demineralized water. Store in plastic bottle. Dilute 1:1 with distilled or demineralized water for use. Caution: Solution shall be mixed in the order given to avoid spontaneous reaction.

3.5 Triethanolamine Solution (20%) - Dilute 100 ml of reagent grade triethanolamine ($HOCH_2CH_2$) 3 N to 500 ml with distilled or demineralized water.

4. Procedure for Preparing Calibration Curve

4.1 From the aggregates to be used in the asphalt mix, prepare 3 sets of duplicate samples at 3% moisture content and containing the following amounts of lime:

Set 1. Two (2) samples at 0.5 percent lime content.

Set 2. Two (2) samples at 1 percent lime content.

Set 3. Two (2) samples at 1.5 percent lime content.

Using a sample size of 600 grams for each sample, compute the quantities of aggregate, lime and water as follows:

$$W_a \text{ (total weight of aggregate, g)} = \frac{\text{Sample Size}}{(1 + M/100)\,(1 + L/100)}$$

$$W_r \text{ (weight of material retained on No. 4 sieve)} = \frac{R}{100} \times W_a$$

$$W_f \text{ (weight of material passing No. 4 sieve, g)} = W_a - W_r$$

$$W_l \text{ (weight of lime, g)} = \frac{L}{100} \times W_a$$

$$V_w \text{ (volume of water, ml)} = \frac{M}{100}\,(W_a + W_l)$$

Where: M = 3% moisture content, percent by dry weight
L = Lime content, percent by dry weight of aggregate, and
R = Percent material retained on No. 4 sieve.

For each sample, mix the aggregate and lime thoroughly to a uniform color. Add the water and mix thoroughly.

Titrate each 600 g sample as described under Procedure for Titration. After titrating the 6 samples, construct a graph showing ml of EDTA solution vs. per cent lime by weight using average figures from Sets 1, 2, and 3.

A separate calibration curve shall be prepared for each mix type where lime is to be used as an anti-stripping additive.

5. Procedure for Test Samples

5.1 At the Asphalt Concrete plant, samples of the lime-aggregate mixture shall be taken at the completion of the aggregate and lime mixing. The samples are to be tested immediately or placed in covered plastic containers or plastic bags and tested as soon as possible.

For testing, weigh a 600 g portion and titrate as described under Procedure for Titration.

Note 1 - If a correction is to be made for variations in moisture content, determine the moisture content (M') of a separate portion of the material passing a No. 4 (4.75 mm) sieve. Computation for the correction are given under Calculations, Note 4.

6. Procedure for Titration

6.1 Place each 600 g sample in a 2-qt. (1.89 L) polyethylene container and add l,200 ml ammonium chloride solution. Place cover on the container and shake the mixture for 2 minutes (±2 seconds). Allow the mixture to settle for 4 minutes (±2 seconds). Pipette a 10 ml aliquot of the supernatant solution into a 250 ml Erlenmeyer flask and add 100 ml of distilled or demineralized water. While thoroughly mixing on a magnetic stirrer, add drops of sodium hydroxide solution until a pH between 13.0 to 13.5 is obtained as measured by the indicator paper. Use stirring rod to transfer drops of solution to indicator paper, add 4 drops of triethanolamine solution and then add about 0.2 g of the indicator powder. While the solution is being stirred on the magnetic stirrer, titrate with EDTA and record the quantity in ml to a pure blue endpoint.

Note 2 - A sharper endpoint may sometimes be obtained by adding approximately half of the anticipated quantity of EDTA solution before the addition of sodium hydroxide.

Note 3 - All equipment must be kept scrupulously clean by thorough rinsing with distilled or demineralized water. All reagents must be stored in polyethylene containers.

7. Calculations

Read the lime content by dry weight directly from the calibration curve corresponding to the titration results in ml of EDTA for the test sample.

Note 4 - Variations of moisture content (above 2%) will have a slight effect on the accuracy of test. Correction for moisture variation may be computed as follows:

$$L' = \frac{1 + M'/100\ L}{1 + M/100}$$

Where: L' = percent lime corrected for moisture variation,

L = percent lime determined from test sample,

M' = percent moisture of test sample as determined in Paragraph 5, Note 1, and

M = 3.0% moisture content.

8. Sampling

8.1 Size of sample - Obtain a 10 lb. (4.54 kg.) sample and mix thoroughly using a spoon. Weigh exactly 600 g as sample size for testing.

8.2 In all cases, samples shall be taken after the aggregate and lime are properly mixed. The samples shall be taken in a random manner before the material enters the dryer.

8.3 The motion of the belt shall be halted and a sample (approx. 10 lbs. (4.54 kg.)) taken by squaring off an area with a square-ended shovel.

Virginia Test Method – 75

Deleted - *Evaluation of Preformed Pavement Marking Tapes*

April 1, 1996

Virginia Test Method – 76

Control Strip Density And Roller Pattern
And Control Strip Procedure Using A Thin-Lift
Nuclear Density Gauge For Asphalt Concrete Mixtures - (Asphalt Lab)

June 10, 2013

1. Scope

1.1 This method details the establishment of the minimum control strip density using the Thin-Lift Nuclear Gauge and a recommended procedure for setting up the Control Strip/Roller Pattern. Other procedures for setting up the Control Strip/Roller Pattern may be used when approved by the Engineer.

1.2 Within the first 500' to 1000' (150 m to 300 m) of mix placement a Roller Pattern and Control Strip will be constructed. The first 75' (25 m)(approximate) length will be the Roller Pattern, and the next 300' (100 m) (approximate) length will be the Control Strip, regardless of the paver width, and should be of the same depth or application rate as called for in the plans and/or contract

*Note A Roller Pattern and Control Strip should only be constructed after a minimum of 500' (150 m) of mix has been placed.

1.3 The Roller Pattern and Control Strip shall be constructed using the same material, the same paving equipment and in the same manner as the remainder of the project.

1.4 To prevent delay in Density Determination, cores/plugs from surface and intermediate mixes shall be cut using a dry method of sawing. Cores/plugs from base mixes may be cut using either a dry method or a wet method of sawing.

1.5 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 Approved Mix Design.

2.2 Approved Paving Equipment.

2.3 Nuclear Gauge Template and white/other approved spray paint

2.4 Thin-Lift Nuclear Density Gauge with printer, must meet requirements of VTM-81.

2.5 Magnesium Nuclear Gauge Calibration Block

2.6 A rolling measuring device that will measure from 1 to 1000 linear feet (1 to 300 meters), or any other device approved by the Engineer.

2.7 Rotary Saw or Coring machine for sawing a core/plug.

2.8 Equipment to weigh cores/plugs (VTM-6).

2.9 All apparatus to be furnished by the Contractor.

2.10 The Maximum Theoretical Specific Gravity for the approved Mix Design as determined in VTM-22.

3. Procedure

3.1 At the beginning of each day a standard count of the nuclear gauge should be performed at the project site.

3.2 To begin the Roller Pattern, make several passes (up and back) on 75' (25 m) (approximate) of one section of the paver width. Move the roller over and roll the same number of passes on the other section of the paver width. (Refer to sketches in section 4.3) Record the number and type of Roller passes placed on the asphalt mat on the Asphalt Nuclear Density Roller Pattern Worksheet.

*Note: Use judgment and experience to make the maximum number of passes before beginning the nuclear gauge readings. (ex. If a mix has historically taken 6 vibratory passes of the roller to achieve compaction, then 4 vibratory passes should be made on the roller pattern section before any nuclear density readings are recorded. If there were no prior experience with a specific type of mix, then 2 passes (one (1) up and one (1) back) would be recommended as a starting point.) The Roller pattern should be constructed in the same manner and with the same compaction equipment that the rest of the pavement will be constructed. If the paver width is wider than 12' (4 m) and a breakdown roller will take more than two roller widths to get coverage over the entire mat then the roller pattern should reflect the procedure that will be used in production.

3.3 Select three (3) locations to be tested for density in the 75' (25 m) roller pattern area. Two (2) locations shall be approximately 30' (9 m) apart on one side of the lane and one (1) location on the opposite side of the lane approximately 15' (5 m) from each of the first two sites. The exact location the gauge is placed shall be marked. The Nuclear Gauge shall always be positioned parallel with the roadway, with the source end toward the paver anytime a reading is taken. To prevent erroneous readings, care must be taken to ensure that the gauge is sitting flat on the asphalt surface and does not rock. Care must also be taken by the gauge operator to ensure that the gauge's source is in the proper test position when readings are taken. Nuclear readings for the Roller Pattern may be taken using the 30-second mode. Tests will be taken after each additional pass from the same three (3) locations, with the gauge sitting in the same position as the first test. It is recommended that the paver stop while the roller pattern is being constructed. Once the roller pattern has been established the control strip will be placed using the same process except the paver will not pause or stop.

3.4 The average of the three (3) readings shall be plotted on the Roller Pattern Graph, in Density, lb/ft^3 or kg/m^3, vs. number of passes. The Roller Pattern shall be rolled until maximum density for the asphalt mixture is obtained. To achieve maximum density, the mat shall be rolled until the average density reading decreases. After the first decrease, the mat shall receive one additional pass of the roller to ensure that this was not a false break. If the mat continues to decrease in density, then the maximum density will be the density achieved one roller pass before the initial decrease in density.

If a false break occurs (the density increases on the additional pass), then continue to make roller passes until the density decreases a second time. Once the density has decreased, make an additional pass. If the density decreases on this pass, then the maximum density will be the density achieved one roller pass before the second decrease. If the density increases, repeat these steps until maximum density has been achieved.

Note: Typically a decrease in 0.5 lb/ft^3 (0.25 kg/m^3) will indicate that maximum density has been achieved.

3.5 Build a 300' (100 m) Control Strip by following the procedure established in the 75' (25 m) roller pattern section. Ten stratified random selected locations will be marked in the 300' (100 m) Control Strip section with the Nuclear Gauge Template (Section 4.3 – Figure 2). The template shall be placed on the mat and positioned parallel with the roadway with the arrows pointing in the direction of the paver. The Template shall be spray painted with white/other approved paint such that the underlying pavement is marked with paint through the cutouts in the template. These locations must be clearly visible when the template is removed. After marking its location with paint the Gauge Template shall be removed and a number painted near the sight (not within the template's boundary).

3.6 The Nuclear Gauge (the special calibration and offset modes will be disabled and set in the one (1) minute mode for testing) shall then be placed within the area marked by the Gauge Template with the source toward the direction of the paver. Nuclear density readings in lb/ft^3 (kg/m^3) using the one-minute mode will be taken at the ten (10) locations marked in the 300' (100 m) Control Strip section. The average of the ten (10) nuclear density tests, in lb/ft^3 (kg/m^3) will become the target density if the average bulk density (see section 3.7) of the cores/plugs determined in this Control Strip is satisfactory.

The dry density determined from the average of the Control Strip should be within ±3 lb/ft^3 (48 kg/m^3) of the Roller Pattern's maximum dry density.

3.7 One set of plugs/cores (2- 4" x 4"'sawed plugs or 2- 4" diameter cores) (2- 100 mm x 100 mm sawed plugs or 2- 100 mm diameter cores) shall be taken for density determination from three of the ten nuclear gauge reading locations in the 300' (100 m) Control Strip section. The sites for the sawed plugs/cores should be the three sites that are closest to the average nuclear gauge target density established in Section 3.6. The plugs/cores shall be taken within the gauge template's boundary directly beneath where the nuclear source of the gauge was located. Compute the bulk density of the 6 plugs/cores (VTM-6). If one plug/core from a site is damaged, then the remaining undamaged plug/core will represent the bulk density of that specific site. If both plugs are damaged, then another set of plugs will be taken from the next site whose nuclear density reading is closest to the target density. The average bulk density for each site will be determined. The percent density (VTM-22) will be calculated from the three average bulk densities determined at each site. If the average percent density of the three sites meets the density requirements of section 315 of The Road and Bridge Specifications the average nuclear density determined in Section 3.6 will become the Target Density, in lb/ft^3 (kg/m^3).

3.7.1 Lift Thicknesses 2.5" (63 mm) and Less - Artificial and rapid cooling methods (such as dry ice and CO_2) are used to chill fresh warm mats sufficiently to dry saw/core the mat for density testing without damaging the sample. Note, use of flammable materials such as propane shall not be used as a rapid cooling method.

3.7.2 Lift Thicknesses In Excess of 2.5" (63 mm) – Wet cooling methods may be used to obtain density plugs/cores on lift thicknesses in excess of 2.5" (63 mm). When wet cooling is used, the cores/plugs must be dried back in the lab and VTM-6 followed to determine the percent density. Artificial and rapid cooling methods are not effective. When wet cooling methods are not used, a period of not less than 12 hours after placement of the mix must pass before density plugs/cores are obtained. Note, use of flammable materials such as propane shall not be used as a rapid cooling method.

3.8 When the same approved mix design is to be used on a roadway other than the one for which the cores/plugs were taken for density determination, a new 375' (125 m) (approx.)

Roller Pattern/Control Strip shall be constructed to determine the Roller Pattern and Target Density for this roadway. The Roller Pattern/Control Strip for this roadway will be determined in the same manner as the original with the exception that only one set (2 sawed plugs/cores) shall be taken from one of the ten nuclear gauge reading locations in the 300' (100 m) Control Strip section. The site for the plugs/cores should be the site that the nuclear density reading is closest to the target density established in Section 3.6.The average bulk density for the site will be determined. The percent density (VTM-22) will then be calculated from the average bulk density. If the percent density meets specification, the average of ten (10) nuclear readings taken at random locations from the stratified 300' (100 m) (approx.) section shall become the Target Density, in lb/ft^3 (kg/m^3), for this roadway.

3.8.1 Lift Thicknesses 2.5" (63 mm) and Less - Artificial and rapid cooling methods (such as dry ice and CO_2) are used to chill fresh warm mats sufficiently to dry saw/core the mat for density testing without damaging the sample. Note, use of flammable materials such as propane shall not be used as a rapid cooling method.

3.8.2 Lift Thicknesses In Excess of 2.5" (63 mm) – Wet cooling methods may be used to obtain density plugs/cores on lift thicknesses in excess of 2.5" (63 mm). When wet cooling is used, the cores/plugs must be dried back in the lab and VTM-6 followed to determine the percent density. Artificial and rapid cooling methods are not effective. When wet cooling methods are not used, a period of not less than 12 hours after placement of the mix must pass before density plugs/cores are obtained. Note, use of flammable materials such as propane shall not be used as a rapid cooling method.

4. Report

4.1 The calculations to determine the percent of Target Density obtained for each lot shall be recorded in the project notebook and used to determine any pay adjustment.

4.2 The forms recommended for use with this test method include, but are not limited to, TL-56, TL-57, TL-58, TL-59, TL-60, and TL-60A.

4.3 Sketches of Roller Pattern/Control Strip

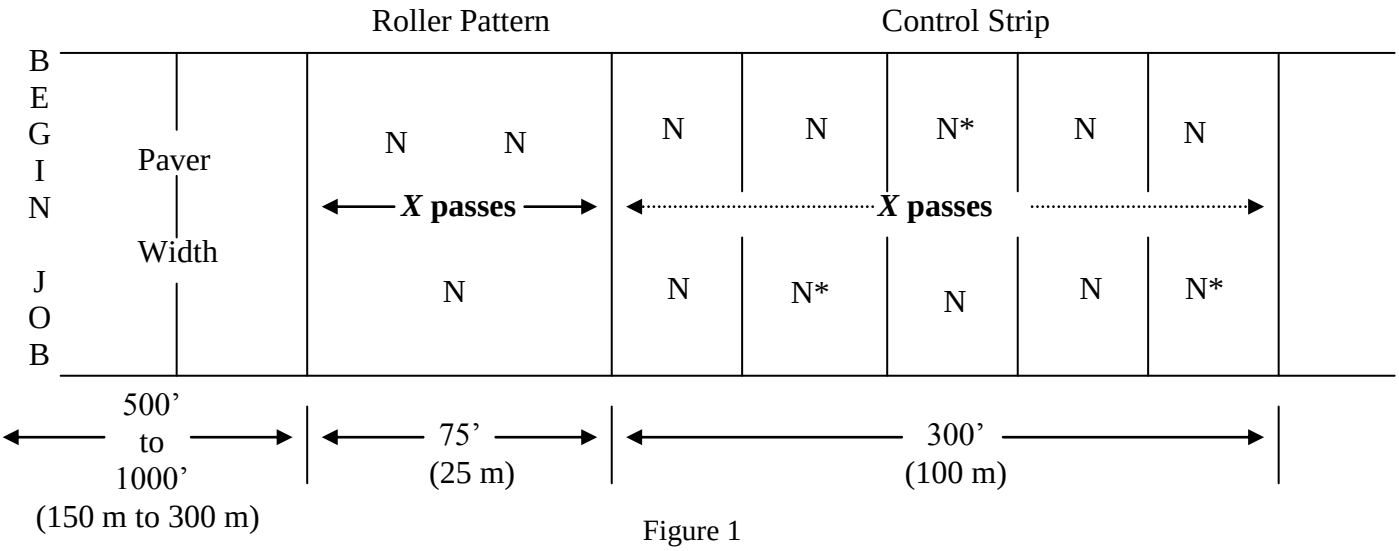


Figure 1

X = Number of passes by roller

N = Location of Nuclear Readings
(Must be selected by random method and sites marked with template before taking readings.)

* = Location of Cores/Plugs
(Three sites closest to target density.)

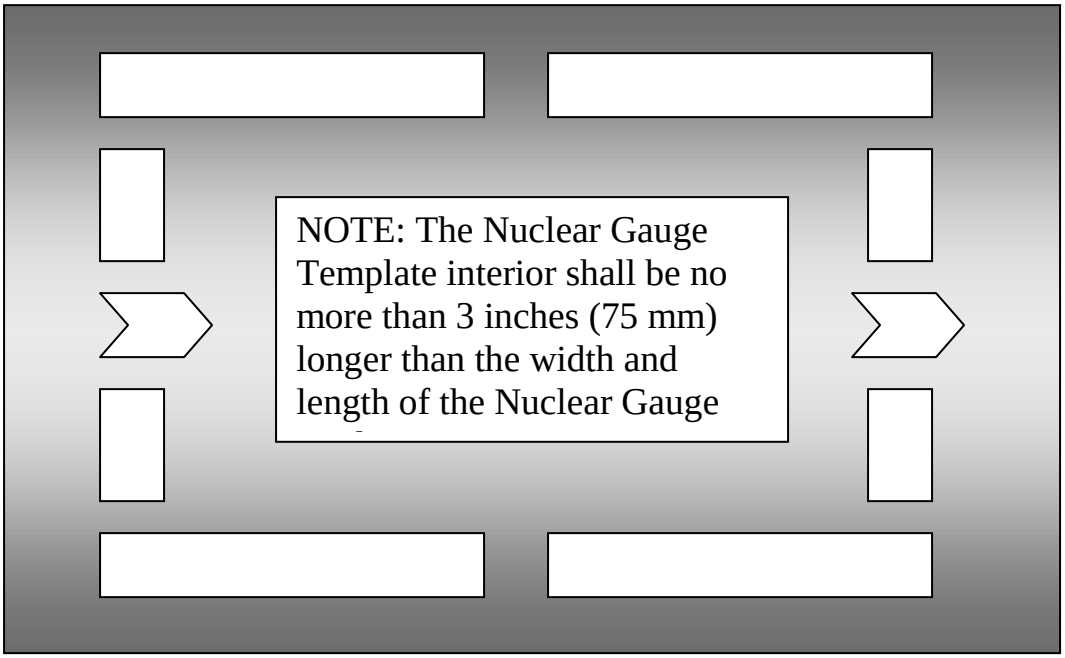
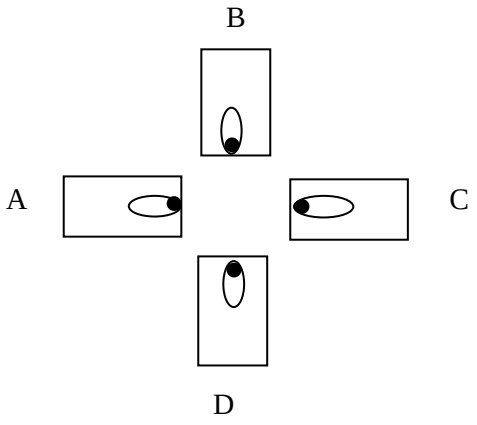


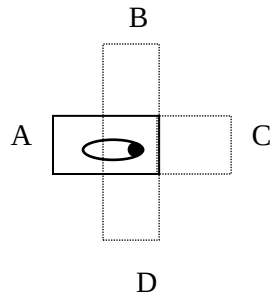
Figure 2 Nuclear Gauge Template

5. Nuclear Density vs Core/plug Density

5.1 When making any comparison of a core/plug density with that of a Nuclear Gauge Density, the Nuclear Gauge Density shall be an average of four (4) readings taken from the core/plug density, as shown in one of the sketches shown below. Also, if a comparison is to be made of any nuclear Density Reading sites, then each site should be an average of four (4) readings taken from each site location in the manner as shown in the sketch below for a core/plug site.



Gauge positions for comparison to a cut core/plug



Gauge positions for comparisons over a core/plug site

- Source

Virginia Test Method – 77

Deleted - Recovery from Deformation of Latex Modified Asphalt Emulsion Residue

April 1, 1996

Virginia Test Method – 78

Residue by Evaporation of Latex Modified Asphalt Emulsion – (Asphalt Lab)

November 1, 2000

1. Scope

1.1 This method of test, which is a modification of AASHTO Designation T59, is a procedure for determining the percentage of asphalt and rubber in an emulsion. The residue from this test may then be used for additional testing.

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 Container - The container in which the sample is to be tested shall be a flat-bottom, cylindrical seamless tin box, 3-7/16 inch (87 mm) in diameter and 2-3/8 inch (60 mm) in depth. The container is commonly known as a 12 ounce ointment can.

2.2 Balance - A balance with adequate capacity accurate to ± 0.lg.

2.3 Oven - A thermostatically controlled oven capable of maintaining a temperature of 280º F (138º C).

2.4 Forceps - Capable of gripping the container.

2.5 Stirring rod - A glass or metal stirring rod with flame polished or rounded ends with an approximate length of six inches (150 mm).

3. Procedure

3.1 Weigh 40 ± 1 g of thoroughly mixed emulsified asphalt containing latex into each of three tin containers, each container and stirring rod having previously been weighed. Place the cans in an oven, which has been adjusted to 245° F (118° C). Leave sample at this temperature for 30 minutes, then increase temperature to 280° F (138° C). After 1.5 hours at 280° F (138° C) remove, with forceps, each of the containers for stirring. Stir the contents of each can until foaming, if any, stops. Return each can and stirring rod to the oven for one hour. After approximately three hours total in the oven, remove the cans and allow to cool to room temperature before weighing.

4. Calculation And Report

4.1 Calculate the percentage of residue for each sample as follows:

Residue, percent = 2.5 (A-B)

Where: A = Weight of tin container, stirring rod, and residue in grams, and

B = Tare weight of tin container and stirring rod in grams.

4.2 Report the percentage of residue by evaporation as the average of the results from the three containers.

Virginia Test Method – 79

Determination of Water Soluble Chlorides in Concrete Core Samples – (Chemistry Lab)

July 1, 2001

1. Scope

1.1 This test method determines the percent chloride, and the pounds per cubic yard of chloride in concrete bridge deck samples.

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 and Chemicals

2.1 Apparatus

2.1.1 Mettler DL40RC Memotitrator.

2.1.2 Mettler DM141 Combination Silver ring electrode.

2.1.3 Analytical Balance capable of weighing 0.0001g.

2.1.4 Magnetic Stirrer hot plate and stirring bar.

2.1.5 Repipet Dispenser.

2.1.6 Shatter box with Puck and Ring Grinder.

2.1.7 Filter Paper Whatman No. 40 and 41.

2.1.8 150 ml beaker.

2.1.9 2,000 ml Erlenmeyer flask for hot deionized water.

2.1.10 250 ml beaker.

2.1.11 Watch glass.

2.2 Chemicals

2.2.1. Concentrated Nitric Acid (HNO3) 36-38% diluted with an equal volume of deionized water (1:1 HNO3).

2.2.2. 0.01N Silver Nitrate (AgNO3).

2.2.3 0.01N Sodium Chloride.

2.2.4 Deionized Water.

3. Procedure

3.1 A representative sample should be ground to about No. 50 sieve or less on a suitable grinder such as a "puck and ring" grinder.

ALL GLASSWARE SHOULD BE ACID CLEANED (1:1 HNO3) AND RINSED WITH DEIONIZED WATER

3.2 AASHTO T-260, Procedure for water-soluble chloride ion content is used with the following modifications.

3.3 Weigh out 2.5 grams to the nearest 0.1 mg into a 150 ml beaker.

3.5 Bring the volume of the filtrate up to 200 ml with deionized water. Allow the filtrate to cool to room temperature.

3.6 Add a drop of methyl orange indicator to each beaker, then add sufficient nitric acid to reach a pink end point. Then add 3 ml solution of 0.01N Sodium Chloride to all the beakers using a repipet dispenser.

3.7 Standardize the 0.01 N AgNO3 to be used as titrant.

3.8 Titrate the three blanks carried throughout the analysis. Average the results and record the value in milliequivalents. This value will be the blank in all subsequent titrations.

3.9 Now titrate each sample on the memotitrator using the standardized 0.01 N AgNO3 (0.01 N AgNO3 can be standardized by Method No. 70 on Memotitrator. The Blank values can also be determined by Method No. 70 on Memotitrator.)

The memotitrator will ask for the weight of the sample, identification number, and the blank value. Then it will titrate the sample automatically and record the results in ml titrant used, in % Cl, and in lbs. of Cl per cubic yard.

Appendix

Standard 0.01 N AgNO3.

Weigh 1.7 grams of reagent grade AgNO3 into a 1-liter volumetric flask, dissolve in deionized water and dilute to 1 liter.

Standard 0.01 N NaCl.

Dry NaCl in oven overnight at 110 C. Weigh exactly 0.5844 grams into a 1-liter volumetric flask, dissolve in distilled water and dilute to 1 liter.

Procedure for Standardizing 0.01 N AgNO3.

Replace the old Factor in the Memotitrator with 1.0000.

Place 70 ml of distilled water in three 120 ml plastic memo beaker. Add 3 ml 0.01 N NaCl to the beakers from a repipet dispenser, and 1-2 drops of methyl orange indicator, then add 1:1 HNO3 drop wise until a permanent pink color is obtained.

Titrate the three beakers according to Memotitrator Method No. 70.

Enter the new Factor into the Memotitrator.

Virginia Test Method – 80

Deleted - *The Design of Dense-Graded Emulsion Mixes*

April 1, 1996

Virginia Test Method – 81

Thin-Lift Nuclear Density Gauge
Performance Requirements – (Asphalt Lab)

November 1, 2000

1. Scope

1.1 This method details the establishment of a procedure to determine, by performance, that a designated model/brand of Nuclear Thin-Lift Gauge is truly a thin-lift measurement gauge. This method does in no way exclude that all State and Federal regulations be met pertaining to Nuclear Density Gauges.

1.1.1 To be tested as a thin-lift gauge, the gauge must also be equipped with the following:

1.1.1.1 Shall use the backscatter method of density determination. The nuclear source shall have a safety position and only one test position. The method to compensate for testing depth shall not include moving of the source while in the test position.

1.1.1.2 Battery pack with AC and DC chargers.

1.1.1.3 Memory and storage capacity to store a minimum of 100 readings by project number, station number, distance from centerline, and position

1.1.1.4 Display and store test data as Density and Percentage Compaction (Marshall) or Percentage Voids.

1.1.1.5 Shall be equipped with a printer capable of printing out density data.

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 Four testing blocks of the following material and dimensions.

2.1.1 Aluminum - 22"L x 14"W x 1.25"D (559 mm x 356 mm x 32 mm) (with machined surfaces on top and bottom).

2.1.2 Aluminum - 22"L x 14"W x 2.00"D (559 mm x 356 mm x 51mm) (with machined surfaces on top and bottom).

2.1.3 Magnesium - 22"L x 14"W x 1.25"D (559 mm x 356 mm x 32 mm (with machined surfaces on top and bottom).

2.1.4 Magnesium - 22"L x 14"W x 2.00"D (559 mm x 356 mm x 51 mm) (with machined surfaces on top and bottom).

2.1.4.1 Tolerances - Length, width and depth shall be within 1/16" (1.6 mm). The surface shall have a smooth, fine machined finish.

2.2 Two base blocks of different densities.

2.2.1 Densities shall be between 100-120 lb/ft^2 (1605-1926 kg/m^2) for block A and between 155-170 lb/ft^2 (1605-1926 kg/m^2) for block B.

2.2.2 Minimum dimensions of base blocks shall be 22"L x 14"W x 8"D (559 mm x 356 mm x 203 mm).

2.2.2.1 Tolerances - The surface shall have a smooth, fine machined finish.

3. Procedure

3.1 The two base blocks are used to represent changes in the base material directly underneath the lift. Designate them as base A, base B or by name, if you so desire.

3.2 Place the 1.25" H (32 mm) Aluminum Block (2.1.1) on top of one of the base blocks. Check to see that it is resting squarely and does not rock.

3.2.1 Set the nuclear gauge on top of the 1.25"H (32 mm) Aluminum Block. Check to see that it is resting squarely and does not rock. Gauges with untrue surfaces will not be tested until this is corrected.

3.3 Take four 1 minute readings and record them and their average on the attached form in the location for that base block and 1.25"H (32 mm) Aluminum Block.

3.3.1 Repeat this process using the same 1.25" H (32 mm) Aluminum Block, but this time place it on the other base block. Record readings and their average in the proper location on the form. Determine the difference in the averages and record on the form.

3.3.2 Repeat this entire procedure, but this time using the 1.25"H (32 mm)Magnesium Block. Record the readings and averages in the proper location on the form.

3.4 Repeat this entire procedure (3.1 thru 3.3.2) again, but this time using the 2.00"H (51 mm) Aluminum and the 2.00"H (51 mm) Magnesium Blocks. Record the readings and averages in the proper location on the form.

3.5 The difference in the averages of each of the performance determinations must be equal to or less than the limits stated below.

3.5.1 Limit = 3.3 or less - Difference in average of 1.25"H (32 mm)Magnesium Block on base block A and its average on base block B.

3.5.1.1 Limit = 2.4 or less - Difference in average of 1.25"H (32 mm) Aluminum Block on base block A and its average on base block B.

3.5.1.2 Limit = 2.3 or less - Difference in average of 2.00"H (51 mm) Magnesium Block on base block A and its average on base block B.

3.5.1.3 Limit = 1.6 or less - Difference in average of 2.00"H (51 mm) Aluminum Block on base block A and its average on base block B.

3.5.2 Any model/brand having results within the stated limits will be considered as an acceptable thin-lift gauge.

3.6 At no time during the entire testing for Performance Procedure will the base block densities be entered into the gauge by manual operator entry or actual measurement with the gauge placed directly on the base block.

4.1 Report as Pass or Fail on the Nuclear Thin-Lift Gauge Performance Requirement Form.

4.2 Gauge models that have had at least 4 of their gauges pass the Performance Requirement Test, as outlined above, and this documented by the VDOT Materials Division, or checked by the manufacturer in accordance with VTM-81 and documented to the VDOT Materials Division will not have to be individually checked unless performance in field use indicates the Performance Requirement Test is necessary.

Thickness:___2.00 (51 mm)___ inches Count Time:_____ minutes

Gauge Densities,lbs/ft^3 (kg/m^3)

No.	Magnesium on Magnesium	Magnesium on Aluminum	Aluminum on Magnesium	Aluminum on Aluminum
1				
2				
3				
4				
Avg.				

Difference Difference

Limit (2.3 or less) Limit (1.6 or less)

Pass Fail

Operator's Initials

Thin Layer Gauge Check

Date:_____ Gauge Make:_____ Gauge Model:

Gauge Serial #:_____ Std. Count

Thickness: 1.25 inches (32 mm) Count Time:_____ minutes

Gauge Densities, lbs/ft^3 (kg/m^3)

No.	Magnesium on Magnesium	Magnesium on Aluminum	Aluminum on Magnesium	Aluminum on Aluminum
1				
2				
3				
4				
Avg.				

Difference Difference

Limit (3.3 or less) Limit (2.4 or less)

Pass Fail

Virginia Test Method – 82

Detection of Contaminated Blasting Abrasive – (Chemistry Lab)

November 1, 2000

1. Scope

1.1 This method of test covers the procedure for determining whether recycled blasting abrasive has been contaminated with oil or grease.

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 1-qt. (1L) container with screw lid.

3. Procedure

3.1 A representative sample, approximately 0.5 pint (0.2 L) by volume, shall be placed in a quart (L) container and covered with clean potable water to approximately a pint (0.2 L) by volume. After lid is in place, the container shall be shaken vigorously for two minutes. After the abrasive has settled, the surface of the water shall be examined for any oily skim or residue.

Virginia Test Method – 83

Determining Pavement Roughness
With a 25-foot Profilograph – (Pavement Design)

November 1, 2000

1. Scope

1.1 This test procedure is used to evaluate pavements for roughness by determining a Profile Index using a California type 25-foot (8 m) profilograph. The procedure also determines individual high points (bumps) for correction.

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. The use of the profilograph requires special care in operations involving traffic. The machine is 33 feet (10 m) long and somewhat difficult to maneuver. Appropriate traffic control practices are essential to its safe operation in field operations involving public or construction traffic. Care should be exercised to avoid operation of the device at times when construction traffic is passing by on adjacent lanes of unopened pavement.

1.3 These tests are to be made according to VDOT Specifications for Asphalt Concrete Pavement Rideability and Hydraulic Cement Concrete Pavement Rideability.

2. Apparatus

A list of equipment for daily operation includes:

2.1 James Cox and Sons' Profilograph Model CS 8200 or equivalent, with operations manual.

2.2 Type TP-4 Thermal Paper (1 roll = 4 miles (6 km)).

2.3 Tape Measure, Minimum 25-foot (8 km).

2.4 Notebook, pens, pencils, etc.

2.5 Tire pressure gauge capable of measuring 30 psi ± 2 psi (207 kPa ± 14 kPa).

2.6 Optional - Blanking band and bump template (plastic scale of special design) for manually reducing or checking profile data.

2.7 Gasoline (for generator) 2-gallons (7.6 L) or more in approved container.

2.8 Paint (Spray or can and brush) to mark pavement.

Additional requirements for calibration and checking profilo- graph.

2.9 Surveyed, 528-foot (161 m) straight traverse on smooth paved surface.

2.10 0.5" (13 mm) thick flat material, recommended minimum 4" x 4" (100 mm x 100 mm).

3. Calibration and System Check

3.1 Calibration and/or system checks should be performed once each month during operation or more often during heavy or rough use, or when test results are questionable.

3.2 Check odometer measurement monthly. Use a flat, straight surveyed distance 300 feet (91 m) or greater and if error greater than 0.1 feet per 100' (30 mm per 33m) recalibrate according to Section 3.3 and 3.4. (Use check procedure when 528 foot (161 m) calibration site is not convenient).

3.3 Horizontal calibration (Odometer Calibration) should be made according to the operations manual at a tire pressure (measuring wheel) of 24 ± 2 psi (166 kPa ± 14 kPa). The Profilograph Model 8200 uses the 528-foot (161 m) surveyed transverse and computer calibration sequence described in the operations manual.

3.4 A record of changes in the Odometer Factor (Model 8200 only) should be maintained with the machine.

3.5 A Vertical Measurement Check should be made by noting the vertical reading of the measurement wheel (digital display on Model 8200) with the machine in a flat, stationary position. Manually raise the measuring wheel and place the 0.5 inch (12 mm) thick material under the wheel. Compare the vertical reading of the measurement wheel. If the difference in the readings are not 0.50 ± 0.02 (inch) (12 mm ± 0.5 mm) the machine should not be used for any test runs on pavement until corrected (Model 8200 requires factory adjustment).

3.6 Program Memory (Model 8200 only) should be checked according to the operations manual (CHECKSUM).

4. Normal Operations, General

4.1 Assemble and start up machine according to operations manual. Important - CAUTION MODEL 8200 - COMPUTER MUST BE OFF BEFORE STARTING GENERATOR.

4.2 Perform maintenance at intervals based on usage, conditions, and manufacturer's recommendations:

4.2.1 Check oil in generator daily, change according to manufacturer's instructions.

4.2.2 Clean printer head once a week during heavy use.

4.2.3 Check and replace or clean air filters on computer and generator at least every two weeks during use.

4.2.4 Grease fittings on wheel assemblies at least once a year.

4.2.5 Clean and lubricate wheel bearings at least once a year.

4.2.6 Change 4 AA alkaline batteries in computer yearly.

4.3 Check parameters (Model CS 8200) by printing parameters for the following values:

ODOM FACTOR	-	As determined by calibration
NULL FACTOR	-	80
DATA FILTER	-	8000
REDUCT LEN	-	528
BLANK WID	-	0.20
BUMP HT	-	0.40
BUMP WID	-	25.0
BUMP LOCATOR	-	ON
BOTTOM BUMPS	-	OFF

Important THE NULL BAND SWITCH ON THE FRONT OF THE CONTROL PANEL MUST BE IN THE "FIXED DISTANCE" POSITION

4.4 A print of the Model 8200 Profilograph Parameter report should be provided to the Engineer with proper Date, Route, Pavement and District entries for each set of tests (multiple runs on project pavements). Pavement code should use FHWA pavement type codes where possible.

01 - Concrete Pavement Rehabilitation (Grinding, patching, etc.)
02 - Other Rehabilitation (Asphalt)
51 - Asphalt Surface Treatment
52 - Asphalt Concrete (Less than 7" (172 mm) thick)
61 - Asphalt Concrete (Equal to or greater than 7" (172 mm) thick)
62 - Flexible Over Rigid (Composite Pavement)
71 - Jointed Plain Concrete
72 - Jointed Reinforced Concrete
73 - Continuously Reinforced Concrete

Additional written notes should be made on each report to adequately define the set of tests, and any manual adjustments to the Profile Index defined in Section 10.2.

5. Test Section

5.1 A Profilograph Test Section is defined as a **one travel lane width (generally 12 feet (4 m)) of pavement where the design speed is 40 miles (64 km) per hour or greater and having a length of 0.1 mile (528 feet (161 m)) except as listed in following instructions.** A test section is to begin and end at a point 25 feet (8 m) from pavement structure for which the contractor is not responsible.

When a pavement section is terminated by a bridge or the end of the test surface (existing pavement or end of project) and is less than 250 feet (76 m) in length it shall be included with the previous test section. If the section is greater than 250 feet (76 m) in length it shall be considered a test section.

If a section is isolated where neither end joins another section (examples: between bridges or between a bridge and the end of the project) and is less than 250 feet (76 m) in length it shall be considered a test section.

6. Initial Paving and Corrective Action Testing

6.1 Test runs made for initial paving operations, either when starting up or after a long shut-down period will be used to aid the Contractor and the Engineer to evaluate the paving methods and equipment.

6.2 Test runs for initial paving operations that do not meet the definitions of Section 5 and test runs made to verify corrective actions to the pavement will not be used to determine daily average profile index or pay adjustments as defined in rideability specifications. These test runs are provided to the Engineer as aides to evaluate the methods and equipment used.

6.3 The testing of initial paving operations will be performed on pavement as soon as possible after construction at the direction of the Engineer and prior to opening to traffic.

7. Surface Preparation

7.1 The paved surfaces to be tested shall be reasonably cleaned by the Contractor of all foreign material that might affect the results before the test is run.

7.2 The operator will monitor buildup of any material (curing agent, asphalt, etc.) on wheels and delay test or clean wheels as appropriate to assure smooth operation of the machine.

8. Pavement Test Run

8.1 Pavement profiles will be taken 3 feet (1 m) from and parallel to each planned pavement marking for 12 foot (4 m) wide travel lanes. Two runs (one representing each vehicle wheelpath) will be made for each traffic lane.

8.2 The Profilograph will be operated at a maximum speed of 3 miles (5 km) per hour.

8.3 The Profilograph will be aligned so that no visible crabbing occurs which may cause side slippage of the measuring wheel. This may require adjustments to the alignment of the rear wheel assembly when entering or leaving a horizontal curve.

9. Individual Profiles

9.1 Individual profiles will be produced with the parameters set according to Sections 4.2 and 4.3 (Model 8200). Begin station, end station, pass number and document point number must be input for proper running of Model 8200. Notes should be made in notebook and/or directly on graph as necessary to assure proper documentation of test run and any manual adjustments to the Profile Index defined in Section 10.2

9.2 Manual adjustment of an individual profile is permitted by noting the reason for adjustment on the strip chart and manually adjusting the count (or inches) defined in Section 10.3 and the Profile Index.

9.3 Additional profiles may be necessary as directed by the Engineer to fully define the limits of an out-of-tolerance surface variation.

10. Determination of Profile Index

10.1 The Profilograph Model CS 8200 can automatically calculate the Profile Index and locate high points having deviations in excess of 0.4 inch (10 mm) in 25 feet (8 m). Follow the operations manual for proper printout of results.

Other machines and the Model CS 8200 in "Strip Chart Mode" will require manual determination of the individual profile Index and location of high points. The method is a variation of California Test 526 to meet Virginia Specifications.

10.2 Manual adjustment of Profile Index for stones, clumps of dirt or other debris:

If, during the Pavement Test Run an individual stone or piece of debris is hit by the profilograph measuring wheel, the operator may note the location and manually remove the penalty from the counts entered in Form TL-38. The operator will mark and note reasons from manual adjustments on the individual profile roll. A maximum of two (2) corrections per test section will be permitted. If excess debris is present, require the contractor to clear the pavement prior to making the test run.

10.3 Equipment for Manual Determination of the Profile Index - To determine the Profile Index, use a plastic scale 1.70 inches (43 mm) wide and 21.12 inches (536 mm) long representing a pavement length of 528 feet (161 m) or one-tenth of a mile at a scale of 1" = 25' (25 mm = 8 m). Near the center of the scale is an opaque band 0.2 inch (5 mm) wide extending the entire length of 21.12 inches (536 mm). On either side of this band are scribed lines 0.1 inch (3 mm) apart, parallel to the opaque band. These lines serve as a convenient scale to measure deviations or excursions of the graph above or below the blanking band. These are called "scallops".

10.4 Manual Method of Counting - Place the plastic scale over the profile in such a way as to "blank out" as much of the profile as possible. When this is done, scallops above and below the blanking band usually will be approximately balanced. See Figure 1.

The profile trace will move from a generally horizontal position when going around superelevated curves making it impossible to blank out the central portion of the trace without shifting the scale. When such conditions occur the profile should be broken into short sections and the blanking band repositioned on each section while counting as shown in the upper part of Figure 2.

Note: This requires different parameter and switch inputs on the Model CS 8200 processor. Virginia is not currently evaluating pavements requiring repositioning of the blanking band within test sections.

Starting at the right end of the scale, measure and total the height of all the scallops appearing both above and below the blanking band, measuring each scallop to the nearest 0.05 inch (1 mm) (half a tenth). Write this total on the profile sheet near the left end of the scale together with a small mark to align the scale when moving to the next section Short portions of the profile line may be visible outside the blanking band but unless they project 0.03 inch (0.8 mm) or more and extend longitudinally for two feet (0.6 m) (0.08" (2 mm) on the profilograph) or more, they are not included in the count. (See Figure 1 for illustration of these special conditions).

When scallops occurring in the first 0.1 mile (0.2 km) are totaled, slide the scale to the left, aligning the right end of the scale with the small mark previously made, and proceed with the counting in the same manner. Note: The Model CS 8200 processor does not align blanking band in adjoining sections. Any difference is slightly in favor of Contractor. The last section counted may or may not be an even 0.1 mile. If not, its length should be scaled to determine its length in miles.

Example:

Section length, miles (km)	Counts, tenth of an inch (mm)
0.10 (0.2 km)	5.0 (127 mm)
0.10 (0.2 km)	4.0 (102 mm)
0.10 (0.2 km)	3.5 (89 mm)
400’ = 0.076 (122 m = 0.12 km)	2.0 (51 mm)
Total 0.376 (0.11 km)	14.5 (368 mm)

The Profile Index is determined as "inches per mile (mm per km) in excess of the 0.2-inch (5 mm) blanking band" but is simply called the Profile Index. The procedure for converting counts of Profile Index is as follows:

Using the figures from the above example:

Length = 0.376 mile (0.6 km), total count = 14.5 tenths of an inch
Profile Index = (1 mile/length of profiles in miles)
X total count in inches

PrI = (1/0.376 (0.6 km)) X 1.45 (37 mm) = 3.9 inch/mi. (22.2 mm/km)

(Note that the formula uses the count in inches rather than tenths of an inch and is obtained by dividing the count by ten.)

The Profile Index is thus determined for the profile of any line called for in the specifications. Profile Indexes may be averaged for two or more profiles of the same section of road if the profiles are the same length.

Example:

		Counts, tenths of an inch (mm)	
	Section, Miles (km)	Left wheel track	Right wheel track
	0.10 (0.2 km)	5.0 (127 mm)	4.5 (114 mm)
	0.10 (0.2 km)	4.0 (102 mm)	5.0 (127 mm)
	0.10 (0.2 km)	3.5 (89 mm)	3.0 (76 mm)
400’ (122 m) =	0.076 (0.12 km)	2.0 (51 mm)	1.5 (38 mm)
Total	0.376 (0.11 km)	14.5 (368 mm)	14.0 (356 mm)
	Pr (by formula)	3.9 (99 mm)	3.7 (356 mm)

Averages = (3.9 + 3.7)/2 = 3.8

The specifications state which profiles to use when computing the average Profile Index for control of construction operations. The specifications require Daily Average Profile Indices and a Profile Index for each test section (see Section 11 of this VTM).

10.5 Equipment for Determination of High Points in Excess of 0.4 inch (10 mm)

Use a plastic template having a line one inch long scribed on one face with a small hole or scribed mark at either end, and a slot 0.4 inch (10 mm) from and parallel to the scribed line. See Figure 2. (The one inch line corresponds to a horizontal distance of 25 feet (8 m) on the horizontal scale of the profilogram).

10.6 Manual Locating of High Points in Excess of 0.4 inch (10 mm)

At each prominent peak or high point on the profile trace, place the template so that the small holes or scribe marks at each end of the scribed line intersect the profile trace to form a chord across the base of the peak or indicated bump.

The line on the template need not be horizontal. With a sharp pencil draw a line using the narrow slot in the template as a guide. Any portion of the trace extending above this line will indicate the approximate length and height of the deviation in excess of 0.4 inch.

There may be instances where the distance between easily recognizable low points is less than 25 feet(one inch) (8 m (25 mm)). In such cases a shorter chord length shall be used in making the scribed line on the template tangent to the trace at the low points. It is the intent, however, of this requirement that the baseline for measuring the height of bumps will be as nearly 25 feet (1 inch) (8 m (25 mm)) as possible, but in no case to exceed this value. When the distance between prominent low points is greater than 25 feet (1 inch) (8 m (25 mm)) make the ends of the scribed line intersect the profile trace when the template is in a nearly horizontal position. A few examples of the procedure are shown in the lower portion of Figure 2.

10.7 Microprocessor Caution - Bump Determination

The Model CS 8200 processor mathematically calculates the high points which can, in cases of very rough pavement provide a different appearing bump than when compared to a Manual Determination by Section 10.5. This is due to the different scales 1" = 25' (25 mm = 8 m) horizontal versus 1" = 1" (25 mm = 25 mm))vertical. The strip chart function of the machine must be used to determine the extent of the high point. The difference of the Model CS 8200 output versus the manual determination is negligible under normal paving circumstances for design speeds of 40 miles (64 km) per hour or greater. A straight edge or string line should be used for final determination of area to be corrected.

11. Average Profile Index

11.1 An Average Profile Index will be calculated for each Test Section (defined in Section 5). A simple mathematical average of individual runs of the same length will be made.

11.2 A Daily Average Profile Index (minimum 0.1 mile section) of all test sections of the same pavement width placed in a day's paving will be calculated using a length weighted average.

Example:

	Section Length	Test Section Profile Index	Weighted Profile Index (PI X Length)
	0.10 (0.2 km)	5.0	0.50
	0.10 (0.2 km)	4.5	0.45
	0.10 (0.2 km)	8.0	0.80
	0.14 (0.23 km)	5.5	0.77
Total	0.44 (0.7 km)	- - - -	2.52

$$\text{Average Profile Index} = \frac{\text{Total Weighted Profile Index}}{\text{Total Section Length}} = \frac{2.52}{0.44} = 5.7$$

12. Reports

12.1 The District Materials Engineer will be provided a profilograph parameter report (Model 8200 only), all profilograph charts with notes of Average Profile Index for each Test Section and a Daily Average Profile Index when appropriate.

The District Materials Engineer will be responsible for notification of test results to appropriate persons.

The Project Inspector and/or Project Engineer are to be verbally notified immediately upon completion of a test when the profile measurement exceeds 15 inches (381 mm) per mile.

12.2 Instructions For Form TL-38, Report of Road Roughness Test, Profilograph Profile Evaluation

Form TL-38 to be completed for each day's paving as defined in VTM-83, or as directed by District Materials Engineer.

Type of Test (Initial or Retest): Retests are required on test sections corrected for having a profile index in excess of 15 inches (381 mm) per mile.

Route: Route number and/or name

Date Tested: Date of actual testing

Project Number: Use full project number

Prime Contractor: Name of prime

Paving Contractor: Name of sub-contractor

Total Project Length (excluding bridges): From project plans, in miles.

Number of Bridges: Number of bridges within area to be paved.

Date Paved: Use dates surface courses were placed for asphalt concrete.

Finished Pavement Width: Use total width of adjoining pavements in feet.

Begin/End Test Section Station: Use plan stations.

Pavement Type: Define pavement structure

Examples - 9" (229 mm) plain jointed concrete, 6" (152 mm) CTA, or 1.5" (38 mm) Sm-2C, 6" (152 mm) BM-2, 6" (152 mm) Aggr 21B

Tested Pavement Width: Width of pavement placed in a single pass (normally 12 (4 m)).

Total Project Mainline Pavement Surface: Generally, calculate by project length (excluding bridges) x finished pavement width, enter in square yards.

Project Pavement Subject to Evaluation: Generally, subtract 25' (8 m) x pavement width from each end of project and each end of bridge, enter in square yards.

Project Pavement Evaluated This Test: Calculate by total length of tested sections x tested lane width, enter in square yards (square meters).

Lane: Use abbreviated code or numerical codes From Pavement DataSystem - Example NBPL or 12 represent North Bound Passing Lane on a four-lane roadway.

Section Length: Test section length, normally 528 feet (161 m). If test runs are of unequal length, use average length. Note unequal lengths on last test section of each run will be common due to curvature of roadway and equipment involved.

Counts (inches): Enter actual counts of each test run, for 12 foot (4 m) pavements only enter right and left, for wider pavements enter right, center and left.

Average: **Average of 2 entries.**

Profile Index: Calculate inches (counts) per mile - Average counts - section length in feet x 5,280 feet (1609) per mile.

Adjustment: Obtain from current Special Provision Section on Pavement Rideability.

Remarks: Code when corrections are required within a test section or to explain an interruption in test section (bridge location).

Total Length: Total of section test lengths.

Daily Average Profile Index: Length weighted average of Profile indices.

Tested By: Operator's name.

Report Number: Assigned by District Materials Engineer.

Date: Date of Report.

A spreadsheet (Lotus 1-2-3) computer disk is available which will perform many of the calculations.

12.3 Instructions for Form TL-39, Report of Road Roughness Test, Price Adjustment Worksheet.

Form TL-39 to be completed at completion of testing for individual construction project.

Route: Route number and/or name.

Project Number: Use full project number.

Prime Contractor: Name of prime contractor.

Paving Contractor: Name of sub-contractor.

Pavement Type: Define Pavement Structure.
Examples - 9" (152 mm) plain jointed concrete, 6" (152 mm) CTA or 1.5" (38 mm) SM-2C, 6" (152 mm) BM-2, 6" (152 mm) Aggr 21B

Total Project Pavement Surface: Generally, calculate by - project length (excluding bridges) x finished pavement width; enter in square yards.

Project Pavement Subject to Evaluation: Pavement surface actually tested, in square yards.

PCC Unit Bid Price: Enter bid price if PCC pavement.

Asphalt Unit Bid Price: Surface, Intermediate and Base - Enter theoretical pounds per square yard based on project typical section.

Enter unit price (per ton (metric ton)) of bid item and calculate bid price per square yard – (square meter) pounds per square yard (kg per square meter) - 2000 pounds (907 kg) per ton x bid price per ton.

Calculate (total) for total asphalt unit bid price per square yard.

Lane: Use abbreviated code or numerical codes from Pavement Data System - Example - NBPL or 12 represent North Bound Passing Lane on a four-lane roadway.

Begin Station: Enter begin station for each test section.

End Station: Enter end station for each test section.

Length: Enter test section length in feet.

Width: Enter test pavement width.

Area: Calculate test section pavement area and enter in square yards.

Bid Price: Calculate bid price of test section pavement appropriate unit bid price per square yard x area in square yards.

Adjustment: Enter price adjustment from Form TL-38 for individual test section.

Adjusted Price: Calculate and enter new price - bid price x adjustment.

Total: Total pavement area, bid price and adjusted price.

Price Adjustment: Calculate price adjustment by subtracting total bid price from total adjusted price.

Date: Date of report.

Report Number: Assigned by District Materials Engineer.

By: Name of person responsible for completing form.

A spreadsheet (Lotus 1-2-3) computer disk is available which will perform many of the calculations.

TOTAL LENGTH			FT	Average Profile Index =							Total Price Adjustment=	$	$ $		

Remarks Code:
1. Bump Correction Required.
2. Bridge Location.
3. Profile Correction Required.

Run By:

District Materials

Report No.:

Date:

VDOT MATERIALS DIVISION FORM TL-38

PROFILE EVALUATION

REV. 6/95

Initial Test :
Date(s) Tested :
Contractor (Prime) :
Location (Section) :
Date Section Placed :
Begin Sta. :
Pavement Type :

Retest :
Through :
End Sta. :

Route:
Project Number:
Lane(s):
Pavement Width:

Total Project Pavement Surface : sq. yd.
Project Pavement Subject to Evaluation : sq. yd.
Project Pavement Evaluated This Test : sq. yd.
HCC Unit Bid Price : per sq.yd.
Asphalt Unit Bid Price

Surface	:	lb. per sq.yd.	@	per ton	=	$	
Intermediate	:	lb. per sq.yd.	@	per ton	=	$	
Base	:	lb. per sq.yd.	@	per ton	=	$	
				Total Asphalt Price	=	$	per sq.yd.

LANE	BEGIN STATION	SECTION LENGTH (FEET)	LANE WIDTH (FEET)	COUNTS (IN.) RIGHT	LEFT	AVERAGE	PROFILE INDEX IN/MI	PRICE ADJUSTMENT	AREA SQ.YD.	BID PRICE	ADJUSTED PRICE	REMARKS
TOTAL LENGTH			FT	Average Profile Index =						Total Price Adjustment=	$	$ $

Remarks Code:
1. Bump Correction Required.
2. Bridge Location.
3. Profile Correction Required.

Run By:

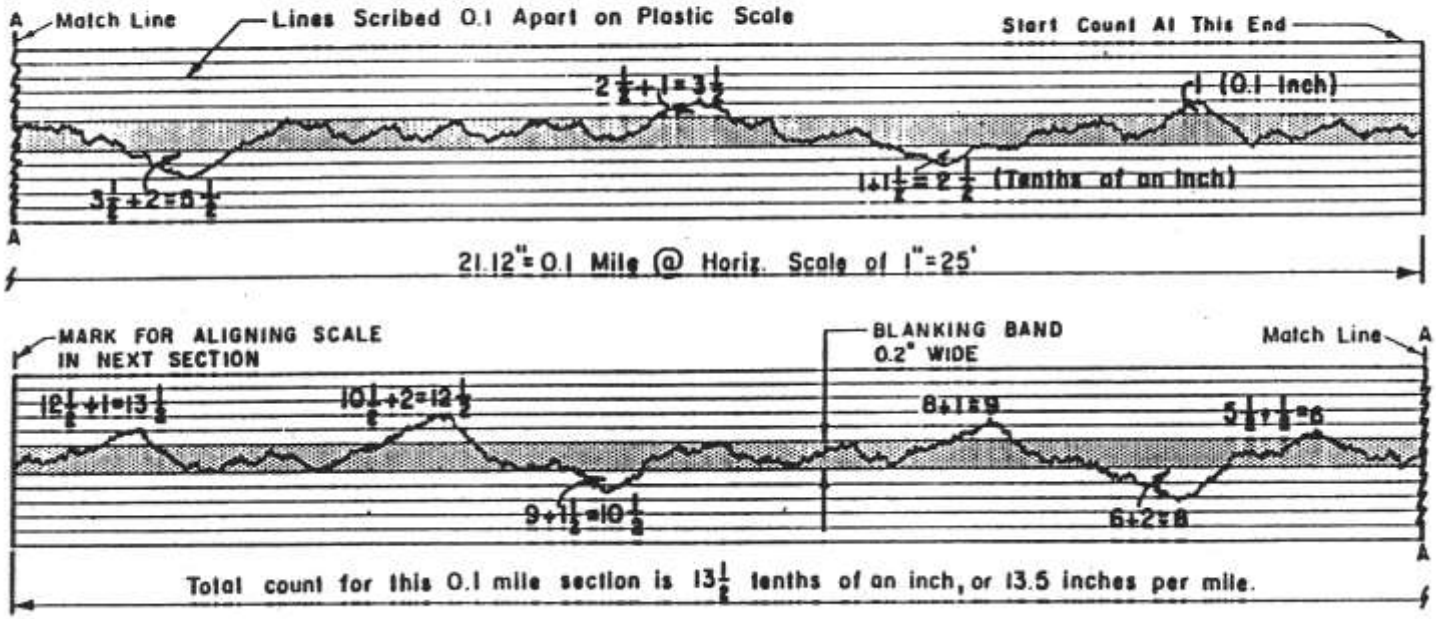
District Materials

Report No.:

Date:

83-11

EXAMPLE SHOWING METHOD OF DERIVING PROFILE INDEX FROM PROFILOGRAMS



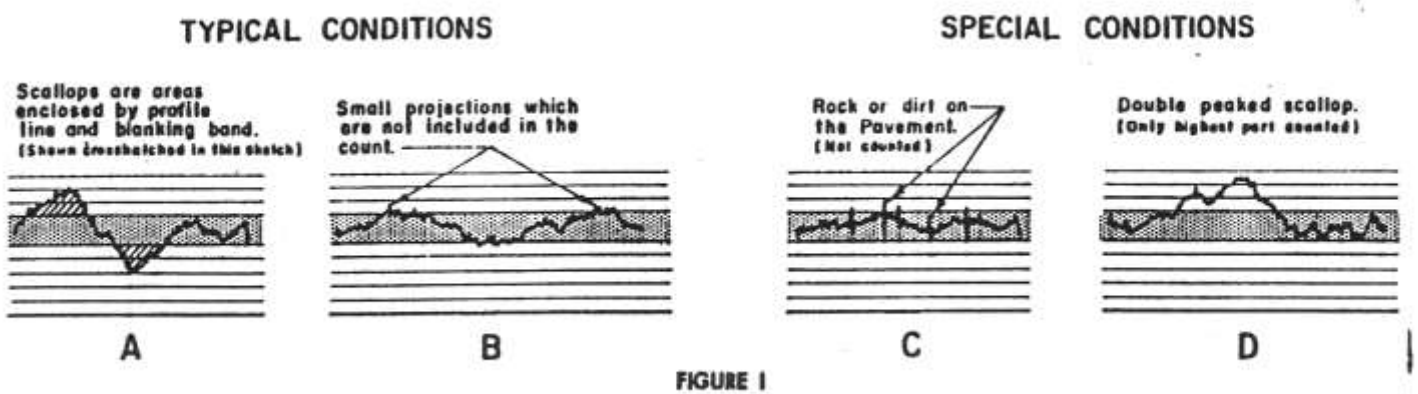
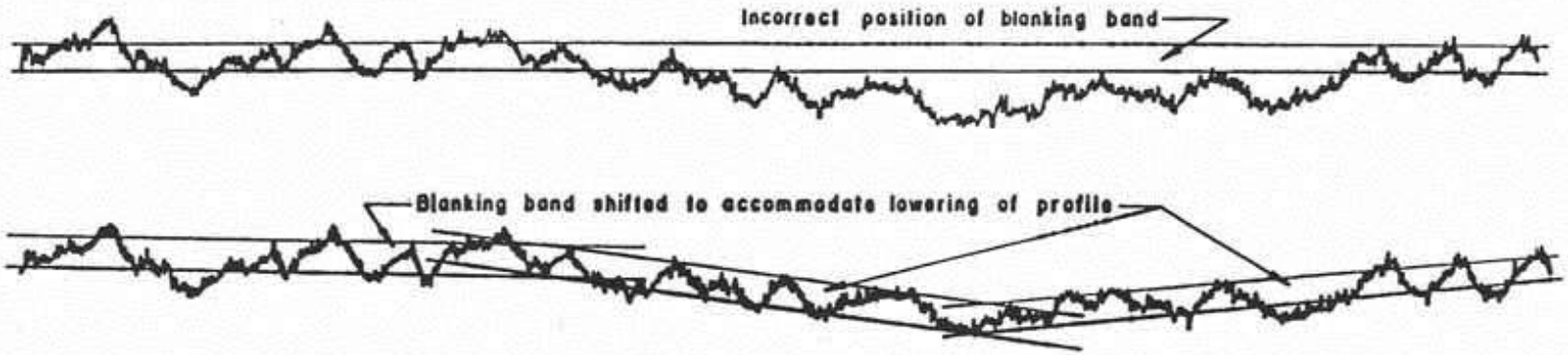
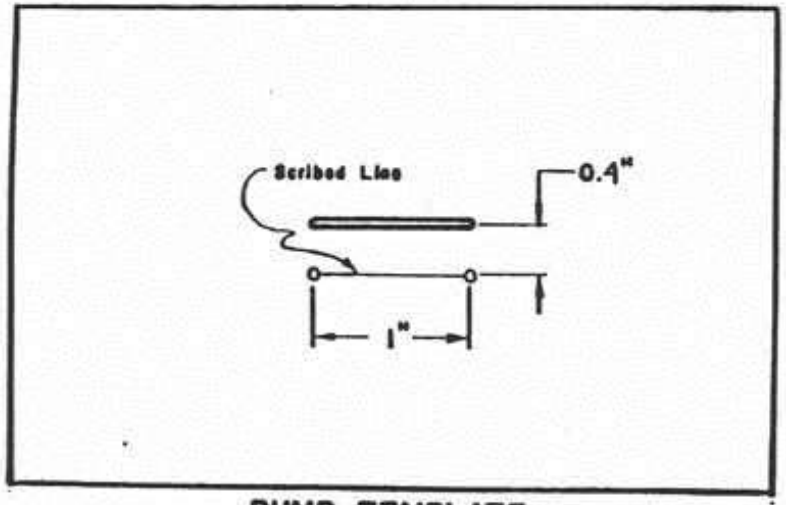


FIGURE I

METHOD OF COUNTING WHEN POSITION OF PROFILE SHIFTS AS IT MAY WHEN ROUNDING SHORT RADIUS CURVES WITH SUPERELEVATION



METHOD OF PLACING TEMPLATE WHEN LOCATING BUMPS TO BE REDUCED



BUMP TEMPLATE

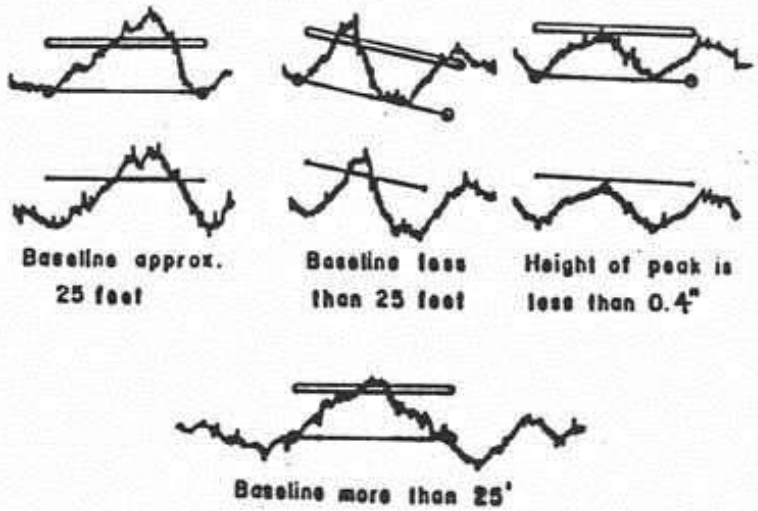


FIGURE 2

Virginia Test Method – 84

Determining the Coefficient of Permeability of Open Graded Drainage Layer Material - (Physical Lab)

November 1, 2000

1. Scope

1.1 This method covers the procedures to be used in determining the Water Permeability of Open Graded Drainage Layer Materials.

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.

1.3 For acceptance or rejection of mix designs or in-place material, two samples are required, provided the coefficients of permeability vary less than 20% and neither fails on permeability requirements. Otherwise, acceptance or rejection will be based on the coefficient of permeability of three samples. For investigative purposes, a minimum of one sample is required.

NOTE: The paragraph designations with "A" in them denote the procedure for laboratory samples, and with "B", the procedure for field samples.

2. Apparatus

2.1 Appropriate Materials Sample

2.1.A.1 (For use with laboratory samples.) Sample Mold of 6" (150 mm) diameter. The mold will act as a channeling device to direct the water flow through the material sample and also serve as a water holding chamber to establish a head of water over the sample. Thus the length must be sufficient to contain the material and water head. The mold may be made of plastic, metal or other appropriate material. Plastic concrete molds (modified by cutting off the bottoms) and metal compaction molds (with the collar left in place and sealed to prevent water loss) work well for this purpose.

2.1.A.2 Mold must have a removable bottom.

2.1.B.1 (For use with 6" (150 mm) diameter field cores.) Water-tight circular tube to seal the core's sides, provide area for head buildup and direct the water flow through the core. The tube is to be as near to the core's diameter as possible, but will have to be slightly larger. A tube the same as, or similar to, the mold used to make the laboratory samples will suffice, if the cores are near the correct 6" (150 mm) size.

2.1.B.1 (For use with 6" (150 mm) diameter field cores.) Water-tight circular tube to seal the core's sides, provide area for head buildup and direct the water flow through the core. The tube is to be as near to the core's diameter as possible, but will have to be slightly larger. A tube the same as, or similar to, the mold used to make the laboratory samples will suffice, if the cores are near the correct 6" (150 mm) size.

2.2 Water-Tight Container (approx. 5 gal. (19 L))

2.3 Sample Suspension Device

2.3.1 Provide for free water flow.

2.3.2 (Unstabilized material only) Use a U.S. Standard No. 100 sieve (0.150 mm) (or screen of equivalent mesh opening size) to support the unstabilized samples and prevent loss of fines. Trim a screen, of equivalent mesh opening to a U.S. Standard No. 100 (0.150 mm) sieve, to fit on top of the sample material inside of the mold. This screen serves to prevent disturbance of material in unstabilized samples.

2.3.3 Sample bottom must be lower than water level and sample top above water level.

2.4 Fluid measuring device (readable to ± 1 ml.) (i.e. a large graduate cylinder) of water container (i.e. 5 gal. (19 L) bucket).

2.5 Scales, if using the water container method, of sufficient capacity to weigh the container full of water, at least 50 lbs. (25 kg) (readable to 0.1 lb. (0.5 kg)).

2.6 Constant Flow Water Source.

2.7 Ruler (readable to ± 1/8 inch (3 mm)).

2.8 Stop Watch (readable to 0.1 sec.).

NOTE: All horizontal surfaces should be level.

3. Sample Preparation

3.A Laboratory Mixes

3.A.1 Prepare material to be tested (batch or mix sample).

3.A.2 Place/Compact material into an appropriate 6" (150 mm) diameter mold. A tight bond between the mold and the sample is required to prevent water piping through the mold-sample interface and thus causing false flow rate measurements.

3.A.3 Fill mold approximately half full with the material to be tested.

3.A.4 Compact/Vibrate material to simulate field conditions.

3.A.5 Cure/Age material to simulate field conditions. Hydraulic cement stabilized samples shall be allowed to cure for a minimum of two days before permeability tests are performed, unless the mix is designed for rapid placement of the next layer, in which case, an appropriate curing time will be observed. Asphalt stabilized samples shall be allowed to cool for at least one day before permeability tests are performed.

3.A.6 Leave sample in mold and remove mold bottom.

3.B Sample Preparation - Field Samples

3.B.1 Use standard practices for field coring pavements to obtain an approximately 6" (150 mm)diameter core sample of the in-place material.

3.B.2 Place the sample in the circular tube device. Bond the sides of the core to the tube, with a sealing material, to prevent the piping of water between the core-tube interface, all flowing water must pass through the core to provide accurate flow rates.

4. Test Permeability

4.1 Obtain a constant water inflow condition.

4.2 Place the sample suspension device in the water tight container and fill the container to overflowing with water.

4.3.A (Stabilized Material) Place the sample in the suspension device.

4.3.B (Unstabilized Material) Place the sample on the U.S. Standard No. 100 (0.150 mm) screen and place in the suspension device. Place a No. 100 (0.150 mm) screen (trimmed to fit the mold) over the top of the sample to avoid disturbing the material or losing fines.

4.4 Direct the water flow into the mold (tube) and through the sample. Take care to reduce the amount of air bubbles created, by adjusting the water flow and by keeping the flow outlet submerged in the water head developed above the sample.

4.4.1 Increase or decrease the flow as necessary to obtain a flow rate which produces a head above the sample, but does not overflow the mold.

4.4.2 Establish a constant water level in the mold. Mark the water level on the mold. Maintain this condition for at least 10 minutes to allow any entrapped air in the sample to be flushed out and to determine a definite constant head elevation.

4.4.3 Mark the water level of the container on the outside of the mold.

4.4.4 Determine the constant head elevation (the distance the water level inside the mold is above the container water level), to 1/8" (3 mm).

4.5 Measure Flow

4.5.A Direct the water flow into the measuring device and time how long it takes to collect a certain volume of water (to 0.05 sec. and 1 ml.). Collect the flow for at least 30 seconds to allow for an averaged flow rate. Due to the limited volume of graduate cylinders and other measuring devices, this method of flow determination is best suited for flows through materials which are not very permeable.

4.5.B Collect the flow in the second container for a timed period (to 0.1 sec.) and weigh the amount of water collected (the scales should have been tared for the weight of the empty second container). Collect the flow for at least 30 seconds to allow for an averaged flow rate. Since larger volumes of water can be collected than with standard measuring devices, this method determines the water flow rate for higher permeability materials.

4.6 Measure the sample length (to 1/8" (3 mm)) and the sample's diameter (to 1/8" (3 mm)).

5. Calculations

5.1 Calculate the cross-sectional flow area of the sample.

5.2 Use the following formula to calculate the sample's coefficient of permeability (k):

$$k = \frac{Q \times L}{H \times A \times t}$$

Q = Amount of water collected (lbs. ml.)

t = Time to collect water (sec.)

A = Cross sectional area of the sample (in^2.)

L = Length of sample (inches) (mm)

H = Head Elevation (inches) (mm)

q' = Flow rate = Q/t (lbs. per sec., kg. per sec.)

Conversion Factors:

86400 sec. = 1 day
144 sq. in. = 1 ft^2.
28350 ml. = 1 ft^3
density of water = 62.43 lbs./ft^3 (1000 kg/m^3)
area of 6" (150 mm) diameter = 28.27 $in.^2$ (17671 mm^2)

Simplified formula for 6" (150 mm) diameter samples (q' in lbs.(kg) per sec.)

$$k = \frac{q' \times L}{H} \times 7060 \text{ (ft. per day)}$$

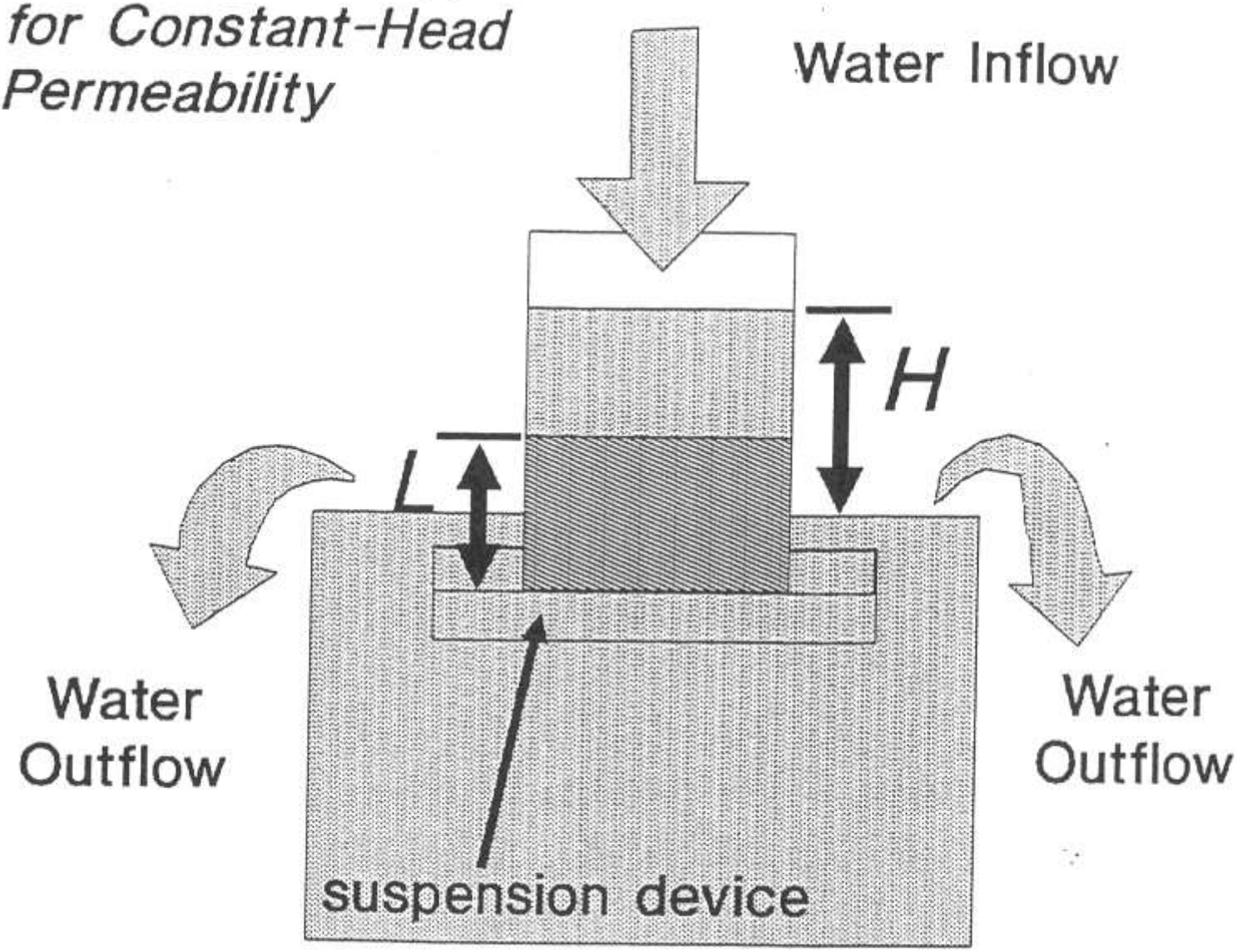
$$k = \frac{q' \times L}{H} \times 4889.24 \text{ (m per day)}$$

Simplified formula for samples of any diameter
(q' in lbs.(kg) per sec., A in in^2 (mm^2), L & H in inches (mm))

$$k = \frac{q' \times L}{A \times H} \times 199{,}300 \text{ (ft. per day)}$$

$$k = \frac{q' \times L}{A \times H} \times 8.64 \times 10^7 \text{ (m per day)}$$

Schematic of Apparatus for Constant-Head Permeability



Virginia Test Method – 85

Deleted - ***Determination of Total Petroleum Hydrocarbons In Contaminated Soil and Water Using Infrared Spectroscopy***

April 1, 1996

<u>Virginia Test Method – 86</u>

Deleted - ***Determination of Benzene, Toluene, Ethylbenzene, And Xylenes (BTEX) In Contaminated Soil And Water Using Capillary Gas Chromatography***

April 1, 1996

Virginia Test Method – 87

Nuclear Asphalt Gauge Content – (Asphalt Lab)

November 1, 2000

1. Scope

This method of test covers a procedure for calibrating and using the Nuclear Asphalt Content for the purpose of finding percent of asphalt.

2. Apparatus

2.1 Balance capable of weighing 5000 grams within ± 1 gram

2.2 Mixer - a mechanical mixer is recommended. Any type of mechanical mixer may be used provided it can be maintained at the required mixing temperature and will provide a well coated homogenous mixture.

2.3 Pans - several pans for the mixes as well as several pans for the asphalt content gauge (these pans usually come with the gauge).

2.4 Oven capable of heating to 350 ± 5° F (177 ± 3° C).

3. Calibrating the Asphalt Content Gauge

3.1 Heat materials to 275° F (140° C) and mix.

3.2 Make a minimum of three (3) samples of known asphalt content.

3.3 Place sample pans in 225° F (107° C) oven.

3.4 Let samples cool to 225° F (107° C).

3.5 Weigh and record weight of sample pan (tare pan).

3.6 Fill pan 1/3 full and rod. DO NOT PACK. Do each layer the same leaving the top layer with a small mound.

3.7 Weigh sample into pans weighing the sample nearest the center of the asphalt content first. Record weight of asphalt. (All asphalt should weigh the same from this point on. Even the field samples.)

3.8 Place plywood or metal plate over sample and stand or use some other means of flattening the sample with the top of the pan.

Virginia Test Method – 89

Quick Set Emulsified Asphalt Setting Time –(Asphalt Lab)

November 1, 2000

1. Scope

1.1 The emulsified asphalt setting time will be used to determine that an emulsified asphalt will meet the minimum requirments of a Quick Set Emulsified Asphalt. This test differs from VTM-60 in that VTM-60 is a mix design procedure, and VTM-89 is a quality control procedure.

1.2 Prior to shipment of each new formulation of emulsified asphalt the contractor shall perform this test procedure to verify that the emulsion will set rapidly enough to facilitateearly release of traffic. The results of the test shall be furnished to the Department as part of the emulsified asphalt certification process. All ingredients used in the test shall be sampled from material proposed for use in the work.

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. Apparatus

2.1 Scale capable of weighing 5000 grams with a precision of 1 gram.

2.2 Suitable heavy gauge round bottom bowl to contain the sample during mixing.

2.3 Long handled spoon of sufficient length to project 4 in. (100 mm) or more out of round bottom bowl.

2. Supply of 6 in. (150 mm) squares cut from 40 - 60 lb (18-27 kg) roofing felt.

2.5 Supply of white paper towels.

3. Procedure

Part A

3.1 To a sample of 199 grams of Type B screenings (passing #4 sieve [4.75 mm]), add one gram of mineral filler and mix for one minute. Add water and mix for one minute. The minimum amount of water required shall be one percent less than that shown on the approved mix design, which corresponds to 15% emulsified asphalt content unless otherwise directed by the Department. In the event that the design was not performed using 15% emulsified asphalt, the minimum amount of water shall be determined by interpolation from the percentages of emulsion used in the design.

3.2 If the mixture is free of visible segregation, balling and stiffening after 3 minutes of continuous mixing, the emulsified asphalt will pass Part A of this test procedure.

Part B

3.3 Place approximately one half of the mixture on a piece of roofing felt and spread until approximately 1/4 in. (6 mm) thick.

3.4 Cure the test pad for 60 +/- 1 minute between 68 - 80° F (20 - 27° C).

3.5 Place a sheet of white paper towel lightly on the surface of the pad after 60 +/- 1 minute of curing.

3.6 If no brown stain appears on the towel, the emulsified asphalt will pass Part B of the test procedure. Disregard black particles of asphalt which stick to the towel.

5. Report

5.1 Pass or Fail Part A

5.2 Pass or Fail Part B

Virginia Test Method – 90

Testing of Silicone Sealants –(Chemistry Lab)

November 1, 2000

1. Scope

1.1 This method covers the test procedures to be used in determining Bond to Concrete Mortar Extrusion Rate, Tack Free Time, Skin Over Time, Movement Capability and Adhesion and Non-Volatile Content of Silicone Sealants.

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 Testing machine as specified in ASTM D-638, equipped with a drive to allow speed of testing of 0.30 inch (8 mm) per minute.

2.2 Suitable self-aligning grips for testing briquets in accordance with AASHTO T-132.

2.3 Briquet molds, same as specified in AASHTO T-132.

2.4 Air powered caulking gun capable of operating at 90 PSI (620 KPa) air pressure.

2.5 Cabinet or Room capable of maintaining a temperature of 77 ± 3° F (25 ± 2° C) at 50 ± 5% relative humidity.

2.6 Chest type freezer capable of maintaining a temperature of 0° F (-18° C).

2.7 Extension Machine consisting of one or more screws rotated by an electric motor through suitable gear reductions. Self aligning plates or grips, one of each pair fixed and the other carried by the rotating screw or screws, shall be provided for holding the test specimens in position during the test.

2.8 Concrete Test Blocks approximately 1" x 1" x 3" (25 mm x 25 mm x 75 mm) or 1" x 2" x 3" (25mm x 50 mm x 75 mm) shall be saw cut from any convenient size specimen of concrete. The concrete shall be class A3. The concrete test blocks can also be purchased from Masonry Test Block Co. which makes blocks for ASTM tests. The blocks must be thoroughly cleaned and dried in an oven at 230 ± 9° F (110 ± 5° C).

2.9 Scales with 200 gram capacity and accurate to 1 gram.

2.10 Balance accurate to one milligram (0.001 gram).

2.11 Unwaxed paper cups, 16 oz. (480 mL) with 3 in. (75 mm) diameter base.

2.12 Unwaxed paper cups 8 oz. (90 mL) with 1.5 in. (38 mm) diameter base.

2.13 Wooden tongue depressors.

2.14 Steep spatula having a 4 to 5 inch (100 mm to 125 mm) long narrow blade.

2.15 Stopwatch or Timer with second divisions.

2.16 Forced Draft oven able to maintain 230 ± 9º F (110 ± 5º C).

2.17 Wax or lubricant to coat inside of molds (nonreactive).

2.18 Diamond tooth saw or other cutting tool capable of producing clean smooth faces.

2.19 Scale suitable for determining the distance between two fixed points of the specimen at any time during the test.

3. Bond to Concrete Mortar Procedure

3.1 Prepare cement mortar briquets in accordance with AASHTO T-132 using Type III cement meeting the requirements of AASHTO M-85 and 20-30 Standard Sand meeting the requirements of ASTM C-190.

3.2 Allow the briquets to cure at least seven (7) days, then saw them in half at centerline perpendicular to the long axis.

3.3 Clean the sawed faces. Remove any laitance by rubbing with a carborundum block, then scrub with a bristle brush under running tap water. Dry the briquets and place in a desiccator until needed. Be sure to keep the matching halves of each briquet together.

3.4 After cooling a matching pair of briquets should be "buttered" with sealant and squeezed together forcing excess sealant out until the blocks are tightly fitted together with only a thin film of sealant between them.

3.5 The specimen halves will then be tightly held together with rubber bands until cured.

3.6 Five (5) test specimens shall be made and tested.

3.7 The specimens shall be tensile tested at a loading rate of 0.3 inch (8 mm) per minute using the self aligning briquet testing grips mounted in the testing machine.

3.8 Report the average bond strength obtained on the five specimens.

4. Extrusion Rate Procedure

4.1 Using the air operated caulking gun place an appropriate size caulking tube of silicone in it Carefully square cut the nozzle to give an inside diameter opening of 1/8" (3.2 mm). Break the seal or cut the tip of the cartridge.

4.2 Set the air pressure at the caulking gun to 90 PSI (620 KPa).

4.3 Weigh a disposable container 16 oz. (480 mL) to the nearest gram.

4.4 With the air pressure of the caulking gun set to 90 PSI (620 KPa), empty the entire contents of the cartridge into the disposable container.

4.5 Record the amount of time taken to extrude the contents of the caulking tube using a stopwatch.

4.6 Weigh the disposable container and the sealant to the nearest gram.

4.7 Calculate the weight of sealant extruded by subtracting the weight of the empty container from the weight of container plus sealant.

4.8 Calculate the extrusion rate per minute as follows:

(W/T) x 60

W = weight of silicone extruded, in grams

T = elapsed time, in seconds

60 = 1 minute

5. Tack Free Time Procedure for Non-Sag Sealants

5.1 Fill the outside bottom indention of the 16 oz (480 mL). unwaxed paper cup with silicone and strike it off smooth with a spatula. Record the time or start a timer.

5.2 Touch the surface of the silicone with a finger at 5, 10, 15, 30, 45, 60 and 90 minutes. The time at which no material will adhere to the finger is the actual Tack Free Time. If a maximum Tack Free Time is desired, then only one test at that maximum time is needed.

5.3 Report the actual Tack Free Time or less than (required Tack Free Time) or greater than (Required Tack Free Time).

6. Skin Over Time Procedure for Self Leveling Sealants

6.1 Fill the outside bottom indention of the 16 oz. (480 mL) unwaxed paper cup with silicone and strike it off smooth with a spatula. Record the time or start a timer.

6.2 Lightly touch the surface of the silicone with a finger without adding any pressure at 15, 30, 45, 60 and 120 minutes. The time at which no material will adhere to the finger is the actual Skin Over Time. If a maximum Skin Over Time is desired, then only one test at that maximum time is needed.

6.3 Report the Actual Skin Over Time or less than (required Skin Over Time) or greater than (Required Skin Over Time).

7. Movement Capability and Adhesion Procedure

7.1 Prepare ten (10) specimens using either 1" x 1" x 3" (5 mm x 25 mm x 75 mm) or 1" x 2" x 3" (25 mm x 50 mm x 7 5mm) Concrete Blocks.

7.2 Simulated roadway joints shall be made by bonding two sawed block faces together in such a manner that in the middle two inches (50 mm) of the formed joint the silicone will be 3/8" (10 mm) deep by 1/2" (13 mm) wide.

7.3 Specimens prepared using Type "A" silicone shall be cured 21 days. Type "B" and "C" silicone shall be cured 28 days prior to testing.

7.4 After curing, five of the specimens shall be soaked in water for seven days prior to testing.

7.5 All specimens shall be tested at 0º F (-18º C).

7.6 The specimen should be placed in the extension machine at 0º F (-18º C) for 4 hours prior to extension. This will allow the specimens to reach a constant temperature. The specimen will then be mounted in the extension machine grips and extended at a rate of 1/8" (3.2 mm) per hour until a width of 1" (25 mm) is achieved. The specimens will then be removed from the grips and allowed to return to the initial 1/2" (13 mm) width at room temperature for two hours. One cycle is defined as cooling for four hours at 0º F (-18º C), followed by extension to a width of 1" (25 mm) and return to the initial width of 1/2" (13 mm) for two hours.

7.7 The specimens shall go through 10 cycles at 0° F (-18° C) with no adhesive or cohesive failures.

7.8 Results shall be reported as satisfactory or unsatisfactory. A result of satisfactory is reported only when a specimen shows no adhesive or cohesive failure after ten cycles at 0° F (-18° C). A result of unsatisfactory is reported when a specimen shows an adhesive or cohesive failure after any cycle.

8. Non-Volatile Content Procedure

8.1 Weigh as rapidly as possible approximately 10 grams of uncured sealant to the nearest 0.001 gram, in an aluminum foil cup approximately 2" (50 mm) in diameter and 1/2" (13 mm) deep.

8.2 Place the cup in a forced draft oven at a temperature of **105 ± 5 ° C** for 24 hours.

8.3 At the end of 24 hours remove the sample and immediately weigh to the nearest 0.001 gram. Place the sample back in the oven for an additional hour and then remove and reweigh again. There should be no change in weight.

8.4 If material has not reached a constant weight place back in the oven until a constant weight is reached.

8.5 When a constant weight is reached place the sample in a desiccator until the sample has cooled to room temperature. Weigh the sample again to nearest 0.001 gram. This is the final weight of sample.

8.6 Percent Non-Volatile shall be calculated in the following manner:

$$(A/B) \times 100$$

Where:

A = Final Weight of Sample

B = Original Weight of Sample

Virginia Test Method – 91

Extraction of Asphalt from Aggregate (HMA)
with the Vacuum Extraction Method
using a Biodegradable Solvent - (Asphalt Lab)

November 1, 2000

1. Scope

1.1 This method is used to separate the Aggregate from its asphalt coating prior to performing a 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. Also, it is recommended that this test procedure not be conducted in areas where open flames of sparks could ignite the solvent.

2. Apparatus

2.1 Vacuum extractor

2.2 Vacuum pump

2.3 Filter paper - Size 33 cm. diameter

2.4 Filtering aid - Celite 521 or equal

2.5 Sieves - Nos. 16 and 200 (1.18 mm and 0.075 mm)

2.6 Mixing Spoon

2.7 Balance - 2000 g capacity, sensitive to 0.1g

2.8 Oven, forced air - Capable of maintaining the required temperature within ± 5° F (2.8° C)

2.9 Hair pic (a vertical comb with 4 to 12 teeth) made of plastic or hard rubber, to be used to un-clog filter paper

2.10 Soft bristled brush

2.11 Containers for holding used water

2.12 Approved drinking water

2.13 Flask - 1000 ml. capacity

2.14 Pan, flat, approximately 17 x 16 x 2.5"H (430 mm x 405 mm x 63 mm) - metal

2.15 Wash bottle, plastic, 500 ml. capacity

2.16 Stainless steel bowl - for mixing sample - sufficient size to hold the largest base HMA sample plus the 750 ml. of biodegradable solvent

2.17 Muffle furnace - a muffle furnace capable of maintaining temperatures between 800 and 1100°F (427 – 593°C) with minimum interior dimensions of 11-1/2"x11-1/2x7-1/2" (292 mm x 292 mm 190 mm)(WxDxH).

2.18 Metal Pan - A metal pan with dimension of approximately 10" x 10" x 2" (25 mm x 254 mm x 50 mm) (WxLxH) that is capable of withstanding temperatures of approximately 1200° F (650° C). Other containers meeting this capacity and temperature requirement may be used.

2.19 Protective gloves - Heat resistant gloves for handling pans with hot aggregate.

3. Reagent

3.1 Biodegradable solvent from VDOT approved list. The solvent must have a flash point less than 140° F (60° C), when tested with Pensky Martens closed cup.

4. Sampling

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). If the mixture is not sufficiently soft to separate with a spatula or trowel, warm the sample (max. 300° F (149° C)) only until it can be handled of mixed.

4.1 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
1½ in. (37.5 mm)	1800 g

5. Moisture Content

5.1 The moisture content determination shall be made as deemed necessary in accordance with AASHTO T 164 8.2.4 Note 5.

6. Procedure

6.1 Weigh sample and record weight as (W_1) to the nearest 0.1g.

6.2 Add 750 ml. or a sufficient amount biodegradable solvent to totally cover the sample. (See 3.1 above). Let stand for 20 minutes stirring 5 to 6 times.

6.3 Weigh filter paper and record weight as (W_2) to the nearest 0.1g.

6.4 Weigh out 100 grams of filtering-aid and record as (W_3) to the nearest 0.1g, add 700 ml. of biodegradable solvent to filtering-aid and stir until completely suspended.

6.5 Immediately pour the suspension of filtering-aid and solvent over filter paper.

6.6 Start vacuum. Leave vacuum on until pad formed by filtering-aid is surface dry.

6.7 Put the #16 (1.18 mm) sieve on the #200 (0.075 mm) sieve and place the #200 (0.075 mm) sieve on top of the asphalt extractor.

6.8 While stirring, pour liquid from sample over the entire surface of the #16 (1.18 mm) sieve making sure not to lose any of the aggregate.

6.9 Pull vacuum until filter paper is dry.

6.10 If filter becomes clogged, use hair-pic and comb through filtering-aid, being careful not to tear the filter paper.

6.11 Add 500 ml. of solvent through filter paper and pull vacuum until paper is dry.

6.12 Pour 300 ml. of fresh biodegradable solvent onto sample and stir until solvent is mixed with sample and pour over the #16 (1.18 mm) screen.

6.13 Repeat step 6.12 four additional times or more if necessary.

6.14 On last washing leave vacuum on until filter paper has a dry appearance. Then vacuum for an additional five minutes to ensure that all solution has drained from the filter.

6.15 Drain reservoir of asphalt extractor into one of the containers.

6.16 If needed, comb dry filter paper and then pour 500 ml. approved drinking water over sample, stir and pour over #16 (1.18 mm) screen.

6.17 Repeat step 6.16 at least 3 to 4 more times or until water becomes clear.

6.18 If filter becomes clogged, use hair-pic and comb through sample being careful not to damage filter.

6.19 Place aggregate into drying pan. Use water wash bottle to wash all particles from mixing bowl onto sieve. Wash mixing spoon over sieve also.

6.20 Remove sieves and place in drying pan.

6.21 Wash sides of funnel ring with water and vacuum for 5 minutes to ensure filter is dry.

6.22 Remove filter paper, being careful not to lose any material, and place in drying pan.

6.23 Place drying pan in oven 230 ± 9° F (110 ± 5° C) for 1 hour. At the end of 1 hour brush and tap screens over the aggregate pan and dry for another 30 minutes.

6.24 Weigh dried aggregate and record weight as (W_4) to the nearest 0.1 g.

6.25 Weigh filter paper and filtering aid and record weight as (W_5) to the nearest 0.1g. Find the difference between this weight and the original weight of the filtering aid and paper. Add this difference to the sample weight. (6.1).

6.26 Calculate results in accordance with Section 1.1 herein.

6.27 When the Asphalt Content is desired perform steps 6.28, 6.29 and 6.30 before doing steps 6.24, 6.25 and 6.26. Disregard sentence 2 and 3 of step 6.25. This will be performed later in the procedure.

6.28 Remove filter paper from the drying pan, being careful not to lose any material and weigh to the 0.1g and record as (W_5).

6.29 Place the pan containing the extracted aggregate in the muffle furnace for 60 ± 5 minutes at 800 ± 25° F (427 ± 14° C) to burn off any residual asphalt.

Note: When limestone aggregate is being used a blank sample is to be rum in the muffle furnace to determine loss of aggregate during the burning process. The burning time and temperature shall be the same as stated herein.

6.30 Calculate the percent asphalt content as follows:

W_1 = Original weight of sample
W_2 = Weight of filter
W_3 = Weight of filtering aid
W_4 = Weight of dried extracted aggregate
W_5 = Final dry weight of filter and filtering aid

$$W_{-200} = W_5 - (W_2 + W_3)$$

$$W_{agg.} = W_4 + W_{-2}$$

$$W_{A.C.} = W_1 - W_{agg.}$$

$$\% \text{ A.C.} = (W_{A.C.}/W_1) \times 100$$

Note: W_{-200} is only the amount of minus 200 (0.075 mm) material collected on the filter during the extraction and is not the total amount of minus 200 (0.075 mm) material present in the mixture. The total minus 200 (0.075 mm) can be determined only after performing Step 6.26 above.

6.31 Calculate the aggregate gradation as specified in 1.1 above using the weight of aggregate ($W_{agg.}$) calculated in 6.30 above.

Virginia Test Method – 92

Testing Epoxy Concrete Overlays for Surface Preparation and Adhesion - (Physical Lab)

November 1, 2000

1. Scope

1.1 This method covers the test procedure used to measure the tensile rupture strength between hydraulic cement concrete and epoxy concrete overlay.

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 Dillon dynamometer mechanical testing device for pulling a bonded pipe cap in tension.

2.2 Core drill with 2.2" (56 mm) inside diameter diamond tipped core barrel.

2.3 A standard 1 1/2" (38 mm) diameter pipe cap, the bottom surface of which has been machined smooth, flat, and shoulder cut to provide a 2" (50 mm) diameter surface.

2.4 A rapid curing epoxy compound with a working (pot) life of 3 to 25 minutes.

2.5 Ruler or measuring device.

2.6 Small propane torch (optional).

2.7 Surface and internal thermometers.

3. Procedure

3.1 Select 1.5' x 3' (0.5 m x 1 m) areas of bridge deck for test patches. The test patches should cover typical surface conditions found on the bridge deck (e.g. if the bridge deck surface contains 10% concrete patching then 10% of the test patches on the bridge deck should be placed on these patches). Test patches shall be placed in the wheel paths, in the area between wheel paths and in other areas that represent the worst surface condition.

3.2 Clean the 1.5' x 3' (0.5 m x 1 m) test patch area with the same equipment to be used in cleaning the entire deck. Clean means to remove all asphaltic materials, oils, dirt, rubber, curing compounds, paint, carbonation, laitance, weak surface mortar and other detrimental materials that can interfere with the curing or adhesion of the overlay. Cleaning is usually achieved by significantly changing the color of the concrete and beginning to expose coarse aggregate particles.

3.3 Record the forward speed of the shotblaster using a stop watch and the number of passes needed to prepare the surface. Record the size of shot and flow of shot.

3.4 Tape off an area 1.5' x 3' (0.5 m x 1 m) using duct tape. Measure and record the temperatures of the air, deck surface and epoxy components.

3.5 Mix the epoxy components A and B by volume as prescribed by the supplier using the same equipment, timing and sequence of operation as will be used in the full scaleplacement of overlay.

3.6 Collect a 50 ml sample of the mixed epoxy and measure and record the epoxy gel time. The gel time is the time interval between the initial mixing of the epoxy and the time the epoxy turns from a liquid to a gel.

3.7 Measure accurately 1/2 quart (0.5 liter) quantities of the epoxy mixture and place each quantity of a 1.5' x 3' (0.5 m x 1 m) test area spreading with a squeegee in the same manner as the full scale operation. The epoxy mixture should be applied uniformly over the cleaned area without puddling. Drop dry epoxy overlay aggregate on test patch at the rate of 10 lbs/yd^2 (5.4 kg/m^2)., or apply to excess.

3.8 Allow the epoxy to cure as required to allow sweeping or vacuuming without damaging the surface (curing time varies according to temperature). Curing of 1st course can be checked by placing thumb on the aggregate and applying pressure. If aggregate moves, curing has not been sufficient. The following minimum cure times are typical:

Time	Temperature
1 hr.	85° F (29° C)
2 hrs.	75° F (24° C)
3 hrs.	65° F (18° C)
5 hrs.	55° F (13° C)

3.9 Sweep or broom the 1.5' x 3' (0.5 m x 1 m) test patch to remove excess aggregate.

3.10 Measure accurately 1 quart of epoxy mixture and place on 1.5' x 3' (0.5 m x 1 m) test patch spreading uniformly with a squeegee without puddling. Apply dry epoxy aggregate on the test patch at a rate of 14 lbs/yd^2 (7.6 kg/m^2)., or apply to excess.

3.11 Allow the epoxy to cure as required to prevent damage from traffic. The following minimum cure times are typical:

Time	Temperature
3 hrs.	75° F (24° C) or higher
5 hrs.	65° F (18° C)
8 hrs.	55° F (13° C)

3.12 Core drill through the hardened epoxy overlay down into the concrete surface 3/8" ± 1/8" (10 mm ± 3 mm) with a diamond tipped core barrel (Figure 1). The inside diameter of the core barrel must be 2.2" (56 mm)

3.13 Vacuum or blow out dust around the core. Bond a 1 1/2" (38 mm) pipe cap that has been machined with a flat bottom surface 2.0" in (50 mm) diameter to the cored overlay disk. The epoxy adhesive used to bond the pipe cap to the overlay should be a rapid curing epoxy with a minimum working life of 3 minutes. Apply a small amount of epoxy adhesive to the pipe cap surface and the cored disk. Do no allow any epoxy adhesive to flow over the edge of the cored disk or down into the cored area. If this occurs, a test result shall not be recorded, an alternate area shall be cored and another test performed. Heat may be applied to pipe cap by means of a small propane torch to decrease the curing time of the adhesive. Never heat the cored disk directly!!! The temperature of the pipe cap shall be monitored and at no time shall the temperature exceed 120° F (49° C).

3.14 Place a plywood template with a 2 1/2" (63.5 mm) diameter hole in the center around the pipe cap. The location of the template corners are marked on the deck so that the test rig for the dynamometer will be centered over the pipe cap during the tensile rupture test. The

plywood template will vary depending on the test apparatus used. The typical dimensions are 3/4" x 12 1/2" x 18 1/2" (19 mm x 318 mm x 470 mm).

3.15 Screw the lower 1/2" (13 mm) threaded hook into the pipe cap (Figure 1). Place the testing apparatus over the pipe cap and align with the marks on the bridge deck. The testing apparatus shop drawings are provided in Figures 2, 3 and 4.

Note: It is of the utmost importance that the equipment be aligned so the axis of the dynamometer will coincide with the extended axis of the pipe cap to give accurate test results.

3.16 Attach dynamometer to upper and lower hooks. Set the load indicator on the dynamometer to zero. Check the date of calibration on the dynamometer. It must have been calibrated within the last 12 months. Apply a tensile load at the rate of approximately 100 lbs. (45.4 kg) every 5 seconds. Record the load at which the pipe cap and connected core is separated from the concrete surface. Record the type of failure. There are five types of failures:

Type 1 - Failure in the concrete at a depth greater than or equal to 1/4" (6 mm) over more than 50% of test area.

Type 2 - Failure in the concrete at a depth less than 1/4"(6 mm) over more than 50% of test area.

Type 3 - Separation of the epoxy overlay from the concrete surface.

Type 4 - Failure within the epoxy overlay.

Type 5 - Failure of the epoxy test adhesive.

A properly applied epoxy overlay on a properly prepared surface should result in a failure in the concrete (Type 1). Record the percent of each type of failure for each pipe cap.

Three pull off tests will be performed on each 1.5' x 3' (0.5 m x 1 m) test patch. The average of the 3 tests will be recorded as one test result. If a tensile rupture test yields a Type 1 failure and the tensile rupture stress is less than 250 psi, (1.72 MPa) this test will be discarded and the test result will be the average of the 2 remaining tensile rupture tests; or the third test if two Type 1 failures occur.

3.17 The hole created by the tensile rupture test shall be repaired with a mixture of the epoxy and aggregate used in the overlay.

4. Calculation

TRS = Tensile Rupture Strength
P = Load (Dynamometer)
A = Area of cored disc
A = $4.0''^2$ (10,300 mm^2) when a 2.25" (57 mm) diameter core is used

$$TRS = \frac{P}{A}$$

5. Sample Worksheet For Test Patches

Surface Preparation by Shotblasting

Number of passes	2
Time	15 seconds
Feet (Meters)	3 (0.9)
Speed	12 ft./min. (0.061 m/s)
Size of Shot	330
Shot Flow Value Position	Wide Open

Epoxy - Lab No. EP 98765

	Course 1	Course 2
Batch Size	10 gallons (38 liters)	10 gallons (38 liters)
Mix Time	10:13 a.m. 6/2/06	12:30 p.m. 6/2/06
Gel Time	19 minutes	17 minutes
Aggregate Removal Time	12:15 p.m. 6/2/06	4:00 p.m. 6/2/06
Open to traffic		4:30 p.m. 6/2/06
Temperatures		
Deck	80º F (29º C)	85º F (29º C)
Air	77º F (28º C)	82º F (28º C)
Part A	75º F (27º C)	80º F (27º C)
Part B	75º F (27º C)	80º F (27º C)

Test Patch

Number	Location	Type Failure	Tensile Rupture Load, lbs. (kg)	Result (P/A) PSI (MPa)
1	Span 1, SBL 8 ft. (2.4 m) left of curb 15 ft. (4.6 m) S. of joint	1 3 2	1. 1300 (590) 2. 1100 (500) 3. 1000 (450)	283 (1.95)
2	Span 2, SBL 6 ft. (1.8 m) left of curb 10 ft. (3 m) S. of joint	2 1 3	1. 1200 (540) 2. 1000 (450) 3. 900 (410)	258 (1.78)
3	Span 3, SBL 9 ft. (2.7 m) left of curb 7 ft. (2.1 m) S. of joint	3 2 1	1. 1300 (590) 2. 1200 (540) 3. discard	313 (2.16)

6. Sample Worksheet For Test Patches

Surface Preparation by Shotblasting

Number of passes	
Time	
Feet (Meters)	
Speed	
Size of Shot	
Shot Flow Value Position	

Epoxy - Lab No. EP

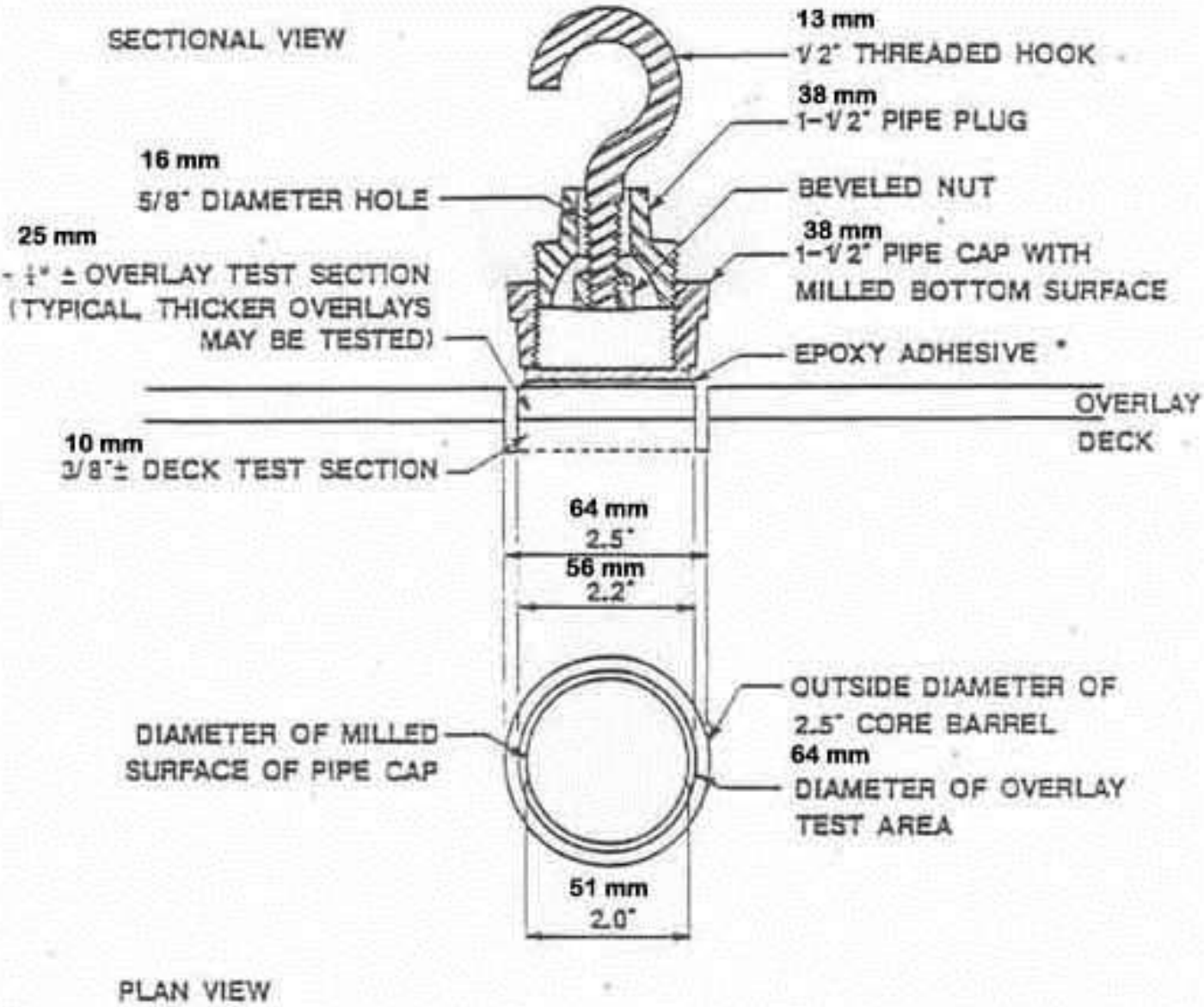
	Course 1	Course 2
Batch Size		
Mix Time		
Gel Time		
Aggregate Removal Time		
Open to traffic		
Temperatures		
Deck		
Air		
Part A		
Part B		

Test Patch

Number	Location	Type Failure	Tensile Rupture Load, lbs. (kg)	Result (P/A) PSI (MPa)
1				
2				
3				

7. References

7.1 American Concrete Institute Manual of Concrete Practice ACI 503R-80 Appendix A - Test Methods.



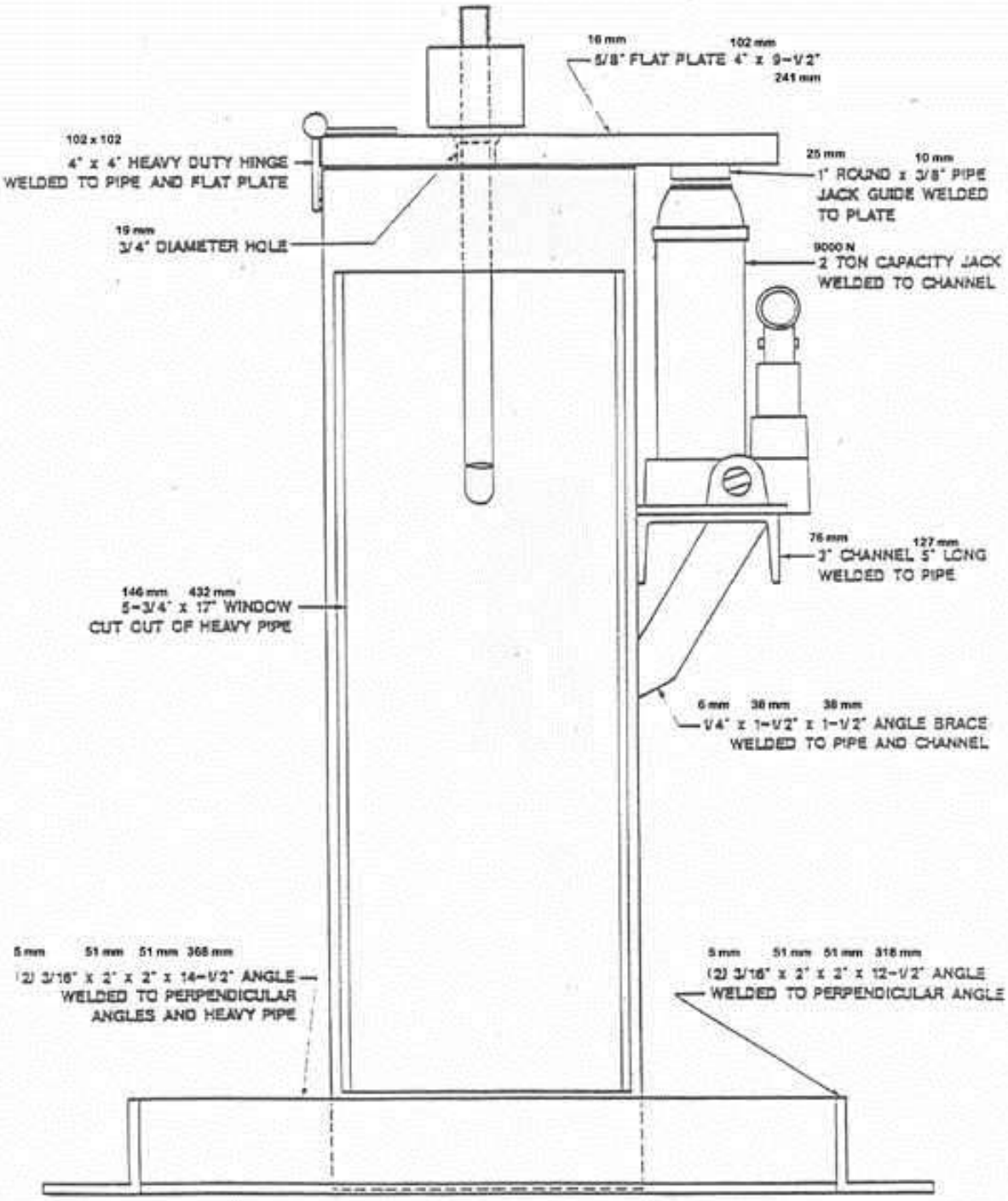
DETAILS OF LOWER CONNECTION

NOTE:

AFTER THE PIPE CAP IS BONDED TO THE DECK AND PRIOR TO TESTING THE CAP, A PLYWOOD TEMPLATE (3/4" x 12-1/2" x 18-1/2") WITH A 2-1/2" DIAMETER HOLE IN THE CENTER IS PLACED AROUND THE PIPE CAP. THE LOCATION OF THE TEMPLATE CORNERS ARE MARKED ON THE DECK SO THAT THE TEST RIG MAY BE CENTERED OVER THE PIPE CAP FOR THE TEST.

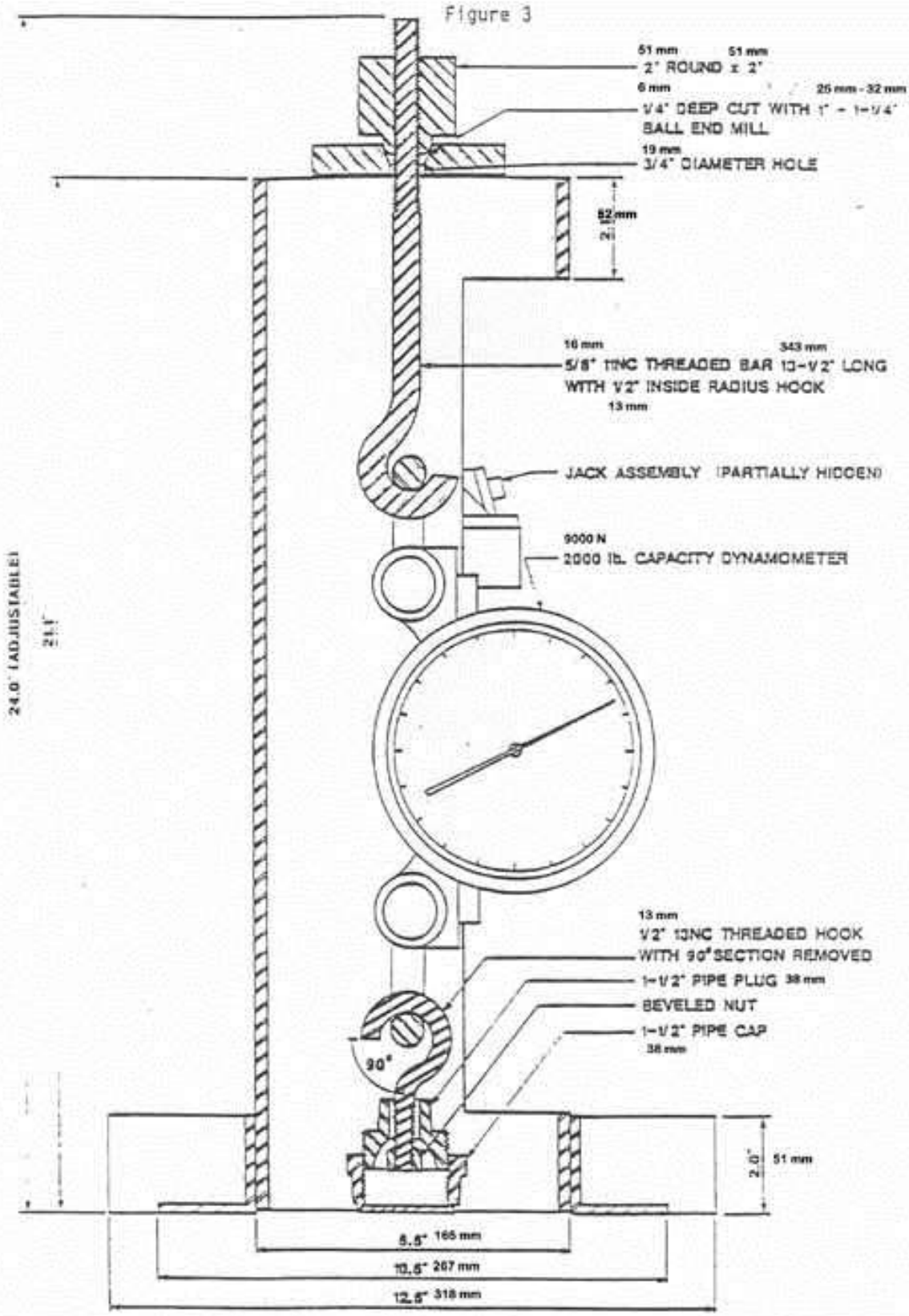
19 mm 318 mm 470 mm
64 mm

* TEST NOT VALID IF EPOXY ADHESIVE ON DECK CONCRETE OR OUTSIDE OF TEST SECTION.



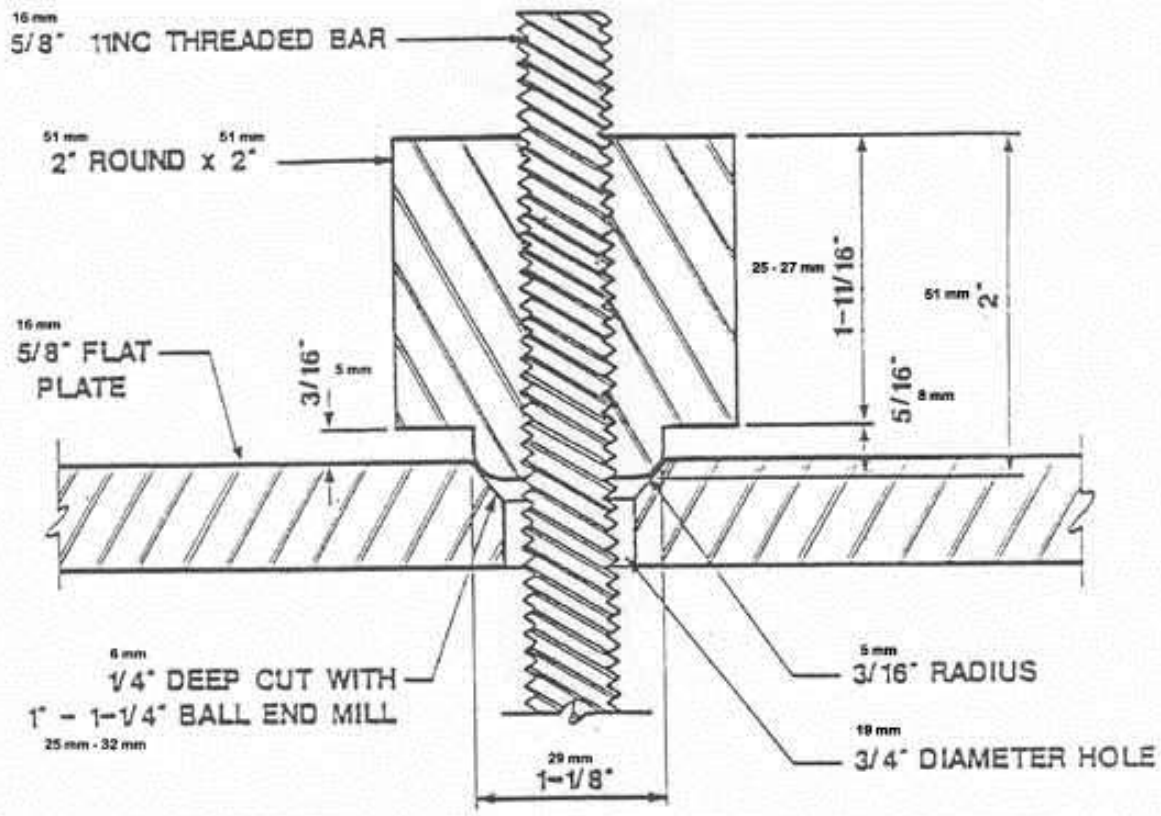
FRONT ELEVATION

Figure 3



SECTION THROUGH CENTER SHOWING FACE OF DYNAMOMETER

Figure 4



DETAIL SHOWING ALLOWANCES FOR ECCENTRICITY
IN UPPER CONNECTION

Virginia Test Method – 93

Nuclear Asphalt Content Gauge Determination
For H.M.A. and Slurry Seal Mixtures – (Asphalt Lab)

November 1, 2000

1. Scope

1.1 This method of testing covers a procedure for calibrating, cross calibration, calibration transfer and using the Nuclear Asphalt Content Gauge for the purpose of finding percent of asphalt.

1.2 This standard may involve hazardous materials, operation, 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 Nuclear Asphalt Content Gauge with Printer and Interface Cable

The gauge must be capable of measuring the asphalt content directly and accurately in 7,000 gram sample pans.

2.1.1 The nuclear asphalt content gauge must be capable of cross calibration with the VDOT laboratory gauges.

2.1.2 Each gauge model proposed to be used for this test method (VTM-93) must be approved by the VDOT Elko Asphalt Laboratory Engineer. Each gauge manufacturer must present his/her gauge to the Department's Elko Asphalt Laboratory and demonstrate to the satisfaction of VDOT the accuracy and flexibility of the gauge in determining asphalt content as specified in 2.1 above. The samples to be tested will be selected by the Elko Asphalt Laboratory Engineer.

2.2 Balance capable of weighing 10,000 grams to within ± gram.

2.3 Mixer - A mechanical mixer is recommended. Any type of mechanical mixer may be used provided it can be maintained at the required mixing temperature and will provide a well-coated homogeneous mixture.

2.4 Pans - Several pans for the mixes. Also several pans for the asphalt content gauge. The pans for the gauge shall be those furnished with the gauge and/or required by the Asphalt Content Gauge Manufacturer.

2.5 Oven - capable of heating to 350 ± 5° F (177 ± 3° C)

2.6 Board - 3/4 in. (20 mm) or heavier or 3/8 in (10 mm) of heavier metal plate having an area slightly larger than the sample pans.

2.7 Hand held tamper, spoon, spatula, asphalt thermometers, etc.

2.8 Aluminum metal plates and siliconized acrylic latex caulk - needed for cross calibration pans only. (see 4.15)

3. Calibrating the Asphalt Content Gauge

3.1 Set up the asphalt content gauge according to the manufacturer's instructions or recommendations.

3.2 Heat materials to 275 ± 5° F (135 ± 3° C) is for H.M.A. or 225 ± 5° F (107 ± 3° C) if for a slurry seal mixture and mix. (Use the liquid asphalt rather than the Emulsion when calibrating for a slurry seal mixture.)

3.3 Make a minimum of four (4) samples of known asphalt content. One sample must be at least 1% above and one at least 0.5% below the mix design target.

3.4 Place sample pans in 275 ± 5° F (135 ± 3° C) oven if for H.M.A. of in 225 ± 5° F (107 ± 3° C) oven if for a slurry seal mixture.

3.5 Weigh and record weight of sample pan (tare pan).

3.6 Fill pan 1/3 full and lightly tamp the mix with a spoon or spatula. Do each layer the same leaving the top layer with a small mound.

3.7 Weigh sample into pans weighing the sample nearest the center of the asphalt content first. Record weight of asphalt. (All asphalt samples should weigh the same from this point on (1 ± gram).

3.8 Place a piece of wax paper over the sample and press down with a wooden board or any metal plate to flatten the sample with the top of the pan.

3.9 With the gauge set for the calibration mode, measure each sample for 16 minutes. At the completion of the calibration sequence, review the Fit Coefficient and the % differences. The Fit Coefficient should be 0.995 to 1.000. No differences should be greater than 0.09%.

3.10 Assign an I.D. number for this mix design and print out calibration.

3.11 Perform a calibration (3.1 thru 3.11) for each Job Mix Design. Unless requested by the Engineer or Contractor, minor adjustments allowed on a Job Mix Design will not warrant a new calibration.

4. Cross Calibration

4.1 When cross calibration is to be used between VDOT's gauge and those of the contractors to establish a correlation between the two, the following changes to 3 above shall be adhered to:

4.11 Make a minimum of five (5) samples of known asphalt contents.

4.12 One of the samples must have an asphalt content higher than anticipated in any of the plant samples and one lower. (Example: 8.0% = Highest, 3.0% = Lowest). The asphalt contents of the remaining samples should fall between this high and low.

4.13 The cross calibration samples for H.M.A. shall be run using a surface mix design. If for a slurry seal mixture, use the approved design for that mixture.

4.14 The sample should be tampered relatively tight using a hand held tamper.

4.15 When the cross calibration between the department's gauge and the contractor's gauge is not going to be done the same day the samples are prepared, the department's calibration pans shall be sealed with a aluminum metal plate and silicon caulking. This will allow the cross calibration to be done at a time convenient to both labs.

4.16 When cross calibration is performed on a contractors gauge the I.D. for that calibration should be the serial number of the contractors gauge.

4.17 The gauge of the contractors as well as that of the departments must be capable of printing out the cross calibration.

4.18 Unless otherwise directed the cross calibration will be performed by the District's Asphalt Testing Labs.

5. Calibration Transfer

5.1 Before any calibration transfer can be performed the cross calibration between the departments gauge and the contractors must have already been done.

5.2 The contractor shall submit to the District's Asphalt Lab prior to production, his gauge print-out's of the calibration on each Job Mix Design that he plans to use.

5.3 Pull up the proper cross calibration of the contractors gauge.

5.4 Dial in the information on the calibration to be transferred and assign it a number.

5.5 Based on the cross calibration data, the constants will be adjusted to reflect the differences between the two gauges.

5.6 Repeat the above procedure for each new design calibration to be transferred.

6. Testing Field Samples - Using Pans

6.1 Set up asphalt content gauge according to manufacturing directions.

6.2 Dry samples to constant weight in 275 ± 5° F (177 ± 3° C) oven if for H.M.A. or 225 ± 5° F (107 ± 3° C) if for a slurry seal mixture.

6.3 Weigh pan and record weight.

6.4 Weigh sample to the same weigh that was used for calibration on the mix. Record weight of asphalt.

6.5 In gauge set up, select the stored calibration I.D. that was run for this sample's Job Mix Design.

6.6 Run sample for a minimum of 8 minutes and determine asphalt content.

Virginia Test Method – 94

Quality Control Testing of Pavement Markings – (Chemistry Lab)

November 1, 2004

1. Scope

This method of test outlines five (5) procedures for quality control testing of pavement markings:

A) Checking for moisture in the pavement

B) Determination of the wet film thickness of liquid markings

C) Determination of film thickness for thermoplastic markings

D) Determination of application rate of glass beads applied by pressurized spray or drop-on methods

E) Visual Inspection

2. Apparatus

The apparatus required for each procedure is outlined in the appropriate section below.

3. Procedures

A) Checking for moisture in the pavement

There are two methods described in this section. Method 1 is to be used prior to application of markings. Method 2 is only to be used during thermoplastic application.

Method 1

a) Apparatus

6 inch x 6 inch (150 mm x 150 mm) clear plastic square

Duct tape

b) Procedure

Select a location representative of the pavement surface where markings are to be applied. Secure all edges of the plastic to the pavement surface with the duct tape. The pavement surface must be visible through the plastic.

After a period of time, check for condensation of moisture on the plastic. The appropriate time between taping and inspecting the plastic will vary with ambient conditions; If moisture is present it will be drawn out more quickly in a sunny location than in the shade. However, shady areas are more likely to contain moisture. Always choose a test location that represents the "worst case" scenario. Generally, a minimum of twenty (20) minutes is recommended.

The presence of moisture on the plastic indicates that there is moisture in the pavement surface.

Method 2

a) Apparatus

#15 Tar paper

Duct tape

b) Procedure - Select a location where markings are to be applied. Place the tar paper on the pavement surface. Secure the tar paper to the surface with the duct tape such that it will not be displaced when the thermoplastic is applied.

Apply the marking material to the tar paper. Wait approximately one (1) minute to allow any moisture in the pavement to condense onto the tar paper. Carefully remove the tar paper from the pavement. (Thermoplastic is applied from 400° F to 475° F. (204° C to 246° C) Work gloves should be worn.)

Inspect the underside of the tar paper for condensation of moisture. Presence of moisture on the tar paper indicates that there is moisture in the pavement surface.

B) Determination of the wet film thickness of liquid marking materials

This procedure is to be used to verify the thickness of all liquid pavement marking materials, except thermoplastic, immediately following application thereof.

a) Apparatus

Calibrated wet mil gauge

*Sample plate (sheet metal - 4 inch x 6 inch (100 mm x 150 mm), 20 to 40 mils (0.5 mm to 1.0 mm) thick)

Piece of cloth

b) Procedure

Select a level location in the path of where the markings are to be applied. Place the plate on the pavement surface and secure it with the duct tape such that it will not be displaced when the marking is applied.

This test cannot be performed on a sample that contains glass beads. The glass bead gun must be turned off prior to application of the marking material to the sample plate.

Apply the marking material to the sample plate using the equipment being evaluated.

Thickness is specified in wet mils for all liquid markings except thermoplastic. Thus, all thickness measurements must be performed while the material is still wet.

Immediately after application, place the gauge into the material on the sample plate until the posts on the gauge are firmly in contact with the plate (see figure 1). The gauge is configured such that the probes indicate a thickness from a line drawn between the posts. The last probe with material on it indicates the thickness. Care must be taken not to press too hard as this may indent the sample plate and give a false reading.

Read the thickness from the gauge.

The gauge should be cleaned with a cloth immediately after taking the reading. Consistent cleaning will prevent build-up of dried material.

C) Determination of film thickness for thermoplastic marking materials

This determination is made on the dried film. One of the two following methods is to be used depending on the quantity of voids in the substrate. The specified thickness is defined as the amount of material thickness above the surface of the roadway. Method 1 is to be used for dense graded substrates or when using an extrusion die applicator. Method 2 is to be used for any type of applicator when the substrate is open graded and a substantial amount of material lies below the effective plane of the pavement surface.

Method 1

a) Apparatus

Calipers accurate to 0.001 inch (0.01 mm)

*Sample plate (sheet metal - 4 in. x 6 in. (100 mm x 150 mm), 20 to 40 mils thick (0.5 mm to 1.0 mm))

b) Procedure

Measure and record the thickness of the sample plate. Select a location in the path of where the markings are to be applied. Place the plate on the pavement surface and secure it with the duct tape such that it will not be displaced when the marking is applied.

This test will not be accurate when performed on a sample that contains drop-on or pressure applied glass beads. The glass bead gun or dispenser must be turned off prior to application of the marking material to the sample plate.

Apply the marking material to the sample plate using the equipment being evaluated.

Thermoplastic is applied from 400 to 475° F (204° to 475°C). Wait until the sample cools sufficiently to be moved without flowing. Carefully remove the sample plate from the pavement. Work gloves should be worn.

Using the calipers, measure the total thickness of the thermoplastic and the sample plate. Subtract the panel thickness from the total thickness to obtain the thickness of the applied material.

NOTES FOR B & C ABOVE:

1 - The samples obtained from the procedures B and C above should be inspected for even material thickness across the entire cross-section of the plate and even edges when viewed from above as detailed in (E).

2 - The methods of sampling outlined above may also be used to collect samples for visual inspection of glass bead distribution and embeddment as outlined in (E).

3 - The section of marking where the thickness samples were obtained does not contain glass beads. When it has thoroughly dried cooled or cured, a new marking with glass beads should be applied over the test marking.

*1) Specified dimensions for length and width of sample plate are minimums. Larger sizes may be required for certain applications, i.e. double yellow lines, or where operator skill dictates.

The specified thickness of the sample plate (20 to 40 mils (0.5 mm to 1.0 mm)) must be maintained: A thinner plate will deform while taking readings and produce false results. A plate thicker than that specified (i.e. sign stock) will alter the distance between the gun and the pavement. This can also result in false readings.

Method 2

****

Under Development

This method will require the use of a new device that will be used to measure The thickness of the marking by taking direct measurements on the surface of the roadway.

****

D) Determination of application rate of glass beads applied by pressurized spray or drop-on methods

There are two methods for making this determination:

Method 1 may only be performed after verifying the speed at which the pavement marking equipment actually travels to achieve the proper wet mil thickness of the applied marking.

Use of Method 2 is not limited.

Development of Table 1

Calibration of the pavement marking equipment involves determining the appropriate pressure and speed required to achieve the appropriate wet mil thickness. Once this speed is established the pressure of the glass bead gun is adjusted to deliver the appropriate quantity of beads per gallon of material.

Table 1 is based on the following: A line that is four (4) inches (100 mm) wide at 15 wet mils (0.38 wet mm) that is 320 feet (98 m) long takes one (1) gallon (3.8 L) of material. Therefore, properly calibrated equipment will deliver the specified quantity of beads in the time it takes to travel 320 feet (98 m). Table 1 simply converts the speed in MPH (KPH) to the time it takes to travel 320 feet (98 m). Since the specified quantity of beads (i.e. 6 lb./gal. (0.72 kg/L) for paint) should be delivered in the time it takes to travel 320 feet (98 m), the values in the Table 1 apply to all bead guns set up to cover 4 inch (100 mm) lines for any specified application rate.

Method 1

a) Apparatus

Calibrated one (1) gallon bucket. (This bucket is graduated in one (1) pound (0.5 kg) increments beginning at six pounds (2.7 kg). Graduations may be marks, indentation's or drilled holes.

b) Procedure

Determine the time required to dispense the specified quantity of beads from Table 1.

Position the bucket under the bead gun such that all beads dispensed will be caught in the bucket.

Turn on the bead gun for the time increment from Table 1 (The pressure must be at the same setting that is used while applying markings.)

Compare the level of beads in the bucket with the appropriate graduation.

If there is a difference of 1/2 inch (13 mm) or greater between the level of the beads and the mark, adjustments must be made to the equipment to close this gap.

Table 1

Vehicle Speed (MPH)	Time to Dispense Specified Quantity of Glass Beads (seconds)
4	54.5
5	43.6
6	36.4
7	31.2
8	27.3
9	24.2
10	21.8
11	19.8
12	18.2
13	16.8
14	15.6
15	14.5
16	13.6
17	12.8
18	12.1

Method 2

This method utilizes Table 2. This table converts the various specification quantities per gallon to units of pounds per linear foot for a four inch line.

a) Apparatus

Canvas Sample Bag

String

Scales or balance accurate to ± 0.01 lb (1 g).

b) Procedure

Mark a distance on the roadway between 50 and 350 feet (15 m and 107 m).

Weigh the sample bag and record.

Tie the sample bag onto the bead gun. Operate the equipment in the same manner as if markings were being applied except that the paint gun should be turned off while collecting the bead sample.

Weigh the sample bag and beads.

Subtract the weight of the sample bag from the weight of the sample bag and beads.

Referring to Table 2, calculate the minimum weight of beads for the distance traveled. The actual weight collected must equal or exceed this value.

Table 2	
Glass Bead Application Rate per Linear Foot (0.305 m) For a Four Inch (100 mm)Line	**Glass Bead Application Rate per Linear Foot (0.305 m) For a Four Inch (100 mm)Line**
Specified Application Rate (lbs. / Gallon) (kg/L)	**Glass Beads per Linear Ft. (lbs. / L.F.) (kg/m)**
6 (0.72)	0.0188 (0.0280)
8 (0.96)	0.025 (0.0373)
10 (1.19)	0.03125 (0.0466)
25 (2.99)	0.0781 (0.1164)
Spec. = 7 lbs./100 ft^2. Equivalent = 7 lbs./300 L.F. (0.0347 kg/m) (for Thermoplastic)	0.0233 (0.0347)

Example

Given: Thermoplastic markings are being applied. A 4.12 lb. (1.87 kg) sample is collected over a distance of 175 feet (53.3 m).

Calculate the beads required:

Table 2 yields 0.0233 lbs./L.F. (0.0347 kg/m) for thermoplastic.

175 x 0.0233 = 4.08 lbs. (minimum)
(53.3 m x 0.0347 = 1.85 kg minimum)

Since the amount collected exceeds 4.08 lbs. (1.85 kg), this is a passing test.

E) Visual Inspection

Knowing material quantities does not assure that everything was distributed correctly. This procedure provides guidelines for the visual inspection of pavement markings. Markings which do not meet the criteria stated below fail this procedure and should be rejected.

Visual inspections are made with regard to one of two (2) items: the marking itself or the glass beads.

1) The Marking

a) The location of markings should be compared with the plans and/or the Manual of Uniform Traffic Control Devices (MUTCD). Markings that do not conform to these requirements are unacceptable.

b) Markings must be of the specified width.

c) Markings must be checked for even thickness. This may be done by either inspecting the samples taken for thickness measurements or viewing the marking directly on the pavement. With either method, look for uneven thicknesses in the cross-section of the marking.

2) The Glass Beads

Visual inspection of glass bead application are either with regard to distribution or embedment

Distribution

a) Beads should cover the entire marking.

b) Beads should be evenly distributed across the entire marking.

c) All beads should either be embedded into or onto the marking with little or no loss onto the adjacent pavement.

Embedment

a) Visual inspections with regard to the embeddment of beads into the marking material should be made directly on the pavement surface. The specifications for bead embeddment are general. It is not feasible to obtain exact percentages of buried vs. non-buried beads.

Generally, a marking that fails the visual inspection for bead embedment exhibits one of the following conditions:

1) Most or all the beads are buried in the marking material.

2) Beads are insufficiently buried (most or all beads are on the surface of the marking).

3) "Pulsed" beads - This is caused by rapid fluctuations in the delivery of the beads to the gun.

4) Most or all beads are on one side of the marking.

Virginia Test Method – 95

Design of Latex Modified Emulsion Treatment
(Micro-Surfacing) – (Asphalt Lab)

November 1, 2000

1. Scope

1.1 AASHTO T245 shall be followed, except it may be modified as listed below:

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 limitation prior to use.

2. Apparatus

Note 2 - A mechanically operated hammer shall be used on all Marshall designs.

3. Test Specimens

3.2 Preparation of Aggregates - The aggregate sample must be representative of the aggregate material to be used on the job site and must meet the gradation requirements of the specification.

3.3 Delete

3.4 Preparation of Mixtures

3.4.1 Run preliminary mix tests to determine the concentration of water, additive and filler (lime or cement) to be used for each specimen to yield the desired consistency and break/set times.

The asphalt percentages for a minimum of 3 sets of mixes are based on the design range in the specifications. The lowest residual is the minimum % residual specified in the design range and the highest is the maximum specified. The intermediate residual(s) is (are) at 1% interval(s).

Based on the above information, the quantities of aggregate, emulsion, water, additive and filler required for each mix are calculated. One mix (usually the middle % residual is calculated to yield 5000g of final mix to determine the maximum theoretical specific gravity (MSG). The remaining mixes are calculated to yield 4000g of final mix. The mix quantity for each % residual will yield 3 specimens of approximately 1200g each. - Note - Calculate the % residual by weight of aggregate.

3.4.2 Mixing can be achieved by a power mixer or hand mixing can be used. The aggregate is weighed into the mixing bowl. The filler is then added and thoroughly mixed with the aggregate. The water and additive are next weighed and thoroughly mixed in. Next the emulsion is weighed in and the mixture thoroughly mixed until all of the aggregate is coated (usually 40 to 50 seconds).

3.4.3 The mix is then poured onto a sheet of plastic (2′ x 2′) (0.6 m x 0.6 m) and spread out to yield a layer 3/8″ - 1/2″ (9.5 mm – 12.5 mm) thick. The break and set times

are determined and the pH is checked. The mixes are left undisturbed for 1-2 hours. The mixes are then placed in a forced-air over for 20 hrs ± 2 hrs. at 140° F (60° C).

3.5 Compaction of Specimen

3.5.1 After curing, the mixes are removed from the oven and cooled to room temperature. Each mix is broken up into small pieces and 3 specimens of 1210g each are weighed out and placed into numbered containers. The remainder of the mix left over from the 5000g mix after the 3 specimens are weighed out will be used to determine the MSG. The specimens are then placed into a forced-air oven and heated to 275 ± 5° F (113 ± 3° C). After about 40 minutes of heating, stir the mixes to break up the pieces. The temperature of the mixes is monitored with thermometers placed directly into the mixes. The mix to be used to determine the MSG is heated under the same conditions. The Marshall molds are also heated at this time in the same oven.

3.5.2 The Marshall compacting hammer is heated to 275° F (135° C) with a thermostatically controlled hot plate. The molding of the specimens should begin when the temperature of the mixes reaches 275 ± 5° F (135 ± 3° C). The mixes should not remain at this temperature for more than 30 minutes before molding.

The mixes are molded as specified in AASHTO T-245 except as stated herein. The filter paper or paper toweling is removed immediately after molding is completed. Within 1.5 hours after molding, the specimens are air cooled and extruded from the mold using the load transfer bar with the Marshall test machine. The specimens are then left to stand undisturbed overnight at room temperature.

4. Procedure

4.1 The stability and flow of each specimen are measured as specified in AASHTO T-245 except as stated herein. The test specimens are placed in a water bath at 140° F (60° C) at staggered time intervals such that each specimen remains in the bath for a minimum of 30 minutes and a maximum of 35 minutes before testing. The Marshall test head guide rods are oiled and the test head maintained at a temperature of 90° F (32° C) using a water bath.

4.2 A recording Marshall testing machine is used to determine stability and flow. Apply the load to the specimen by means of the constant rate of movement of the testing machine head of 2 inches (50.8mm) a minute until the load decreases as indicated by the Stability/Flow Chart. All 3 stability and flow tests for each % residual are recorded on the same chart. The Marshall test plugs are to be saved for the determination of % residual. The stability and flow are determined from the test charts of each % residual. The average of the 3 specimens for each % residual will be that % residual's stability and flow. The flow value is that point at which the stability reaches the maximum.

Other Required Tests and Calculations

Bulk Specific Gravity of Aggregate (B.S.G.A.)

Determined as specified in AASHTO T-84 and T-85

To be calculated at time of Design

$$\text{B.S.G.A.} = \frac{100 - \text{A.C.}}{\dfrac{\%\ \text{Agg.}}{\text{Sp.Gr.Agg.}}}$$

Effective Specific Gravity of Aggregate

To be determined at time of Design

$$\text{Eff.Sp.Gr.} = \frac{\%\ \text{Agg.}}{\dfrac{100}{(\text{Max.Sp.Gr.})\text{Rice}} - \dfrac{\%\ \text{Asphalt}}{\text{Asphalt Sp.Gr.}}}$$

Using the effective specific gravity of the aggregate, you can calculate the maximum specific gravity for the other asphalt contents.

Maximum Specific Gravity (Max.Sp.Gr.)

Determined as specified in AASHTO T-209

$$\text{Max.Sp.Gr.} = \frac{100\ .}{\dfrac{\%\ \text{Agg.}}{\text{Eff.Sp.Gr.Agg.}} + \dfrac{\%\ \text{Asphalt}}{\text{Asphalt Sp.Gr.}}}$$

Example:

$$\text{Eff.Sp.Gr.} = \frac{93.5}{\dfrac{100}{2.427} - \dfrac{6.50}{1.030}} = \frac{93.5}{41.20 - 6.31} = \frac{93.5}{34.89} = 2.680$$

$$\text{Max.Sp.Gr.} = \frac{100}{\dfrac{94.0}{2.680} + \dfrac{6.0}{1.030}} = \frac{100}{35.07 + 5.83} = \frac{100}{40.9} = 2.445$$

$$\text{B.S.G.A.} = \frac{100 - 7.5}{\dfrac{92.5}{2.65}} = \frac{92.5}{34.9} = 2.650$$

For correction Factor - Subtract B.S.G.A. from Eff.Sp.Gr.

$$2.680 - 2.650 = 0.030$$

5. Reporting

5.1 The producer shall submit the completed design for each mix type and a copy of the completed laboratory work sheet. The design must have the Engineers approval prior to being used in VDOT work.

5.1.1 Delete Note 8

Compatibility tests shall be run to determine the compatibility of completed design aggregated gradation and emulsified asphalt.

Tester: _____

Data: _____

Aggregate Specific Gravity

Sample ID:	_____	_____	_____	_____
SSD "B"	_____	_____	_____	_____
Under Water "C"	_____	_____	_____	_____
Pan and Aggr.	_____	_____	_____	_____
Pan Tare	_____	_____	_____	_____
Oven Dry "A"	_____	_____	_____	_____
B - C	_____	_____	_____	_____
A - C	_____	_____	_____	_____
B - A	_____	_____	_____	_____
Bulk Dry SpGr. A/(B-C)	_____	_____	_____	_____
Bulk SSD SpGr. B/(B-C)	_____	_____	_____	_____
Apparent SpGr. A/(A-C)	_____	_____	_____	_____
Absorption % (B-A) / A x 100	_____	_____	_____	_____

Virginia Test Method – 97

Resilient Modulus for Asphalt Concrete – (Asphalt Lab)

November 1, 2000

1. Scope

This test method outlines the procedures for determining the resilient modulus (M_R) of laboratory-prepared of field- recovered core samples of asphalt concrete mixtures.

2. Significance and Use

Resilient modulus values can be used to characterize pavement materials under various temperatures and stress states that simulate the conditions of a pavement under moving wheel loads.

3. Apparatus

3.1 Testing Machine:

A testing machine, type Mark VI, model B, using pneumatic repeated loading manufactured by Retsina Company, Oakland, CA., or any testing machine having the capability of applying a load pulse over a range of frequencies, load durations, and load levels.

3.2 Temperature-Control System:

Air bath capable of maintaining constant temperature between 32° and 140° F and within ±2° F (0° - 60° C ± 1° C) of the specified temperature within the range for a period of 24 hour prior to testing.

3.3 Measurement and Recording Systems:

Two linear variable differential transducers (LVDT's) are used to measure the resultant deformation across the horizontal diameter.

An electronic load cell with a capacity of 200 lbs. (90 kg) is used to measure the repetitive loads.

An electronic system consisting of a microprocessor, a digital readout, a timing mechanism, control switches, A/D converter, and a signal processing hardware is used as a data acquisition device.

Calipers capable of measuring to 1/100 of an inch (0.25 mm) are used for determining the relative dimensions of samples.

4. System Calibration Procedure

The equipment shall be calibrated on a regular basis. If it is used daily, perform checks once a week of when M_R data are inconsistent.

4.1 LVDT's Calibration before mounting in the yoke, transducers are calibrated with the differential translator micrometer, in English units, as follows:

a. Plug each transducer into the respective receptacle on the electronics package back panel (T1=t1, T2=t2).

b. Press CALIBRATE and TRANSDUCER keys and select SI units.

c. VERY CAREFULLY touch transducer tip, after the cap has been removed, with your finger and check for meter response before proceeding.

d. Retract the micrometer to a reading of about 6000 micro-inches and then advance it to a reading of 2000 micro-inches. Insert transducer, then slowly turn thumb screw until contact is made.

e. Advance the micrometer to a reading of 1750 micro-inches, to reduce possible error due to slack (backlash) within the micrometer threads.

f. Now press the ZERO key, then the INIT key. The transducer is now zeroed.

g. Advance the micrometer from 1750 micro-inches, now press the SPAN key. The display should read approximately 1750 micro-inches, the transducer is now calibrated and ready to be placed in the yoke.

i. Repeat steps (a) through (g) for all channels. This process should be repeated five times to ensure accuracy. The readings from steps above should correlate to within 15 micro-inches of 1750.

Note that this micrometer will give accurate and reproducible movements in increments of one full turn of the micrometer stem. Actual tip movement is 1/100 of the movement indicated on the stem. One full turn indicating 0.025 inch change is actually 1/100 of this value or 250 micro-inches.

4.2 Load Cell Calibration: The load cell is calibrated according to the following procedure:

a. Plug load cell into the appropriate receptacle on the electronics package back panel.

b. Press the CALIBRATE key, then press the LOAD CELL key.

c. With the load cell UNLOADED and in the normal operating position (Vertical), depress the ZERO key to zero the meter.

d. Load the load cell with an accurately weighed 25 lb weight (if the weight is other than 25 lb, go to NUMBER ENTRY key before calibration routine and key in your predetermined weight), then press the SPAN key. The reading should show 25 lb (or the predetermined weight).

4.3 Thermocouple Calibration: Use the following procedure to calibrate the thermocouple:

a. Place thermocouple in ice bath, preferably in a styrofoam cup.

b. Insert thermocouple; allow thermocouple to cool approximately 30 seconds.

c. Press ZERO Key (preset for 32° F) (0° C).

d. At sea level, boil water, keeping thermocouple off of bottom of pot.

e. Press SPAN key (preset for 212° F) (100° C).

5. Test Specimens:

5.1 Core Specimens:

Core should have relatively smooth, parallel surfaces and should be 4 in. (100 mm) in diameter and 1.75 to 3 in. (45-75 mm) thick. Cores that are obviously deformed of have any visible cracks must be rejected. The drilled core consisting of more than one layer of the pavement structure shall be separated to single layers of 1.75 to 3 in. (45-75 mm) in thickness.

5.2 Laboratory-Prepared Specimens:

Specimens shall be marked with two perpendicular diameters using a pavement type (Grease) pencil and template. Measure the thickness of the specimen at each point. The four measurements shall be averaged to determine the thickness of the test specimen.

Measure the diameter (D) of the test specimen at mid-height along the horizontal and vertical direction, respectively. The two measurements shall be averaged to determine the diameter of the test specimen.

Place the specimens in the controlled-temperature cabinet set at the desired testing temperature for at least 12 hours prior to testing.

6. Test Procedure

Place the yoke on the alignment stand. Retract the side-mounting screws equally. Place the specimen or proving ring in the alignment stand. (Be sure the transducer tips are withdrawn with plastic protectors removed while inserting the specimen). Align the specimen, with one of the crossed lines horizontal and the other vertical. Center the specimen in the yoke. Tighten the side-mounting screws gently. Note that excessive amount of pressure put on the sides of the sample by tightening the screws will affect the reproducibility of the results.

Place a ball bearing on top of the load foot, which is placed on top of the specimen. Align the specimen directly under the plunger-load cell complex. (ALWAYS PICK UP THE YOKE ASSEMBLY BY THE SPECIMEN). The center of all three parts (plunger, load cell and specimen) should lie on a common axis. The transducers should lie in a diametrical plane horizontal to the vertical axis of the plunger-load cell specimen alignment.

Adjust the pressure regulator to the desired load for testing, by switching to CREEP mode and LBS range. (The transducer tips should be withdrawn while making this adjustment.) WARNING: maximum load is 200 lbs (equivalent to 55 psi (387 kPa) air pressure) for the Mark VI-A and 1000 lbs (450 kg) for the Mark VI-B.

Switch the electronics package to setup mode. Use the INIT key to zero the display meter. Turn the transducer adjusting screws to allow the transducer tip to make contact with the specimen. DO NOT run the transducer tip up against the specimen unless the electronics package is monitoring the contact, excessive tip movement can destroy the transducer. Adjust the first transducer to give a reading of about 200 micro-inches). Then adjust the second transducer to give a combined reading of 400 micro-inches). (Blinking LEDs and alarm indicates over-range and the device will shut off automatically). Then zero the display meter with the INIT key.

NOTE:

* Choice of testing load depends on the temperature and the strength of the specimen. Loads at high temperature must be lower compared to those at low temperatures. It is, also, not advisable to use high loadings on low-modulus specimens, because the resulting high, non-recoverable distortions accumulate and destroy the specimen. SHRP P07 recommends to use loads equal to 30, 15, and 5% of indirect tensile strength for test temperatures of 41, 77, and 104ºF (5º, 25º and 40ºC) respectively.

* Cores taken from pavements are sometimes irregular, in which case Plaster of Parispads can be formed on which the yoke side-mounted screws of transducer tips can rest. Sometimes the surface of the specimen is too irregular for good contact by the load foot of the base of the load frame. Smooth areas of the specimen can be formed with Plaster of Paris or shaped by the concave side of the load foot and a sheet of sand paper.

OPERATIONAL SUMMARY

1. Turn on Electronics package of Mark VI, Set up mode will be displayed.

2. The display will go through some parameters and finally stops at Horizontal Deformation.

3. Press Number Entry to select parameter such as:

   Number of tests =10 Cycle T = 1.00 secs.
   Sample # =3 Sample thickness = 2.5 inches (63.5 mm)

4. Place the sample in the yoke, tighten thumb screws and transfer to the loading frame. Release air pressure by turning the air regulator knob counter clockwise.

5. Press INIT key to initialize T1, T2 to zero.

6. Move T1 to make contact with the sample and read about 200 micro-inch

7. Move T2 to make contact with the sample and read about 400 micro-inch

8. Press INIT again. The machine will display T1, T2 = zero .

9. Press SOLENOID to activate loading (light comes on).

10. Turn AIR REGULATOR on (clockwise) until a value of HDEF = 50 micro-inch is obtained.

11. Press LOAD (some value say 30 lb will be displayed).

12. Press HDEF (HDEF = 50 micro-inch is displayed).

13. Press ABORT key to save the setup parameters.

14. Press OPERATE at 0.05 second.

15. Press REPORT key to obtain a test data summary print out. The print out includes the selected input parameters (Poisson's ratio, load level, sample thickness, number of tests, cycle time etc..) the resulting horizontal deformations for each load applied and the resilient modulus computed based on the following equation:

$$M_R = \frac{P \times (u + 0.2734)}{t \times d}$$

where:

M_R = resilient modulus, psi
P = applied load, lb
u = Poissons ratio (a ratio of .35 is generally assumed)
t = specimen thickness, in
d = average horizontal deformations, in

Testing Hints

* In order to provide a more homogenous stress distribution in a specimen and avoid the possible modulus variations in the initial stages of the test, it is suggested to record the modulus after preconditioning the sample for approximately 25 cycles or until the modulus values remain fairly constant.

* Each specimen should be tested at least twice across each perpendicular diameter. Usually, the values will agree within 10%, if they differ by more, repeat the test. A consistent difference greater than 10% is the result of a nonisotropic specimen. If the difference is severe (over 50%) a new sample should be manufactured or cored.

* A synthetic specimen made from Teflon is tested before and after the testing to insure the accuracy of the readings and verify the calibration of the system.

Virginia Test Method – 98

Sampling Marshall Volumetric-Quality Index – (Asphalt Lab)

November 1, 2000

1. Scope

1.1 This method outlines the procedures for sampling asphalt mixtures and the total size of each sample per test.

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. Size of Sample

The size of the samples shall be as follows:

2.1 Marshall Volumetrics (Quality Index)

MIX TYPE	MIN. SAMPLE SIZE	NO. OF BAGS PER SAMPLE
SM-9.0	35 lbs. (16 kg.)	1
SM-9.5	35 lbs. (16 kg.)	1
SM-12.0, 19.0	35 lbs. (16 kg.)	1
IM-19.0	35 lbs. (16 kg.)	1
BM-25.0	35 lbs. (16 kg.)	1
BM-37.0	60 lbs. (27 kg.)	2

3. Sampling Plant Mixes Asphalt Mixtures At Place of Manufacture

3.1 Three samples for Marshall Volumetrics (Quality Index) shall be taken from the truck by means of a square point shovel. Using the shovel. Using the shovel, remove 6 in. (150 mm) of the material from the top by scraping horizontally across the location to be sampled. This will leave a relatively flat area from which to take the samples. With horizontal movements, shovel through the area to be samples and place the material in the bag(s) for the first sample. The second shovel full shall be taken beside the first location and placed in the bag(s) for the second sample. The third shovel full shall be taken beside the second location and place in the bag(s) for the third sample. Remove another 6 in. (150 mm) of material from the same location where the first three shovels where the first three shovels were taken and repeat these steps until the 3 samples have the minimum amount of material specified in Section 2.1.

NOTE 1: If the weight of the sample is over 35 lbs. (16 kg), split the sample into two bags and properly label and identify the samples.

Virginia Test Method – 99

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

December 2009

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 28 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 and RAP aggregates in the percentages determined in 4.1.1 and then remove the particles passing the breakpoint sieve for the mixture type being designed. Use RAP aggregates retained from ignition oven extraction of the RAP sample. Wash the coarse aggregate and determine the Dry Rodded Unit Weight of the resulting combined coarse aggregate fraction in accordance with AASHTO T-19.

$$VCA_{DRC} = \left(\frac{(G_{ca})\gamma_w - \gamma_s}{(G_{ca})\gamma_w} \right) x100$$

where,

γ_s =	Unit weight of the coarse aggregate fraction in the dry rodded condition (lbs/ft^3) (kg/m^3) [2]
γ_w =	unit weight of water (62.4 lbs/ft^3) (1000 kg/m^3)
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[1]
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 (^{o}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 Gyrations. 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:

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

$$\text{VMA} = 100 - \left(\frac{Gmb}{Gsb}\right)Ps \text{ and}$$

$$\text{VTM} = 100\left(1 - \frac{Gmb}{Gmm}\right)$$

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 Gyrations. 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, $\boldsymbol{V_a}$, shall be 3.0 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}

$$VCA_{DRC} = \left(\frac{(G_{ca})\gamma_w - \gamma_s}{(G_{ca})\gamma_w} \right) x100$$

where,

γ_s	=	Unit weight of the coarse aggregate fraction in the dry rodded condition (lbs/ft^3) (kg/m^3) [2]
γ_w	=	Unit weight of water (62.4 lbs/ft^3) (1000 kg/m^3)
G_{ca}	=	The bulk specific gravity of the coarse aggregate measured from the VCA sample

Measure γ_s for each trial gradation: Using the combined aggregate sample developed for VCA testing in Section 4.1.2 select two representative specimens and test each in accordance with AASHTO T-85. Report the average Gsb of the two specimens as the G_{ca} for that trial blend. The two samples must meet the inter-lab d2s reported in AASHTO T-85.

5.2.2 VCA_{mix}

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

Where:

G_{mb}	=	bulk specific gravity of compacted specimens
G_{ca}	=	combined bulk specific gravity of the coarse aggregate as measured in Section 5.2.1

P_{bp}	=	$$P_{bp} = (P_s)(PA_{bp})x100$$ Percent aggregate **by total mixture weight** retained on and above the breakpoint sieve: Where: $$Ps = (100 - AC) =$$ Percent aggregate in the mixture expressed as a decimal (94% = 0.94) and $$PA_{bp} = (100 - \%\ passing\ the\ break\ point\ sieve) =$$ 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)

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%
100	19	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
90	12.5	100.0%	94.0%	64.0%	100.0%	100.0%	100.0%	98.0%
69	9.5	89.3%	65.0%	33.0%	100.0%	100.0%	100.0%	94.0%
27	4.75	12.0%	8.0%	6.0%	96.0%	100.0%	100.0%	71.0%
20	2.36	1.5%	2.0%	1.6%	67.0%	100.0%	100.0%	56.0%
17	1.18	0.9%	1.4%	1.5%	48.0%	100.0%	100.0%	44.0%
16	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%
9	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

Use the calculated RAP G_{se} as follows for use in the final mix Gsb

	RAP Gravities
	RAP 1
Gmm	2.499
%AC	5.60%
G_{se}	**2.730**
Gb	1.03
Pba	0.8

Where:

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

Step 5: Determine VCA_{DRC} for trial blend 1 in accordance with AASTHO T-19 and prepared as described in Section 4.1.2

Using virgin 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^3]	0.00283	
Unit Weight of Rodded Stone [kg/m^3]	1537.5	= (6.1145 – 1.7635) / .00283

Using this unit weight and the measured G_{ca} VCA_{DRC}.

Select two specimens as described in Section 4.1.2 and measure the trial blend Gca:

DATA	Test 1	Test 2
(1) Weight of empty drying pan, g	185.1	185.1
(2) Weight of oven dry sample and pan, g	2193.0	2185.0

(3) Weight of SSD aggregate and pan in air, g	2202.2	2199.0	
(A) Weight of oven dry sample = (2) - (1)	2007.9	1999.9	
(B) Weight of SSD sample in air = (3) - (1)	2017.1	2013.9	
(C) Weight of SSD sample in water, (*basket tared*), g	1264.2	1265.2	
CALCULATIONS	Test 1	Test 2	Average
Dry Bulk Specific Gravity, $G_{sb(Dry)}$ $\frac{A}{(B-C)}$	2.667	2.671	2.669

VCA_{DRC}		
Gca	2.669	
Unit Weight of Water (γ_w)	997.5	[kg/m^3]
Unit Weight of Stone (γ_s)	1537.5	[kg/m^3]
VCA_{DRC}	**42.2%**	$=\left(\frac{(2.669*997.5)-1537.5}{(2.669*997.5)}\right)x100$

$$VCA_{DRC}=\left(\frac{(G_{ca})\gamma_w-\gamma_s}{(G_{ca})\gamma_w}\right)x100$$

Step 6: Determine the Blend Gsb for VMA calculations.

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

	G_{SB}	BIN % (P_n)	(P_n) / G_{SB}	
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_{se})	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_{sb}			**2.693**	= 100 / 37.13

Step 7: 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_{mb}	VTM %	VMA %
A	C	B	$\frac{A}{B-C}$	$100\left(1-\frac{Gmb}{Gmm}\right)$	$100-\left(\frac{Gmb}{Gsb}\right)Ps$
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	**2.342**	**3.9%**	**18.9%**

Using the information from the gyratory volumetrics calculate VCA_{mix}

G_{mb}	2.342	
Gca	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
VCA_{mix}	**40.8%**	$=100-\left(\frac{2.342}{2.669}x67.4\right)$

Where:

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

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

Step 9: 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 10: Optimize AC content in accordance with Section 4.2 and VDOT's Special Provision for Stone Matrix Asphalt

Step 11: 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 per

VTM 102. 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 – 100

Determination of Draindown Characteristics In Uncompacted Asphalt Mixtures – (Asphalt Lab)

November 1, 2000

1. Scope

1.1 This test method covers the determination of the amount of draindown in an uncompacted asphalt mixture sample when the sample is held at elevated temperatures comparable to those encountered during the production, storage, transport and placement of the mixture. The test is particularly applicable to mixtures such as porous asphalt (open-graded friction course) and Stone Matrix Asphalt (SMA).

1.2 The values stated in the gram-millimeter 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 the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Reference Documents

2.1 AASHTO Standards:

T 245 Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus

M 92 Standard Specification for Wire-Cloth Sieves for Testing Purposes

3. Definitions

3.1 **Draindown** - For the purpose of this test method, draindown is considered to be that portion of material which separates itself from the sample as a whole and is deposited outside the wire basket during the test. The material which drains may be composed of either asphalt cement or a combination of asphalt cement and fine aggregate.

4. Summary of Method

4.1 A sample of the asphalt mixture to be tested is prepared in the laboratory or obtained from field production. The sample is placed in a wire basket which is positioned on a pre-weighed paper plate. The sample basket and plate are placed in a forced air oven for one hour at a pre-selected temperature. At the end of one hour, the basket containing the sample is removed from the oven along with the paper plate and the paper plate is weighed to determine the amount of draindown that occurred.

5. Significance and Use

5.1 This test method can be used to determine whether the amount of draindown measured for a given asphalt mixture is within acceptable levels.

6. Apparatus

6.1 Oven, capable of maintaining the temperature in a range from 250-350° F (120-175° C). The oven should maintain the set temperature to within ± 3.6° F (±2° C).

6.2 Paper plates of appropriate size. The paper plates used should be of appropriate durability to withstand the oven temperatures.

6.3 Standard basket meeting the dimensions shown in Figure 1. The basket shall be constructed using standard 0.25 inch (6.3 mm) sieve cloth as specified in AASHTO M 92.

6.4 Spatulas, trowels, mixer and bowls as needed.

7. Sample Preparation

7.1 Laboratory Prepared Samples

7.1.1 **Number of Samples -** For each mixture tested, the draindown characteristics should be determined at three different temperatures. The three temperatures should be the anticipated plant production temperature as well as 25° F (15° C) above and below. For each temperature, duplicate samples should be tested. Thus for one asphalt mixture, a minimum of six samples will be tested.

7.1.2 Dry the aggregate to a constant mass and sieve it into appropriate size fractions as indicated in AASHTO T 245, Section 3.2.

7.1.3 Weigh into separate pans for each test sample the amount of each size fraction required to produced complete mixture samples having a mass of 1200 grams. The aggregate fractions shall be combined such that the resulting aggregate blend has the same gradations as the job-mix-formula. Place the samples in an oven and heat to a temperature not to exceed the mixing temperature established in 7.1.1 by more than approximately 50° F (28° C).

7.1.4 Heat the asphalt cement to the temperature established in 7.1.1.

7.1.5 Place the heated aggregate in the mixing bowl. Add any modifiers (Note 1) and thoroughly mix the dry components. Form a crater in the aggregate blend and add the required amount of asphalt. The amount of asphalt shall be such that the final sample has the same asphalt content as the job-mix-formula. At this point, the temperature of the aggregate and asphalt cement shall be within the limits of the mixing temperature established in 7.1.1. Using a spatula (if mixing by hand) or a mixer, mix the aggregate (and modifier if any) and asphalt cement quickly until the aggregate is thoroughly coated.

7.2 **Plant Produced Samples**

7.2.1 **Number of Samples -** For plant produced samples, duplicate samples should be tested at the plant production temperature.

7.2.2 Samples may be obtained during plant production by sampling the mixture at any appropriate location such as the trucks prior to the mixture leaving the plant or at the paver. Samples obtained during actual production should be reduced to the proper test sample size by the quartering method.

8. Procedure

8.1 Transfer the laboratory produced or plant produced uncompacted mixture sample to a tared wire basket described in 6.3. Place the entire sample in the wire basket. Do not consolidate or otherwise disturb the sample after transfer to the basket. Determine the mass of the sample to the nearest 0.1 gram.

8.2 Determine and record the mass of a paper plate to the nearest 0.1 gram. Place the basket on the paper plate and place the assembly into the oven at the temperature as determined in 7.1.1 or 7.2.1 for 1 hour ± 1 minute.

8.3 After the sample has been in the oven for 1 hour ± 1 minute, remove the basket and paper plate. Determine and record the mass of the paper plate to the nearest 0.1 gram.

9. Calculations

9.1 Calculate the percent of mixture which drained by subtracting the initial paper plate mass from the final paper plate mass and divide this by the initial total sample mass. Multiply the result by 100 to obtain a percentage.

10. Report

10.1 Report the average percent drainage at each of the test temperatures.

NOTE 1 - Some of modifiers such as fibers or some polymers must be added directly to the aggregate prior to mixing with the asphalt cement. Other types of modifiers must be added directly to the asphalt cement prior to blending with the aggregate.

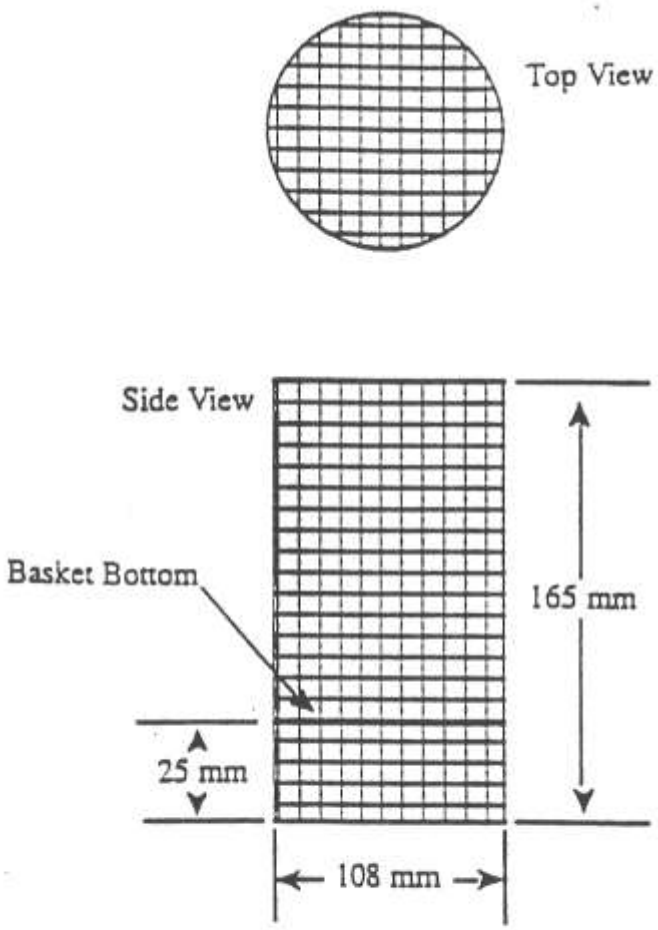


Figure 1 - Wire basket assembly.

Virginia Test Method – 101

Determination of Penetration of Gravity Filled Polymer Crack Sealers – (Physical Lab)

November 1, 2000

1. Scope

This method covers the procedure for determining penetration of polymers into a fine sand to access the polymers ability to penetrate fine cracks in Hydraulic Cement Concrete.

2. Apparatus

a. 4 oz. (114 ml) wax paper cups, maximum dimensions of cup top-inside diameter, 2 5/16" (59 mm); bottom-inside diameter 1 11/16" (43 mm); height 2 3/8" (60 mm)

b. MX-45 filter sand available from: Foster Dixana Corporation, P.O. Box 2005, Columbia, SC 29202, 1-800-774-7263 or (803) 794-2872

c. Quart can with inside rim removed

d. 8 oz. (240 ml) plastic specimen cups

e. Wood stirring stick or metal spatula

f. Tared balance 2000 grams capacity

g. Disposable gloves

h. Polymer (epoxy, urethane, methacrylate)

i. Stopwatch

j. External Table Top-Vibrator

k. Thermometer

3. Procedure

This test should be conducted at 25 ± 2° C.

a. Weigh 100 g of MX-45 filter sand into a 188 ml wax paper cup.

b. Vibrate paper cups containing filter sand on vibrator for 10-15 seconds.

c. Measure polymer components into 240 l specimen cups.

d. Mix polymer components according to manufacturer's recommendation in a quart (liter) can using a metal spatula or wood stirring stick.

e. Pour 40 grams of polymer on top the 100 g of filter sand in the 118 ml wax paper cup. Record weight of polymer (B).

f. Allow the polymer and sand in the paper cup to set 24 hours.

g. Remove as much of the paper cup from around the hardened polymer and sand matrix as possible and lightly brush any loose sand from matrix. Weigh the hardened polymer sand matrix (C).

h. Calculate percent polymer penetration as

$$\frac{C}{A+B} \times 100 = \%\ \text{penetration}$$

A = Weight of 100 grams Sand and paper cup
B = Weight of 40 grams Polymer
C = Weight of Hardened Polymer Sand Matrix

i. Report the percent penetration as average of three separate determinations.

Virginia Test Method – 102

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

December 13, 2013

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 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 ±9°F (125 ±5° 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° F (650° 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° F ±9° F (125° C ± 5° 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).

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 5*00* 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. <u>Calibration</u>

A mixture calibration procedure is required. For mix designs containing RAP, sufficient quantity of RAP should be sampled such that the available 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. (See section 6C.) 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 Asphalt mixtures

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 from four individual batches (not quartered from the same, single batch) 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 available 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 ± 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:

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

where:

MCA = Mixture Calibration Average
AC % = Difference between actual binder content (including available RAP AC%) and measured asphalt content

6A.15 If the difference between any two asphalt binder contents from the four specimens exceeds 0.15 percent, then discard the high and the low result and report the average MCA resulting from the remaining two specimens.

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 ± 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:

Measured AC = Weight of sample (before) - Weight of sample (after)

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:

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

where:

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

6C. Procedure for determining the available asphalt content of RAP

6C.1 This procedure determines the available asphalt contribution of the RAP material to the total asphalt content of the mix/specimens before performing the mix calibration procedure on asphalt mix designs that contain RAP (6A).

6C.2 For mix designs containing RAP, a sufficient quantity of RAP (80 lbs./stockpile) should be sampled such that the available binder content of the RAP may be measured in the ignition oven, The available binder content of the RAP stockpile will be determined from the average of four representative samples (RAP only) tested per Section 7A for Hot Mix Asphalt Mixtures, using a 0.0 correction factor in 7A.2, minus a default RAP correction factor of 0.4%

$$RAP\ AC_A = RAP\ (average\ \%ACi) - 0.4\%$$

Where:

- RAP AC_A = Available Asphalt Content of RAP
- ACi = Asphalt content by ignition oven method

- RAP (average %ACi) = $\frac{\text{\%ACi test 1 + \%ACi test 2 + \%ACi test 3 + \%ACi test 4}}{4}$
- 0.4% = Default RAP correction factor

Example: A contractor wishes to supply a SM 12.5A mix with 30% RAP to the department. Tests on the RAP stockpile show the asphalt content of the RAP by ignition oven is 5.3%. The available asphalt content from the RAP for the SM 12.5A mix is:

RAP (average %ACi) – 0.4% = RAP AC_A

5.3% -0.4% = 4.9%

6C.3 As an alternative to determining the available binder content of RAP using the default correction factor outlined in section 6C.2, the available binder content of the RAP may be estimated from the average of four samples (RAP only) tested per Section 7, using a 0.0 correction factor in 7A.2, minus the average extracted asphalt content of two representative specimens from the same bulk sample of RAP. Extraction shall be performed in accordance with any of the methods defined in AASHTO-T164. The portions of RAP should be representative of the stockpile to be used and should be reduced to size using a sample splitter. The RAP correction factor is calculated according to the following equation:

RAP (average %ACi) –RAP (average %ACe) = RAPcf

Where:

- RAPcf = RAP correction factor
- ACi = Asphalt content by ignition oven method
- ACe = Asphalt content by extraction method
- RAP (average %ACi) = $\frac{\text{\%ACi test 1 + \%ACi test 2 + \%ACi test 3 + \%ACi test 4}}{4}$
- RAP (average %ACe) = $\frac{\text{\%ACe test 1 + \%ACe test 2}}{2}$

And the Available asphalt content of RAP (RAP AC_A) in stockpile is calculated as:

RAP (Average %ACi) – RAPcf = RAP AC_A

The RAP correction factor (RAPcf) shall be determined at mix design and submitted as part of mix design approval package for each RAP stockpile used.

Note: Good quality control practice when managing a stockpile would be to periodically measure the RAP specific gravity during production to insure consistent performance of the mix.

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 ± 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 ± 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:

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

7B.13 Calculate actual asphalt contact using the following:

Actual AC = Measured AC -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.

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.

Virginia Test Method – 104

Elastic Recovery of Asphalt Binder – (Asphalt Lab)

November 1, 2000

1. Scope

1.1 Measures the elastic recovery of asphalt binders.

1.2 This standard may involve hazardous material, 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 Mold - The mold shall be similar in design to that shown in Fig. 1 and shall be made of brass.(See page 2 for Fig. 1)

2.2 Water Bath - The water bath shall be maintained at the specified test temperature, varying not more than ± 1.0º F (±0.5º C) from this temperature. The volume of water shall not be less than 10 litres. The depth of water shall be not less than 2 inches (50 mm) such that the mold can be immersed to a depth of 1 inch (25 mm). The water in the bath shall be free from oil and slime or other organic growth.

2.3 Testing Machine - For pulling the briquet of asphalt material apart. Any apparatus may be used which is so constructed that the specimen will be continuously immersed in water as specified in Section 3.4, while the two clips are pulled apart at a uniform speed, as specified, without undue vibration.

2.4 Thermometer - A thermometer having a range of 18 to 89° F (-8 to 32° C).

3. Procedure

3.1 Assemble the mold on the base plate. To prevent the material under test from sticking, coat the surface of the plate and the interior surface of sides a and a' with a suitable release agent(Note 1).

NOTE 1: Mixtures of glycerine and dextrine or talc, Dow-Corning Silicone Shop Grease or castor oil - Versamid 900 have been proven suitable.

3.2 Heat the sample with care to prevent local overheating until it has become sufficiently fluid to pour. After thorough stirring, taking care not to entrain any air bubbles, pour the asphalt binder into the mold. Pour the material in a thin stream back and forth from end to end until the mold is more than level full. In filling the mold, take care not to disarrange the parts of the mold and so distort the briquet. Let the mold and contents cool to room temperature for a period of 30 to 40 minutes and then place the base plate and filled mold in the water bath, maintained at 77 ± 1.0° F (25 ± 0.5 °C) for 30 minutes. Remove the base plate and filled mold from the water bath and with a hot trimmer cut off the excess asphalt binder so that the mold is just level full. Take care during the trimming

operation that the specimen is not pulled away from the base plate or from the side pieces of the mold.

3.3 Place the base plate and mold, with briquet specimen, in the water bath or testing machine and keep at 77 ± 1.0° F (25 ± 0.5 ° C) for a period of 90 ± 5 minutes.

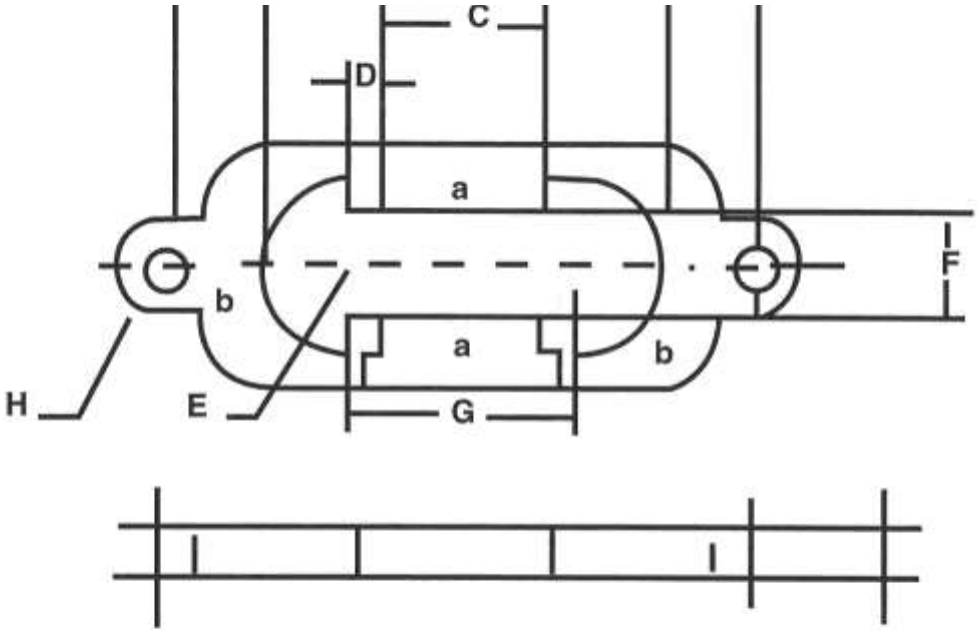
3.4 To start the test, attach the clips to the pins or hooks of the testing machine and pull the clips apart at a rate of 5 cm/minute. Stop after 10 cm of elongation is reached. Cut the specimen in half and leave undisturbed for 60 minutes. At the end of the test period, retract the half specimen until the two clipped ends touch and note the elongation in cm.

4. Calculation

% Recovery = (10 - X)/ 10 x 100

X = Observed elongation after rejoining the sample, cm

C - Distance between clips 29.7 to 30.3 mm
D - Shoulder 6.8 to 7.2 mm
E - Radius 15.75 to 16.25 mm
F - Width at mouth of clip 19.8 to 20.2 mm
G - Distance between centers of radii 42.9 to 43.1 mm
H - Hole diameter 6.5 to 6.7 mm
I - Thickness 9.9 to 10.1 mm



A - Distance between centers 111.5 to 113.5 mm
B - Total length of briquet 74.5 to 75.5 mm
C - Distance between clips 29.7 to 30.3 mm
D - Shoulder 6.8 to 7.2 mm
E - Radius 15.75 to 16.25 mm
F - Width at mouth of clip 19.8 to 20.2 mm
G - Distance between centers of radii 42.9 to 43.1 mm
H - Hole diameter 6.5 to 6.7 mm
I - Thickness 9.9 to 10.1 mm

Virginia Test Method – 105

Deleted: Slump of Portland Cement Concrete – (Physical Lab)

October 1, 2004

Virginia Test Method – 106

Ride Quality Testing on Ride Specifications Projects – (Pavement Design)

May 1, 2001

1. **Scope**

1.1. This document describes the test method for measuring the longitudinal profiles of a pavement's surface using an inertial system for ride quality testing and evaluation.

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 determines the applicability of regulatory limitations prior to use.

2. Apparatus

2.1. Test equipment shall be configured to meet the specifications of the ASTM E950 Class II profiler.

2.2. The test equipment shall include at a minimum:

2.2.1. Data Acquisition System to store and process sensor, accelerometer and distance measurement data
2.2.2. Two height sensors, one mounted over each wheel path on the front bumper
2.2.3. Two accelerometers, one mounted on each height sensor located in the wheel path

2.3. The safety equipment shall include a light bar mounted on the roof of the vehicle. For the operator, a safety vest, hardhat and proper shoes.

3. **Significance and Use**

3.1. This test method provides a means of measuring wheel path roughness on Ride Specification Projects

3.1.1. Wheel path roughness is determined by processing the longitudinal pavement profile obtained by the wheel path sensor and correcting for the vehicle response using an accelerometer. The wheel path roughness is reported as the International Roughness Index (IRI) and recorded in units of inches per mile (mm per km).

4. **Restrictions on Testing**

4.1. Ambient air temperature will be a minimum of 32° Fahrenheit (0° C) during testing.

4.2. Pavement surface shall be free of debris.

4.3. Pavement surface shall be free of standing water.

4.4. Visibility shall be greater than ½ mile (0.8 km).

4.5. Vehicle test speed will be between 25 mph (40 kph) and 60 mph (97 kph) and be consistent (± 5mph (± 5 kph)) through each test site, as traffic conditions will allow. Vehicle test speeds shall not exceed the posted speed limit. For posted speed limits less than 60 mph (97 kph), then testing shall be conducted at that speed, as traffic conditions allow. For posted speed limits greater than or equal to 60 mph (97 kph), then testing shall be at 60 mph (97 kph), as traffic conditions allow.

5. <u>Testing</u>

5.1. Testing Procedures

5.1.1. Identify the project limits (beginning and ending mile point) and mark with a paint strip (if traffic conditions allow).

5.1.2. Identify a fixed object (bridge, intersection, HTRIS node, etc.) prior to the project beginning mile point, place a cone with reflective tape at this location (if traffic conditions allow).

5.1.3. Record a description of the fixed object in the field notes for the project file.

5.1.4. Using the DMI, measure and record the distance from the fixed object to the project beginning mile point.

5.1.5. Start testing prior to the fixed object and obtain a constant speed. Minimum distance of 500 feet (152 m).

5.1.6. At the fixed object, initiate pavement profile testing using the optical triggering device

5.1.7. At the project beginning mile point, mark the location with the event key in the profiler software

5.1.8. Continue testing through the project while maintaining a constant speed and remaining in the left and right wheel paths.

5.1.9. At the project ending mile point, mark the location with the event key in the profiler software.

5.1.10. At a distance approximately 528 feet (161 m) beyond the ending mile point, terminate testing.

5.1.11. Pavement Sections not to be Profiled (unless directed otherwise by the requesting agency)

5.1.12. Projects with a total length less than 0.5 miles (0.8 km)

5.1.13. Pavement Shoulders

5.1.14. Bridge Decks

5.1.14.1. When bridges are within the project limits, testing shall be suspended at the initial deck expansion joint and resume at the final deck expansion joint.

5.1.14.2. When bridge decks are beginning or end termini, testing shall begin or end at the corresponding bridge expansion joint.

5.1.15. Truck climbing lanes less than 0.5 miles (0.8 km) in length

5.1.16. Acceleration, Deceleration Lanes or ramp pavements

5.1.17. Signalized Intersections

5.1.17.1. When signalized intersections are within the project limits, testing shall suspend (or results flagged) when testing speed drops below 25 mph (40 kph) and resume when a speed of 25 mph (40 kph) is attained.

5.1.18. Stop Sign Controlled Intersections

5.1.18.1. When a Stop Sign Controlled intersection are within the project limits (Stop Sign caused testing vehicle to come to a stop), testing shall suspend (or results

flagged) when testing speed drops below 25 mph (40 kph) and resume when a speed of 25 mph (40 kph) is attained.

5.1.19. Railroad Crossings

5.1.19.1. When railroad crossings are within the project limits, testing shall suspend (or results flagged) when testing speed drops below 25 mph (40 kph) and resume when a speed of 25 mph (40 kph) is attained.

5.1.20. Permanent Obstructions in Wheel Path

5.1.20.1. When permanent obstructions (manholes, valves, etc.) are located within the wheel path, the operator shall flag that location during testing. Data for reporting section shall not be subjected to the ride specifications.

5.1.21. Temporary Obstructions in Wheel Path

5.1.21.1. When temporary obstructions (cones, debris, etc.) are located within the wheel path, the obstruction shall be removed prior to testing

5.2. Testing Prior to Overlay ("before")

5.2.1. The project-long Mean Roughness Index (MRI) shall be calculated for each test run. A test run shall start a minimum of 528 feet (161 m) (if possible) prior to the project start location and conclude 528 feet (161 m) (if possible) after the project end location.

5.2.2. "Before" testing shall be conducted a minimum of two test runs for each travel lane tested.

5.2.3. If the difference between the project-long MRI for the two test runs is less than 5% or 3 in./mi. (50 mm/km) whichever is greater, then data collection is complete for the "before" testing. Data for both test runs shall be reported for each tenth (0.1) mile (0.2 km) and each hundredth (0.01) mile (0.02 km) increment.

5.2.4. If the difference between the project-long MRI for the two test runs is greater than 5% and 3 in./mi. (50 mm/km), then the data for the first two test runs are discarded and two additional test runs are performed. If the difference between the project-long MRI for the two additional test runs is less than 5% or 3 in./mi. (50 mm/km) whichever is greater, then data collection is complete for the "before" testing. Data for the two additional test runs shall be reported for each tenth (0.1) mile (0.2 km) and each hundredth (0.01) mile (0.02 km) increment. If the difference between the project-long MRI for the two additional test runs is greater than 5% and 3 in./mi. (50 mm/km), then a third additional test run shall be conducted and an average project-long MRI determined. The mean, standard deviation and precision (coefficient of variance) for the three additional test runs shall be calculated. If the precision is less than 5% or 3 in./mi. (50 mm/km) whichever is greater, then the "before" testing is complete. Data for all three additional test runs shall be reported for each tenth (0.1) mile (0.2 km) and each hundredth (0.01) mile (0.02 km) increment. In addition, the mean, standard deviation and precision for the MRI shall be reported.

5.2.5. If the precision for the three test runs is greater than 5% and 3 in./mi (50 mm/km)., then an analysis of the three runs shall be performed. Using a paired analysis approach (comparing each run to one another), it will be determined if one of the three test runs is potentially flawed. A flawed test will have a MRI difference greater than 5% when compared to the other two tests. This test run shall be removed and a fourth test run conducted and the MRI calculated. The mean, standard deviation and precision (coefficient of variance) for the three test runs shall be calculated. If the precision is less than 5% or 3 in./mi. (50 mm/km) whichever is greater, then the "before" testing is complete. Data for the three test runs shall be reported for each tenth (0.1) mile (0.2 km) and each hundredth (0.01) mile (0.02 km) increment. In addition, the mean, standard deviation and precision for the MRI shall be reported.

5.2.6. If the precision is greater than 5% and 3 in/mi. (50 mm/km), then a paired analysis is performed on the four test runs. It will be determined which test runs are potentially

flawed. These test runs will be noted in the field log and testing shall conclude. The mean, standard deviation and precision (coefficient of variance) for the four runs shall be calculated. Data for all four runs shall be reported for each tenth (0.1) mile (0.2 km) and each hundredth (0.01) mile (0.02 km) increment. In addition, the mean, standard deviation and precision for the MRI shall be reported. The Central Office (State Pavement Engineer) shall be contacted and the source of the differences will be determined. The requesting agency will be informed of the test results as well.

5.2.7. Testing After Overlay ("after")

5.2.8. The project-long Mean Roughness Index (MRI) shall be calculated for each test run. A test run shall start a minimum of 528 feet (161 km) (if possible) prior to the project start location and conclude 528 feet (161 km) (if possible) after the project end location. These locations should correspond with the "before" testing locations.

5.2.9. "After" testing shall be conducted a minimum of two test runs for each travel lane tested.

5.2.10. If the difference between the project-long MRI for the two test runs is less than 5% or 3 in./mi. (50 mm/km) whichever is greater, then data collection is complete for the "after" testing. Data for both test runs shall be reported for each tenth (0.1) mile (0.2 km) and each hundredth (0.01) mile (0.02 km) increment.

5.2.11. If the difference between the project-long MRI for the two test runs is greater than 5% and 3in./mi. (50 mm/km), then the data for the first two test runs are discarded and two additional test runs are performed. If the difference between the project-long MRI for the two additional test runs is less than 5% or 3 in./mi. (50 mm/km) whichever is greater, then data collection is complete for the "after" testing. Data for the two additional test runs shall be reported for each tenth (0.1) mile (0.2 km) and each hundredth (0.01) mile (0.02 km) increment. If the difference between the project-long MRI for the two additional test runs is greater than 5% and 3 in./mi. (50 mm/km), then a third additional test run shall be conducted and an average project-long MRI determined. The mean, standard deviation and precision (coefficient of variance) for the three additional test runs shall be calculated. If the precision is less than 5% or 3 in./mi. (50 mm/km) whichever is greater, then the "after" testing is complete. Data for all three additional test runs shall be reported for each tenth (0.1) mile (0.2 km) and each hundredth (0.01) mile (0.02 km) increment. In addition, the mean, standard deviation and precision for the MRI shall be reported.

5.2.12. If the precision for the three test runs is greater than 5% and 3 in./mi. (50 mm/km), then an analysis of the three runs shall be performed. Using a paired analysis approach (comparing each run to one another), it will be determined if one of the three test runs is potentially flawed. A flawed test will have a MRI difference greater than 5% when compared to the other two tests. This test run shall be removed and a fourth test run conducted and the MRI calculated. The mean, standard deviation and precision (coefficient of variance) for the three test runs shall be calculated. If the precision is less than 5% or 3 in./mi. (50 mm/km) whichever is greater, then the "after" testing is complete. Data for the three test runs shall be reported for each tenth (0.1) mile (0.2 km) and each hundredth (0.01) mile (0.02 km) increment. In addition, the mean, standard deviation and precision for the MRI shall be reported.

5.2.13. If the precision is greater than 5% and 3 in./mi. (50 mm/km), then a paired analysis is performed on the four test runs. It will be determined which test runs are potentially flawed. These test runs will be noted in the field log and testing shall conclude. The mean, standard deviation and precision (coefficient of variance) for the four runs shall be calculated. Data for all four runs shall be reported for each tenth (0.1) mile (0.2 km) and each hundredth (0.01) mile (0.02 km) increment. In addition, the mean, standard deviation and precision for the MRI shall be reported. The Central Office (State

Pavement Engineer) shall be contacted and the source of the differences will be determined. The requesting agency will be informed of the test results as well.

6. Calculations

6.1. Long Wavelength = 300 feet (91 m)
6.2. Profile Sampling Interval = 0.25 feet (0.08 m)
6.3. Quarter-Car Simulation
6.4. Data Summarized at 0.01-mile (0.02 km) intervals
  6.4.1. IRI for Each Wheel Path
  6.4.2. MRI for each interval
6.5. Invalid data (due to sensor or speed errors) removed from data summaries
  6.5.1. Low speed cut-off set at 25 mph (40 kph)

7. Quality Control, Quality Assurance and Equipment Calibrations

7.1. Please refer to VDOT Standard Operating Procedure – Ride Testing

8. Definitions

8.1. Roughness – Deviation of a surface from a true planar surface with characteristic dimensions that affect vehicle dynamics and ride quality
8.2. Longitudinal Pavement Profile – Set of perpendicular deviations of the pavement surface from an established horizontal reference plane to the lane direction
8.3. International Roughness Index – Statistic used to estimate the amount of roughness in a measured longitudinal profile. Computed from a single longitudinal profile using a quarter-car simulation
8.4. Mean Roughness Index (MRI) – Arithmetic average of the two mean wheel path IRI values for a designated test run. Invalid data will not be included.

9. References

1. ASTM E867 – Terminology Relating to Traveled Surface Characteristics
2. ASTM E950 – Standard Test Method for Measuring Longitudinal Profile of Vehicular Traveled Surfaces with an Inertial Profiler
3. AASHTO PP37-00 – Standard Practice for Quantifying Roughness of Pavements
4. VDOT Standard Operating Procedure – Ride Testing
5. ICC Users Manual – Profiling Software

Virginia Test Method – 107

Galvanized Steel Bend Test – (Physical Lab)

November 1, 2000

1. Scope and Purpose

This method covers the procedure for testing steel that has been galvanized *after* fabrication. Recent problems have indicated that galvanizing after fabricating may lead to an increase in embrittlement of the steel. The act of fabrication may increase the likelihood of developing cracks through which hydrogen embrittlement is accelerated by galvanization. Specifically, reinforcing steel has shown a tendency to fail on project sites while being cold-worked after galvanization. This problem is also addressed in ASTM A-143. Recommendations are made concerning the minimum cold bend radii for the steel. It is suggested that a cold bending radius of three times the bar section thickness will be acceptable to avoid an increase in the possibility of embrittlement. Sharper bending may be performed with the necessary precautions of heating or stress relieving.

2. Apparatus

a. Vise or other acceptable method for securing reinforcing steel.
b. Lever or other approved method for bending back the steel.

3. Procedure

Clamp the steel into a vise and bend using a lever. The steel should be subjected to a reverse bending of those sections that were previously bent during fabrication. The steel should be bent at least 5° and continued until noticeable plastic deformation has occurred. This practice should be sufficient to determine the presence of excessive hydrogen embrittlement. Failure should be considered as fracture of the steel before it reaches 5° or undergoes plastic deformation. Flaking or spalling of the galvanized coating is not to be construed as an embrittlement failure.

Virginia Test Method – 108

Post Construction Inspection of Underdrains, Crossdrains, and Edgedrains

(Soils Lab)

November 10, 2014

1. Scope

This test method outlines the equipment and procedures for inspection of Underdrains, Crossdrains, Edgedrains, and Prefabricated Geocomposite Pavement Edgedrains (PGPE) (collectively, "underdrains") by video camera and bore scope to document the condition of the pavement prism drainage system (perforated and non-perforated pipes, panels, geotextile, backfill materials, endwall, rodent screen, and outlet markers) after their installation. Inspection results shall be detailed and documented on report forms as found herein.

2. Video Inspection Apparatus

A video camera capable of capturing clearly visible images to view and record the condition of the underdrain system for inspecting underdrains with 4-inch and 6-inch diameter pipes shall be used. The Engineer will approve the video camera system based on actual in-field performance in capturing, recording, and documenting clearly legible images as specified herein. The camera shall have a titler/keyboard for data entry and an audio microphone for verbal descriptions by the camera operator. The video camera shall have a maximum outside diameter of 2 1/2 inches. The length of the camera cable shall be a minimum of 200 ft, with a footage counter on the cable reel, to inspect a segmented drainage system from either end. The camera system shall have a locator system for finding and documenting the position of the camera at any given point along the inspection route.

For PGPE systems, a borescope capable of capturing clear images shall be used to view and record the condition of the prefabricated drainage panel . The borescope shall have a maximum diameter of 3/8 inch and a minimum cable length of 25 feet with a footage counter on the reel.

3. Deficiencies

The Engineer will consider the following list of deficiencies as unacceptable underdrain installation criteria that require corrective action:

1. Crushed or collapsed pipe (including couplings or other pipe fittings) that prevents passage of the 2 ½ inch diameter camera.

2. Pipe that is partially crushed or deformed (including splits and cracks) for a length of 12 inches or greater, even if the deficiency allows the passage of the 2 ½ inch diameter inspection camera.

3. Any blockages or sediment buildup caused by rodent's nests, open connections, cracks or splits in the pipe.

4. Sags in the longitudinal pipe profile as evidenced by ponding of water for continuous lengths of 10 feet or greater. The pipe shall be flushed with water prior to checking for sags.

5. Blocked and/or flattened PGPE panels that will not allow the passage of a 3/8 inch diameter borescope camera.

6. Outlet pipes that are installed with less than a 2% uniform positive grade sloped toward the outlet end.

7. Freeboard of less than 12 inches from the outlet pipe invert to the bottom of the ditch.

8. Pipe that has been penetrated or otherwise damaged by the installation of guardrail posts, sign posts, delineator posts, etc.

9. Cracked endwalls, reverse sloped installations, separation of outlet pipe from the back of the endwall, missing rodent screens, and missing or improperly installed outlet markers where required.

10. Cavities or undermining of the backfill at the endwall evidenced by or leading to the instability of the endwall or erosion at the endwall or on the slope.

4. Procedures

Where a video or borescope camera is used, the location, date, and time of the inspection using the titler/keyboard furnished with the camera system shall be identified for incorporation into the video. The audio recording shall also be used to provide a verbal detailed description of any deficiency. Where deficiencies are noted, they shall be located and marked using the camera's locator system.

All deficiencies shall be noted on the inspection report with complete descriptions including their corresponding location on the project using, for example, station numbers, lane direction, lane identification, distance from outlet, etc. If no deficiencies are noted, an "OK" entry shall be made under remarks for that particular outlet.

Where deficiencies are noted that require corrective action, sufficient description and detail shall be provided on the report to indicate the extent of the deficiency, any accompanying damage, and what corrective measures are needed to repair or replace the installation.

5. <u>Reports</u>

The attached form shall be used to report the inspection findings.

Virginia Department of Transportation

Underdrain Inspection Report

CONTRACTOR: _____

DATE: _____

PROJECT NO.: _____ UPC NO.: _____

BY: _____

TYPE of Underdrainage system: _____

OUTLET			LANE		TESTED LENGTHS			METHOD		INSP.	EW-12	
NO.	STATION	PIPE DIA.	DIR	Shoulder Right/Left	① DIR	② OUTLET Dist.	③ TOTAL DIST.	CAMERA	Borescope	SATISF. Y / N	SATISF. Y / N	COMMENTS

① DIRECTION IN WHICH CAMERA IS LOOKING, WHICH MAY BE OPPOSITE THE LANE DIRECTION.

② LENGTH OF NON-PERFORATED PIPE

③ TOTAL TESTING DISTANCE OF PERFORATED PIPE (MAINLINE)

Virginia Test Method – 110

Method of Test For Determining Rutting Susceptibility Using The Asphalt Pavement Analyzer – (Asphalt Lab)

November 1, 2000

1. Scope

1.1. This method describes a procedure to test the rutting susceptibility of asphalt-aggregate mixtures using the Asphalt Pavement Analyzer (APA).

2. Significance and Use

2.1. This method is used for the laboratory evaluation of the rutting susceptibility of hot-mix asphalt. Both laboratory and field produced mix can be tested and compared to pre-determined criteria. The allowable rut depth criteria is based on expected traffic loading and mix type.

3. Apparatus

3.1. Asphalt Pavement Analyzer (APA) – A thermostatically controlled device designed to test the rutting susceptibility of hot mix asphalt by applying repetitive linear loads to compacted test specimens through pressurized hoses.

3.1.1. The APA shall be thermostatically controlled to maintain the test temperature and conditioning chamber at any setpoint between 86° and 140° F within 0.7 ° F (30° and 60° C within 0.4°C).

3.1.2. The APA shall be capable of independently applying loads up to 120 lb (533 N) to the three wheels. The loads shall be calibrated to the desired test load by an external force transducer.

3.1.3. The pressure in the test hoses shall be adjustable and capable of maintaining pressure up to 120 psi (830 kPa).

3.1.4. The APA shall be capable of testing three beam specimens or six cylindrical specimens simultaneously.

3.1.5. The APA shall have a programmable master cycle counter which can be preset to the desired number of cycles for a test. The APA shall be capable of automatically stopping the test at the completion of the programmed number of cycles.

3.1.6. The hoses shall be Gates 77B Paint Spray and Chemical ¾ inch (19.0 mm), 750 psi (5.17 MPa) W.P. GL 07148. The hoses should be replaced when any of the outer rubber casing has worn through and threads are exposed. Follow the APA manufacturer's instructions for the technique on replacing hoses.

3.2. Balance, 12,000 gram capacity, accurate to 0.1 gram.

3.3. Mixing utensils (bowls, spoon, spatula)

3.4. Ovens for heating aggregate and asphalt cement.

3.5. Compaction device and molds

4. **Preparation of Test Specimens**

4.1. Number of test specimens – One test will either be three 3 in. x 5 in. x 12 in. (75 mm x 125 mm x 300 mm) beam specimens or six cylindrical 6 in. diameter x 3 in. (150 mm diameter x 75 mm) specimens.

4.2. Field Compacted Specimens

4.2.1. Roadway core specimens shall be 6 in. (150 mm) diameter with all surfaces of the perimeter perpendicular to the surface of the core within 5 mm. Cores shall be trimmed with a wet masonry saw to a height of 3.0 ± 0.1 in. (75 ± 3 mm). The cores shall have a snug fit in the APA mold or be shimmed with Plaster-of-Paris.

4.2.2. Roadway beam specimens shall be 3 in. x 5 in. x 12 in (75 mm x 125 mm x 300 mm). with a wet masonry saw. All surfaces of the perimeter perpendicular to the surface of the core within 0.2 in (5 mm). The beams shall have a snug fit in the APA mold or be shimmed with Plaster-of-Paris.

4.3. Plant Produced Mixtures

4.3.1. Samples of plant produced mixtures shall be obtained in accordance with AASHTO T 168. Mixture samples shall be reduced to the appropriate test size recommended in Section 12.0, placed in a covered metal container and heated to the appropriate compaction temperature recommended in Section 211.03 (d) 6 of the specifications.

4.3.2. Samples shall be compacted according to Section 5.5

4.4. Laboratory Prepared Mixtures

4.4.1. Mixture proportions are batched in accordance to the desired Job Mix Formula. Required batch sizes are determined in accordance with Section 13.

4.4.2. The asphalt binder and aggregate shall be heated to the temperature specified in Section 211.03 (d) 6 of the specifications.

4.4.3. Dry mix aggregates and hydrated lime (when lime is used) first, then add the optimum or other specified percentage of asphalt cement. Mix the material until all aggregates are thoroughly coated.

4.4.4. Test samples shall be short term oven aged in accordance with AASHTO PP2-99 at the appropriate compaction temperature recommended in Section 211.03 (d) 6 of the specifications.

4.4.5. Samples shall be compacted according to Section 5.5

4.5. Laboratory Compaction of Specimens

4.5.1. One of several devices may be used to compact specimens in the laboratory. Details regarding the procedures for compacting specimens in each device should be referenced to the equipment manufacturer's instructions.

Note: Recent studies have shown that samples compacted with different laboratory compaction devices may have significantly different results. Virginia's existing criteria is based on beam specimens. New criteria would need to be developed for cylindrical specimens

4.5.2. Laboratory prepared specimens shall be compacted to contain 8.0 ± 0.5% air voids.

4.5.3. Compacted specimens should be left at room temperature (approximately 77° F (25° C)) to allow the entire specimen to cool for a minimum of 3 hours.

METHOD A - Vibrating Compaction

4.5.4. Apparatus - Asphalt Vibratory Compactor, Model AVC II. *Note: prior to compacting samples the compaction head on the AVC II needs to be calibrated to produce a sample height of 3 in. (75 mm) following the manufacturer's instructions. Be sure to include both the base plate and the silicone coated cardboard specimen disk when calibrating the height. Calibration should be repeated once per year.*

4.5.5. The following specimen compaction procedures can be used for compacting beam specimens

4.5.6. Temperature of the loose mixture at the starting of the compaction should be within ± 9 ° F (± 5 °C) of the specified compaction temperature for the mixture. Place the specimen mold on top of a counter adjacent to the compaction machine. Insert a preheated base plate into the mold. Remove loose HMA from the oven and pour the entire batch into the mold. Level the mixture, rod the mixture 20 times around the perimeter and 20 times evenly dispersed across the center of the sample. Form the sample into a slight mound. Place a silicone coated, cardboard specimen disk on top of the sample.

4.5.7. Transfer the specimen mold to the supporting base of the machine and fit it in the recessed area.

4.5.8. Set the control unit CYCLE TIME to 30 seconds (More time may be necessary to compact harsh mixtures). Turn MODE switch to AUTO, VIBRATING switch to AUTO, and pull up (disable) the EMERGENCY STOP.

4.5.9. Press both green palm buttons simultaneously (you do not need to hold down the palm buttons once the vibrators start). This will cause the vibrating assembly to move downward automatically and when it gets down to a certain position, the vibrating actions will be activated automatically. Under the static compression force and the vibrating actions, the compaction head will move downward to consolidate and compact the loose asphalt mixture confined in the specimen mold for 30 seconds. For most dense-graded HMA, compaction will be achieved in less than 10 seconds after the vibration is activated. At this point the bottom surface of the vibrating assembly base plate will be in contact with the top surface of the specimen mold and the compaction head is "bottomed out". When this occurs, turn the vibratory control from "auto" to "off". This will help level the specimen. After the compaction time is completed, the vibrating compaction assembly will automatically retract. This completes the compaction operations. If at the end of the vibrating time the bottom surface of the vibrating assembly base plate is not in contact with the top surface of the specimen mold, this implies that the specimen has not been compacted to the specified density. Rotate the mold 180° and re-compact.

4.5.10. Lift the specimen mold from the compaction position, move forward and slide the edges of the specimen mold under the restraining brackets and position the specimen mold in the recessed area at the extruding support base.

4.5.11. On the control unit, turn the MODE switch to EJECT. Press and hold down both green palm buttons to raise the extrusion cylinder head to extrude the specimen out of the mold. Remove the compacted specimen with the base plate together from the rigid bottom of the mold and place them on a firm counter top. Press the OPEN button on the control unit to retract the extrusion cylinder head. Then remove the specimen mold from the extrusion supporting base.

4.5.12. Compacted specimens should be left at room temperature (approximately 77° F (25° C)) to allow the entire specimen to cool for a minimum of 3 hours. After this time, the base plate should be heated with a propane torch or heat gun to facilitate removal.

METHOD B - Superpave Gyratory Compaction

4.5.13. Apparatus (see AASHTO TP4)

4.5.14. Compaction of cylindrical specimens with the Superpave Gyratory Compactor can be accomplished in several ways. Specimens can be compacted directly to the specified height of 3 inches (75 mm), or specimens can be compacted to the number of gyrations at which the target air void content of 8.0 ± 0.5% has been estimated.

4.6. Remove the mold and base plate from the oven set at the compaction temperature. Place a paper disc in the bottom of the mold assembly.

4.6.1. Check the temperature of the loose mixture and verify it is within the limits of Section 211.03 (d) 6 of the specifications. Transfer the mixture to the mold with care to avoid segregation of the mixture. Place a paper disk on the top of the mixture.

4.6.2. Place the mold and mixture in the Superpave Gyratory Compactor and begin compaction as described in the compactor's operation manual.

4.6.3. When the compaction procedure is completed, remove the mold and compacted specimen from the compactor. Extrude the specimen from the mold with care to avoid distorting the specimen until it is cooled.

5. Determining Air Void Contents

5.1. Determine the bulk specific gravity of the test specimens in accordance with AASHTO T 166 (ASTM D 2726)

5.2. Determine the maximum specific gravity of the test mixture in accordance with AASHTO T 209 (ASTM D 2041)

5.3. Determine the air voids contents of the test specimens in accordance with AASHTO T 269 (ASTM D 3203)

6. Selecting The Test Temperature

6.1. The test temperature should be representative of the environment in which the paving mixture will be utilized. The standard test temperature for Virginia is 120 °F (49 °C).

6.2. The pre-heating oven and APA shall be calibrated according to Annex A at least once per year.

*Note: The **LTPPBind** software, available from FHWA, can be used to determine a precise temperature for a specific project location. Select the depth to surface of layer at 0 in (0 mm) for surface mixtures. For evaluating other layers in the pavement structure, select the depth in millimeters to the top of the layer. The **LTPPBind** software will determine the high pavement design temperature 0.8 in (20 mm) below the input depth as used in binder grade selection and mixture performance modeling. Use the map to select the project location. The high temperature for the nearest weather station will be displayed. For projects with low traffic loads (i.e. < 10 million ESAL's) the temperature corresponding to 50 percent reliability should be used; for projects with high traffic loads, the temperature corresponding to 98 percent reliability should be used.*

7. Specimen Preheating

7.1. Place the specimens in the molds.

7.2. Specimens shall be preheated in the temperature calibrated APA test chamber or a separate calibrated oven for a minimum of 4 hours. Specimens should not be held at elevated temperatures for more than 24 hours prior to testing

8. Rut Test Procedure

8.1. Set the hose pressure gage reading to 120 +/- 5 psi (830+/- 35 kPa). Set the load cylinder pressure reading for each wheel to achieve a load of 120 ± 1 lb (533 ± 4.5 N).

8.2. Stabilize the testing chamber temperature at 120° F (49° C) unless otherwise specified.

8.3. Secure the preheated, molded specimens in the APA. The preheated APA chamber should not be opened more than 6 minutes when securing the test specimens into the machine. Close the chamber doors and allow 10 minutes for the temperature to restabilize prior to starting the test

8.4. Apply 30 cycles to seat the specimens before the initial measurements. Make adjustments to the hose pressure as needed during the 30 cycles.

8.5. Open the chamber doors, unlock and pull out the sample holding tray.

8.6. Place the rut depth measurement template over the specimen. Make sure that the rut depth measurement template is properly seated and firmly rests on top of the testing mold without rocking.

8.7. Zero the digital measuring gauge so that the display shows 0.00 mm with the gauge completely extended. The display should also have a bar below the "inc." position. Take initial readings for beams at each of the three center locations on the template. (For cylindrical specimens, the four outside locations are used). Measurements shall be determined by placing the digital

measuring gauge in the template slots and sliding the gauge slowly across the each slot. Record the smallest measurement for each location to the nearest 0.01 mm.

8.8. Repeat steps 9.6 and 9.7 for each beam or set of cylinders in the testing position. All measurements shall be completed within six minutes.

8.9. Push the sample holding tray in and secure. Close the chamber doors and allow 10 minutes for the temperature to equalize.

8.10. Set the PRESET COUNTER to 8000 cycles.

8.11. Start the test. When the test reaches the number of cycles set on the counter, the APA will stop and the load wheels will automatically retract.

8.12. Repeat steps 9.6 through 9.8 at the completion of the test.

9. Calculations

9.1. The rut depth at each location is determined by subtracting the measurement after 8000 cycles from the initial measurement.

9.2. Determine the average rut depth at each interval for each test position. For beam specimens, use only the three center measurements for calculating the average rut depth. For cylindrical specimens, use the average of all four measurements to calculate the average rut depth.

9.3. Calculate the average rut depth from the three test positions. Also, calculate the standard deviation for the three test positions (three beams or pairs of cores).

9.4. Outlier evaluation – If the standard deviation of the set is greater than or equal to 2.00 mm, then the position with the rut depth farthest from the average may be discarded. The testing procedure, device calibration, and test specimens should be investigated to determine possible causes for the excessive variation.

9.5. The APA rut depth for the mixture is the average of three beam specimens or six cylindrical specimens.

10. Report

10.1. The test report shall include the following information:

10.1.1. The laboratory name, technician name, and date of test.

10.1.2. The mixture type and description.

10.1.3. Specimen type.

10.1.4. Average air void content of the test specimens.

10.1.5. The test temperature

10.1.6. The average rut depths to the nearest 0.1 mm at 8000 cycles.

10.2. Passing Rut Depth Criteria

Traffic ESAL's	Mix Type	Proposed Maximum rut Depth, mm
< 3 million	SM 9.5-A, SM 12.5-A, SM-2A	7.0
3 – 10 million	SM 9.5-D, SM-12.-D, SM-2D	5.5
> 10 million	SM 9.5-E, SM-12.5E, SM-2E	3.5

Note: The criteria in section 12.3 were developed from a large data base of good performing surface mixes from Virginia. The beam specimens were compacted to 8% air voids. The beams were tested at 49 ℃ (120 ℉), with a 533 N (120 lb) vertical wheel load and 830 kPa (120 psi) hose pressure

11. NONMANDATORY INFORMATION - Calculation of Specimen Masses

11.1. Beam Specimens

11.1.1. Volume of specimen = 75 mm x 125 mm x 300 mm = 2812.5 cm^3.

11.1.2. Total mass of beam specimen, g = Gmm @ Opt. A.C. x 0.94 x 2812.5 cm^3

11.2. Cylindrical Specimens

11.2.1. Volume of Specimen = $(1/4\pi \times (150\ mm)^2 \times 75\ mm)/1000 = 1325.4\ cm^3$

11.2.2. Total mass of cylindrical specimen, g = Gmm @ Opt. A.C. x 0.94 x 1325.4 cm^3

Note: Experience indicates the specimen weights should target a density two percent lower than the desired density, hence the 0.94 factor

Annex-A

(Mandatory Information)

A. **Calibration –** The APA and pre-heating ovens shall be calibrated at least once per year.

A.1. **Temperature calibration of the APA and specimen preheating oven** – the APA and pre-heating ovens must be calibrated with a NIST traceable thermometer (an ASTM 65 C calibrated thermometer is recommended) and a metal thermometer well to avoid rapid heat loss when checking the temperature.

A.1.1. **Preheating Oven Temperature Stability** - set the oven to the appropriate temperature determined in Section 7.0. Place the thermometer in the well and place them on the center of the shelf where the samples will be preheated.

A.1.2. Allow the temperature of the oven chamber, thermometer and well to stabilize (approximately one hour). Open the oven door and read the thermometer without removing it from the well. Record this temperature. Close the oven door.

A.1.3. Thirty minutes after obtaining the reading in Section 4.1.2, obtain another reading of the thermometer, following the same steps as Section 4.1.2. Record this temperature.

A.1.4. If the readings from Sections 4.1.2 and 4.1.3 are within 0.7 ° F (0.4 °C), then average the readings. If the readings differ by more than 0.7 °F (0.4 °C) then continue to take readings every thirty minutes until the temperature stabilizes within 0.7 °F (0.4° C) on two consecutive readings.

A.1.5. **Preheating oven Temperature Uniformity** – To check the uniformity of the temperature in the oven, move the thermometer and well to another location in the oven so they are on a shelf where samples will be pre-heated, but as far as possible from the first location.

A.1.6. Take and record readings of the thermometer at the second location every thirty minutes until two consecutive readings at the second location are within 0.7 °F (0.4 °C).

A.1.7. Compare the average of the two readings at the first location with the average of the stabilized readings at the second location. If the average temperatures from the two locations are within 0.7 ° F (0.4° C), then the oven is relatively uniform and may be used for conditioning APA specimens.

A.1.8. **Preheating Oven Temperature Accuracy** – Average the temperatures from the two locations in Section 4.1.7. If that temperature is within 0.7 °F (0.4 °C) of the set point temperature on the oven, then the oven is reasonably accurate and the calibration is complete. If the set point differs from the average temperature by more than 0.7° F, 0.4 °C then adjust the oven set point appropriately to raise or lower the temperature inside the chamber so that the thermometer and well will be at the desired temperature determined in Section 7.0.

A.1.9. Place the thermometer and well in the center of the shelf. At thirty minute intervals, take readings of the thermometer. When two consecutive readings are within 0.7 °F (0.4 °C) of the test temperature determined in Section 7, then the oven has been properly adjusted and the calibration is complete. If these two conditions are not met, then repeat Section 4.1.8.

A.1.10. **APA Temperature Stability** – Turn on the main power and set the chamber controller and water temperature controller so that the temperature inside the testing chamber is 120° F (49 °C) or the temperature determined in Section 7.

A.1.11. Place the thermometer in the well and place them on the left side of the shelf where the sample mold will be placed. Allow 5 hours for the temperature in the APA to stabilize.

A.1.12. Once the Temperature has stabilized, open the chamber doors and read the thermometer without removing it from the well. Record this temperature. Close the chamber doors.

A.1.13. Thirty minutes after obtaining the reading in Section 4.1.12, obtain another reading of the thermometer, following the same steps as Section 4.1.12. Record this temperature.

A.1.14. If the readings from Sections 4.1.12 and 4.1.13 are within 0.7° F (0.4° C), then average the readings. If the readings differ by more than 0.7° F (0.4° C) then continue to take readings every thirty minutes until the temperature stabilizes within 0.7° F (0.4° C) on two consecutive readings.

A.1.15. **APA Temperature Uniformity** – to check the uniformity of the temperature in the APA chamber, move the thermometer and well to the right side of the shelf where the samples are tested.

A.1.16. Take and record readings of the thermometer at the second location every thirty minutes until two consecutive readings at the second location are within 0.7° F (0.4° C).

A.1.17. Compare the average of the two readings at the left side with the average of the stabilized temperature at the right side. If the average temperatures from the two locations are within 0.7° F (0.4° C), then the APA temperature is relatively uniform and acceptable for testing. If the average of the readings differs by more than 0.7° F (0.4° C), consult the manufacturer on improving temperature uniformity.

A.1.18. **APA Temperature Accuracy** – Average two temperatures from the two locations determined in Sections 4.1.14 and 4.1.16 are within 0.7° F (0.4° C) of 120° F (49.0° C) or the temperature determined in Section 7.0, then the APA temperature calibration is complete. If the set point differs from the average temperature by more than 0.7° F (0.4° C), then adjust the APA chamber and water set point appropriately to raise or lower the temperature inside the chamber so that the thermometer and well will be at 120° F (49.0° C) or the desired temperature determined in Section 7.0.

A.1.19. Place the thermometer and well in the center of the shelf. At thirty minute intervals, take readings of the thermometer. When two consecutive readings are within 0.7° F (0.4° C) of 120° F (49.0 °C) or the test temperature determined in Section 7, then the APA has been properly adjusted and the calibration is complete. If these two conditions are not met, then repeat Section 4.1.18

A.2. **APA Wheel Load Calibration** – The APA Wheel Loads will be checked with the calibrated load cell provided with the APA. The loads will be checked and adjusted one at a time while the other wheels are in the down position and bearing on a dummy sample or wooden block of aproximately the same height as the test sample. Calibration of the wheel loads should be accomplished with the APA at room temperature.

A.2.1. Remove the hose rack from the APA. Jog the wheel carriage until the wheels are over the center of the sample tray when the wheels are in the down position. Raise and lower the wheels 20 times to heat up the cylinders.

A.2.2. Adjust the bar on top of the load cell until the total height of the load cell – load bar assembly is 4.1 in. (105 mm).

A.2.3. Position the load cell under one of the wheels. Place wooden blocks or dummy samples under the other two wheels.

A.2.4. Zero the load cell.

A.2.5. Lower all wheels by turning the cylinder switch to CAL.

A.2.6. If the load cell is not centered left to right beneath the wheel, raise the wheel and adjust the position of the load cell. When the wheel is centered left to right, it should be centered front to back by unlocking the sample tray and SLOWLY moving front to back until the wheel rests in the indentation on the load cell bar.

A.2.7. Adjust the pressure in the wheel cylinder to obtain 120 ± 1 lb (533 ± 4.5 N). Allow three minutes for the load cell reading to stabilize between adjustments. Record the pressure and the load.

A.2.8. With the wheel on the load cell remaining in the down position, raise and lower the other wheels one time. Allow three minutes for the load cell to stabilize. Record the pressure and load.

A.2.9. With the other wheels remaining in the down position, raise and lower the wheel over the load cell one time. Allow three minutes for the load cell to stabilize. Record the pressure and load.

A.2.10. Repeat Sections 4.2.3 through 4.2.9 for each wheel/cylinder.

A.2.11. Return the load cell to the first wheel and repeat Sections 4.2.3 through 4.2.9.

A.2.12. Place the load cell under the second wheel and repeat Sections 4.2.3 through 4.2.9

A.2.13. Place the load cell under the third wheel and repeat Sections 4.2.3 through 4.2.9

A.2.14. The current cylinder pressures will be used to set the wheel loads to 120 ± 1 lb (533 ± 4.5 N).

Virginia Test Method – 111

Determination of Night Time Color of Pavement Markings – (Chemistry Lab)

December 1, 2004

1. Scope

1.1 This test is used to determine the nighttime color properties of pavement marking material. This procedure includes the pavement marking material sample preparation, if needed, and the color measurement of the sample under nighttime illumination. This procedure shall follow the general outline of ASTM E 811-Standard Practice for Measuring Colorimetric Characteristics of Retroreflectors Under Nighttime Conditions, Procedure B. The exception shall be that the entrance angle shall be 88.76° and the observation angle shall be 1.05° as required in ASTM E 1710- Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer. The measurement instrument used shall be a PR-650, Spectracolorimeter manufactured by Photo Research or equivalent.

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. Referenced Documents

ASTM Standards

E 811 Standard Practice for Measuring Colorimetric Characteristics of Retroreflectors Under Nighttime Conditions

E1710 Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer

D4960 Standard Test Method for Evaluation of Color for Thermoplastic Traffic Marking Materials

D6628 Standard Specification for Color of Pavement Marking Materials

AASHTO Standards:

T 250 Standard Method of Test for Thermoplastic Traffic Line Material

M247 Standard Specification for Glass Beads Used in Traffic Paints

3. Test Method Guidelines

This test method includes the procedures for sample preparation and the measurement of nighttime color of the pavement marking materials listed below:

Thermoplastic, Acrylic and Epoxy Paint samples are prepared in the lab.

Preformed Thermoplastic and Tape samples are prepared by the manufacturer and submitted for testing.

High Performance Durable Markings are spray applied and specialized equipment is needed for application to the road surface. Consequently, the manufacturer shall prepare these high performance durable markings and submit them for testing.

All pavement marking samples prepared in the laboratory shall be handled in accordance with the manufacturer's instructions.

Glass beads conforming to VDOT specifications shall be AASHTO M247, Type I, 80% rounds.

Refer to the applicable method below for the sample preparation.

Refer to section 10 for nighttime color measurement procedures.

4. Thermoplastic Sample Preparation Guidelines

The thermoplastic pavement marking material is melted and drawn down to a film of uniform thickness and area. Glass beads are applied as an even layer while the material is molten, and the specimen is allowed to cool

4.1 **Safety Considerations –** The thermoplastic pavement marking material is melted and drawn down to a film of uniform thickness and area. Glass beads are applied as an even layer while the material is molten, and the specimen is allowed to cool.

4.2 **Materials and Equipment**

1 - 2 Quart (1 L) can of thermoplastic material

4 inch (100 mm) draw down bar with a 90 mil (2.3 mm) opening

` Spatula

Glass Bead Dispenser capable of dispensing beads at a uniform rate of 7 - 8 pounds per 100 ft^2 (0.35 kg – 0.40 kg/m^2)

Glass Thermometer capable of reading 20 - 500º F (-7 to 260 º C)

Sample Plates:

1. Nonporous material (aluminum) approximately 8 inches wide by 20 inches long. (200 mm x 510 mm)

2. Flooring tile 6 x 12 inches (150 mm x 300 mm)

Forced Air Oven maintained at 425 ± 3º F (218 ± 16º C)
Wire Brush
Glass beads conforming to VDOT specifications:(AASHTO M247, Type I, 80 % Rounds)

4.3 **Thermoplastic Sampling -** Samples are obtained from the manufacturer through an independent inspection agency.

4.4 **Sample Preparation -** Melt the thermoplastic material in accordance with AASHTO T 250. Preheat the draw down bar in the oven for at least 30 minutes prior to drawing down sample. Remove the thermoplastic sample from the heat source. Insure that the material temperature is 400 to 425º F (204 to 218º C). Stir thoroughly to ensure a homogeneous blend of the thermoplastic material. Place the drawdown bar on the sample plate surface. Pour the molten thermoplastic into the draw down bar. Slowly pull the bar across the plate forming a continuous line approximately 12 – 18" (150 mm to 300 mm) long. (See Diagram A) Immediately pass the glass bead dispenser over the line and deposit the required amount of beads (11-12 grams per foot) (36-40 grams per meter) onto the surface of the thermoplastic line. Allow the line to completely cool and remove excess beads that have not adhered to the line with a wire brush.

4.5 Refer to Section 10 for nighttime color measurement.

5.0 <u>Preformed Thermoplastic Sample Preparation Guidelines</u>

Preformed thermoplastic material is fabricated by the manufacturer. The material is in sheet form and is ready to be melted to the road surface.

5.1 **Safety Considerations -** Thermoplastic material is heated to a temperature of 400° F (204° C) . This material can cause serious burns to the body. Safety equipment must be worn when handling. This includes eye protection, apron and gloves. The oven should be operated in a laboratory hood and the drawdown operation should be performed in an area with adequate ventilation.

5.2 **Materials and Equipment**

Sample of preformed thermoplastic 8 x 20 inches (200 mm x 510 mm)

Aluminum plate

Adhesive (all-purpose adhesive)

Heat source (propane torch)

Sample Plates:

1. Nonporous material (aluminum) approximately 8 inches wide by 20 inches long (200 mm x 510 mm).

2. Flooring tile 6 x 12 inches (150 mm x 300 mm)

5.3 **Preformed Thermoplastic Sampling**

Samples are obtained directly from the manufacturer through their own shipping service.

5.4 **Sample Preparation** - Sample preparation is not required. However, due to the brittleness of the material, the sample may be affixed to an aluminum plate using minimal heat or adhesive. If heating is required to affix the sample to the plate, a burner (torch) may be used to heat the sample enough to bond to the aluminum plate. Care should be taken to ensure the material is not over heated to the point of discoloring or creating a change in the glass bead embedment.

5.5 Refer to Section 10 for nighttime color measurement.

6. Epoxy Sample Preparation Guideline

Epoxy Traffic Paint is supplied as a two component material. Component A (Pigment & Resin) and Component B (Hardener). These components are mixed in a 2:1 ratio. (two parts of component A to one part component B).

6.1 **Safety Considerations** - These components can be corrosive in nature and produce hazardous fumes. Safety equipment must be worn when handling. This includes eye protection, apron and gloves. When mixing components, epoxy should be handled in a ventilation hood. Drawdown operation should be performed in an area with adequate ventilation.

6.2 **Materials and Equipment**

One quart can of each component (Part A and B).

Adjustable draw down bar or Byrd Type applicator.
Wet Film Thickness Gage
Glass Beads conforming to VDOT Specifications
Paint Stirring Sticks
Solvent (Acetone) for clean-up
Glass Bead Dispenser capable of dispensing beads at a uniform rate of 25 pounds of glass beads per gallon (3g/L) of epoxy .
Sample Plates:

1. Nonporous material (aluminum) approximately 8 inches wide by 20 inches long. (200 mm x 510 mm)

2. Flooring tile 6 x 12 inches (150 mm x 300 mm)

6.3 **Epoxy Sampling** - Epoxy samples are obtained from the manufacturer through an independent inspection agency.

6.4 **Sample Preparation** - Place the draw down bar or Byrd Type applicator on the sample plate. The epoxy material will be applied at a thickness of 20 ± 1 mils. (051 mm).

Accurately measure 2 parts (by volume) of Part A to 1 part (by volume) of Part B. Stir the two components until completely mixed (approximately1-2 minutes).

Pour the epoxy into the draw down bar and slowly move the bar along the sample plate to form a continuous film 12 to 18 inch (300 – 460 mm) long. Check the film thickness of the epoxy using a wet film thickness gage to ensure 20 ± 1 mils (0.51mm) of epoxy have been applied. Immediately following thickness testing, pass the bead dispenser over the applied line depositing the required amount of beads (25 lbs./Gal) to the surface (47 grams per foot for sample plate). (155 grams per meter for sample plate).

Allow the sample to completely cure for a minimum of 1 hour. Once cured remove excess glass beads from the surface using a wire brush.

6.5 Refer to Section 10 for nighttime color measurement.

7. Latex Traffic Paint Sample Preparation Guideline

Latex (Acrylic Resin) Traffic Paint is a water base single component material. Due to its quick drying time, paint shall be tightly sealed in its container when not being tested.

7.1 **Safety Considerations -** Paint may contain components that are hazardous if inhaled. Safety equipment should be worn when handling. This includes eye protection, apron and gloves. Drawdown operations should be performed in an area with adequate ventilation.

7.2 **Materials and Equipment**

One quart of paint
Adjustable draw down bar or Byrd Type Applicator
Paint stirring stick
Glass Beads conforming to VDOT Specifications
Wet Film Thickness Gage
Water for clean-up
Glass Bead Dispenser capable of dispensing beads at a uniform rate of 6 pounds (0.7 kg per Liter) of glass beads per gallon (liter) of paint.
Sample Plates:

1. Nonporous material (aluminum) approximately 8 inches wide by 20 inches long (200 mm x 510 mm).

2. Flooring tile (6 x 12 inches) (150 mm x 300 mm)

7.3 **Paint Sampling**

Paint samples are obtained from the manufacturer through an independent inspection agency.

7.4 **Sample Preparation**

Place the draw down bar or Byrd applicator on the sample plate. The paint application thickness (wet film thickness) shall be 15 mils (0.38 mm). Stir the sample keeping the stick on the bottom of the can to ensure no air is being trapped in the paint.

Pour the paint into the draw down bar and slowly move the bar along the sample plate to form a continuous film 12 to 18 " long. Check the film thickness of the paint using a wet film thickness gage to ensure 15 wet mils (0.38 mm) of paint has been applied.

Immediately following thickness testing, pass the bead dispenser over the applied line depositing the required amount of beads (6 lbs./Gal) (0.7 kg/) to the surface (9 grams per foot for sample plate) 30 grams per meter for sample plate). Allow the applied marking to dry over night. Once dried remove excess beads from the sample using a wire brush.

7.5 Refer to Section 10 for nighttime color measurement.

8.0 Pavement Marking Tape Sample Preparation Guidelines

Pavement marking tape is supplied directly from the manufacturer in small rolls or pieces for lab testing.

8.1 **Safety Considerations** – There are no hazards associated with handling pavement marking tape.

8.2 **Materials and Equipment**

PM Tape Sample

Plastic Mounting Sheet (17 x 6.5 inches) (430 mm x 165 mm)

Adhesive, if necessary

8.3 **Tape Sampling -** Samples are normally obtained directly from the manufacturer. Samples may be cut from rolls or pieces.

8.4 **Sample Preparation -** Tape samples (17 inches (430 mm) in length) are cut from rolls and affixed to the 17 x 6.5 inch (430 mm x 165 mm) plastic sheet using either the adhesive on the tape back or any other suitable adhesive.

8.5 Refer to Section 10 for nighttime color measurements.

9.0 High Performance Durable Pavement Marking Sample Preparation Guidelines

9.1 **Safety Considerations** – High Performance Durable Pavement Marking samples are normally prepared by the manufacturer. This product is fabricated from the combination of separate components (a base component and a catalyst). Fully cured samples submitted for testing should not be hazardous.

9.2 **Materials and Equipment -** This material will be applied to a flat plate.

9.3 **Sampling -** This material will be submitted for testing by the manufacturer.

9.4 **Sample Preparation -** This material should be submitted for testing on a sample plate. No other sample preparation should be required.

9.5 Refer to Section 10 for nighttime color measurement.

10. Nighttime Color Measurement Summary

The measurement of nighttime color of pavement marking materials shall follow the guidelines of ASTM E-811 with the exceptions noted in Section 1.1. Nighttime color is measured using a standard CIE, Illuminant A light source and a spectracolorimeter. Results are expressed as (x,y) chromaticity coordinates for the 1931, CIE Chromaticity Diagram.

10.1 **Safety Considerations** - Nighttime color measurements are taken in a dark laboratory. Care should be taken to avoid tripping in this dark environment. The light source produces an intense light beam. Care should be taken to avoid direct viewing of this light beam.

10.2 **Materials and Equipment**

Dark laboratory (Light Tunnel)
Spectracolorimeter (PR-650) or equivalent
CIE Illuminant A light source
Sample platform and equipment stands (Diagram B)

10.3 **Nighttime Color Measurement Procedure**

1. Ensure Quality Control Guidelines (Section 11) are met prior to taking color measurements.

2. The PR-650 shall be located in a light tunnel, mounted on a stand as shown in Diagram B. Although the diagrams attached to this procedure depict the setup in this lab, the sample size, length, and distance from the PR-650 may be altered to fit any given laboratory size. This holds true as long as:

   A. The geometry of the sample in relation to the spectracolorimeter and light source is consistent with this procedure.
   B. The sample is of sufficient size to adequately cover the measuring field (black dot) when viewed through the eyepiece of the PR-650.
   C. The signal from the sample is strong enough to obtain a repeatable reading from the PR-650. Care shall be taken to eliminate any excess stray light during measurements.

3. Turn on the Illuminant A light source and allow it to warm up for 15 minutes. Ensure the zero and gain settings are adjusted per the manufacturer's instructions.

4. Place the sample on the platform and ensure the sample is positioned at the correct entrance angle of 1.24°. This angle can be adjusted with the knobs on the bottom of the stand.

5. With the spectracolorimeter shutter open and the lens cap removed, ensure the black dot in the field of view is centered on the sample by looking through the eyepiece and checking its location in relation to the sample. If it is not, adjust the sample on the sample holder, or reposition the spectracolorimeter.

6. Press the *red* **0/I** key to turn on the PR-650. Press this key several times to increase the brightness of the display.

7. Turn the overhead lights off.

8. Close the shutter and depress the measurement key located on the top right center of the PR-650.

9. The machine will make two audible clicks as it collects the spectral data.

10. Record the data displayed on the PR-650 display.

11. Ensure the display is set to show the *Yxy CCT* data. For more details on how to set the display and measurement parameters, see the PR-650 operating manual. If the correct setting is chosen, the display should appear as the one seen in Diagram C.

12. Record the values for *x*, *y*, and the *reflectivity reading(* at the top of the screen).

13. To make additional measurements,
    a. Repeat step 7 - 11 to measure the same sample, or
    b. Repeat steps 3 - 11 to measure additional samples. The machine automatically shuts off after 3 minutes of not being used and must be turned on again as described in step 6.

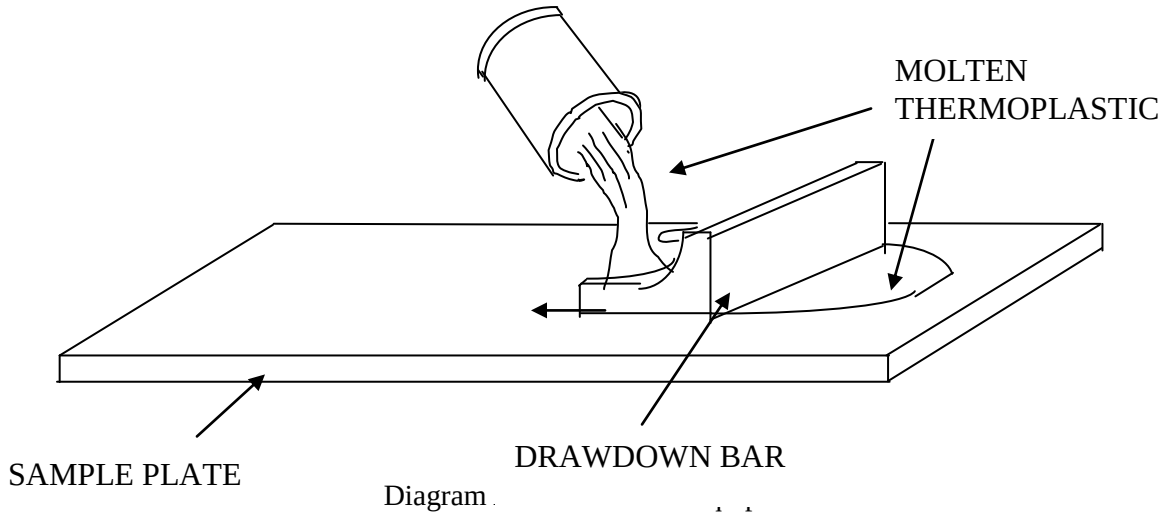
14. When finished, turn the overhead lights on and Illuminant A light source off, open the shutter and replace the lens cap. Depress and hold the *red* **0/I** button until the lighted display turns off. The PR- 650 is now off.

11. Quality Control

Sample Preparation:
To ensure adequate repeatability, it's critical that all samples are prepared consistently. This includes draw down thickness and glass bead application.

Color Measurement:

1. Ensure the light source and the spectracolorimeter are calibrated per the manufacturer's instructions.
2. Prior to measuring any sample, the instrument set up (distances, geometry, background light) must be verified.
   Distances, geometry and background light are critical to ensure consistent and accurate test results. (Refer to the nighttime color measurement procedure for correct equipment operation)
3. Quality control standards must be analyzed once all instrumentation is set up.
4. Quality control standards test results must be within the allowable range for each standard.
5. Test the applicable quality control standards and record results. Ensure results are within allowable range prior to testing regular samples.



Diagram

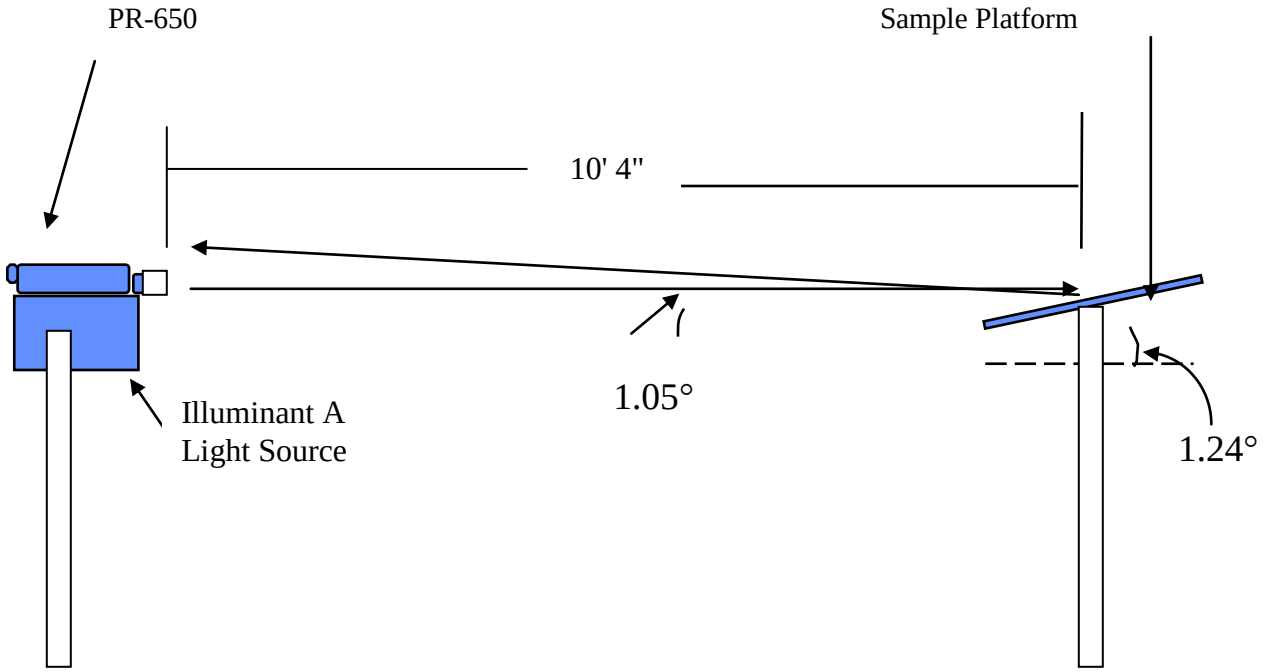


Diagram B Nighttime Color Measurement Equipment Setup

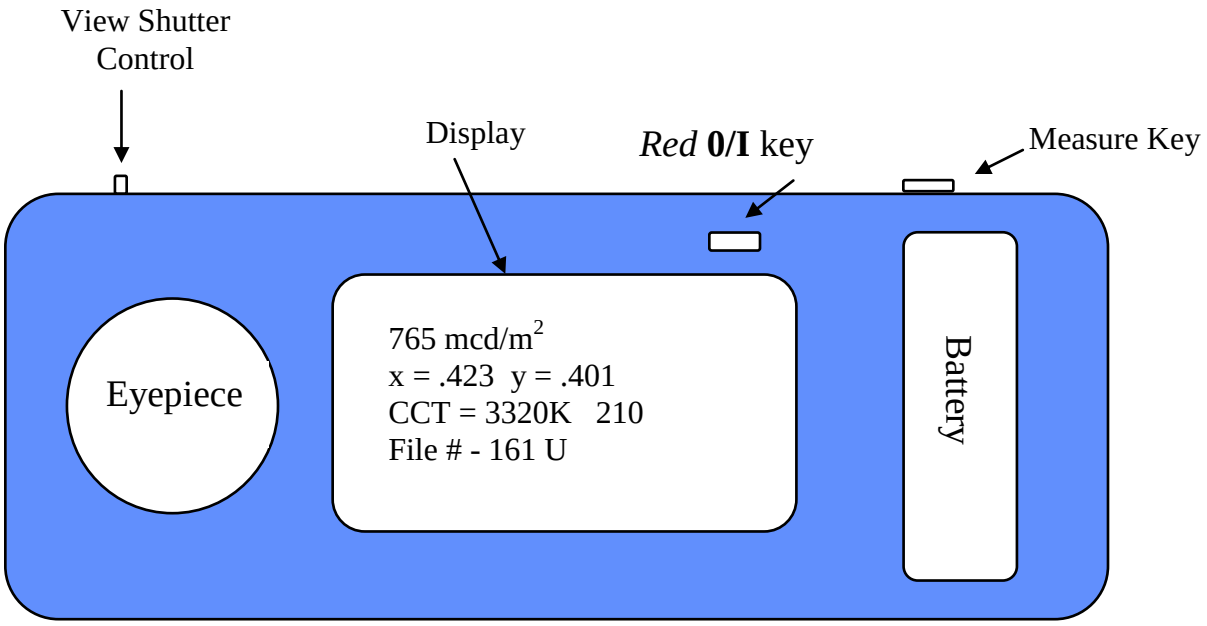


Diagram C PR-650 Rear View and Display

<u>Virginia Test Method – 112**</u>**

Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration – (Physical Lab)

May 3, 2016

VTM 112 consists of Method A and Method B. Method A follows ASTM C1202 (*Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration)* with some exceptions. Method A listed below defines those exceptions including the curing method of the concrete cylinder. Only Method A can be used to fail a test specimen. Method B which follows AASHTO TP 95 *(Standard Test Method for Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration)* is an alternate method listed below under Method B. To use Method B, a correlation must be made with Method A according to the criteria listed in Method B.

Note 1. Sample, cast specimen, cylinder, test specimen and specimen all refer to the concrete cylinder being tested and the terms are used interchangeably.

<u>Method A:</u>

This test method shall be in accordance with ASTM C1202 (*Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration***)** with the following exceptions:

Section 6.2.1 *Coating*- Non-conductive duct tape may be used as a coating.

Section 7.2 Deionized water may be used instead of distilled water.

Section 7.3 Deionized water may be used instead of distilled water.

Section 7.5 The Applied Voltage Cell may be made of Teflon or Plexiglas with conductive grate instead of mesh.

Sections 8 and 9 The specimen is either coated with epoxy before sawing the specified slice or afterwards using duct tape.

Section 8.2.3 *Accelerated Moist Curing*– Seven days after casting, the cylinders are to be removed from the moisture room (specified in ASTM C39) and placed in a 100 °F (38 ºC) water bath for 21 days. Twenty-one days in the 100 °F (38 ºC) water bath is the curing needed for cylinders that arrive to the laboratory after the initial 7-day curing period. The only exception to this curing method is that latex concrete cylinders are cured according to one of the following options:

a) 2-day moist-cured and 26-day air-cured at 100°F +/- 5°F and 50% +/- 10% relative humidity.

OR

b) 2-day moist-cured and 54-day air-cured at 75°F +/- 5°F and 50% +/- 10% relative humidity.

OR

c) in accordance with contract specifications.

Section 8.2 The cylinder may be transported to the lab in the mold in which the cylinder was cast.

Section 8.3 The slice is taken from the center 2 inches (50 mm) of the cylinder, parallel to the top of the cylinder core. The use of belt sander is not required.

Section 9.1 Distilled or deionized water may be used in place of boiled tap water.

Section 11.2 The correction factor is not applied.

Method B:

AASHTO TP 95 *(Standard Test Method for Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration)* may be used for acceptance provided the following criteria have been met:

1. The calibration of the resistivity meter must be verified using the manufacturer's calibrated verification board. The calibration (using both high and low positions on the board), will be verified initially, after testing every 30 samples and at the end of each testing period. If at any time the calibration verification does not match the manufacturer's supplied verification board values, testing will cease and all test values after the last valid verification test will be discarded. Testing will not resume until the instrument provides the resistivity values found on the verification board.
2. Latex concrete will not be tested using AASHTO TP 95.
3. The same curing method is used as stated in Section 8.2.3 of Method A. When the cylinder is removed from the 100 °F (38 ºC) water bath, the cylinder is placed into a room temperature water bath (73 °F ± 5 (23 °C ± 3)) for 2 hours. After the two hours, the cylinder is removed from the water bath, immediately placed into a suitable pan large enough for the cylinder to rest on the bottom. One inch of clean tap water (73 °F ± 5 (23 °C ± 3)) is added to the pan. The cylinder is rotated in the water one complete turn. A clean, damp cloth is used to wipe the surface to a clean (to remove surface laitance), moist condition before testing with the resistivity meter. The cloth must be rinsed clean periodically and the water in the pan replaced when the water becomes somewhat murky (approximately every 5 samples).
4. A correlation is developed using at least 200 comparison tests of multiple mix designs with a minimum R^2 correlation value of 0.75.
5. The equipment type or model used for the correlation will be used to perform all acceptance testing. Anytime the equipment type or model used to develop the correlation is changed, the correlation will be redone.
6. The portion of the correlation graph with less than 30 percent of the lower resistivity values will not be used.
7. The correlation must be approved by Central Office Materials before use.
8. AASHTO TP 95 will not be used if the correlated value is greater than 500 coulombs below the specification limit.
9. If the %RSD on the average test result is above 7.5%, repeat the test after soaking the cylinder an additional one hour in the water bath (73 °F ± 5 (23 °C ± 3)). If the repeat data provides a %RSD greater than 7.5%, average all 16 values for the report. If the repeat data provides a %RSD equal to or below 7.5%, use the average of the last 8 readings.
10. The use of a correction factor is not required (AASHTO TP 95, Section 11.2).
11. The report will list two individual cylinder test values converted to coulomb values using the correlation along with the average value of the two test results.

Virginia Test Method – 113

Sand and #10 Screenings – Silica Content – (Chemistry Lab)

November 1, 2000

1. Scope

1.1 To establish a consistent method in which to analyze fine aggregate samples for Silica. Siliceous (Non-Polishing) and # 10 Screenings are required in asphalt surface mixtures and concretes subject to abrasion based on past Research.

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. Summary of Test

2.1 The fine aggregate is ground to a fine powder and digested with HCl. Non-siliceous material is dissolved in the acid leaving only the insoluble siliceous material on the filter paper. The filter paper is ashed and the residue is weighed and calculated as % Silica.

3. Apparatus and Chemicals

3.1 Apparatus

3.1.1 Sample Splitter
3.1.2 Ring and Puck
3.1.3 Analytical Balance – capable of weighing 0.1 mg
3.1.4 # 50 Sieve – 0.0117 inch (0.30 mm)
3.1.5 Hot Plate
3.1.6 Rubber policeman
3.1.7 Oven at 230° F ± 9° F (110° C ± 5° C)
3.1.8 Whatman #42 filter paper
3.1.9 Meker cone burner
3.1.10 Dessicator
3.1.11 Brush
3.1.12 Funnel
3.1.13 Glass Stir Rod
3.1.14 Tongs

3.2 Glassware

3.2.1 250 ml beaker
3.2.2 Porcelain crucible, 50 ml
3.2.3 400 ml beaker

3.3 Reagents

3.3.1 Hot deionized water
3.2.1 conc. HC1
3.2.3 1:1 HC1:deionized water

4. Procedure

4.1 Split sample down to approximately 25 grams and dry overnight at 230°F (110°C). Allow sample to cool at room temperature in a dessicator.

4.2 Grind in a ring and puck grinder until entire sample passes through #50 mesh, 0.0117 inch (0.30mm) sieve.

4.3 Weigh out approximately 0.6 gm into a tared weigh pan.

4.4 Record weight and transfer sample to a 250 ml beaker.

4.5 Add 30 ml concentrated HCl and mix well using a glass stirring rod.

4.6 Place beaker on a hot plate and evaporate slowly to dryness. Do not let sample splatter while drying.

4.7 When no HCl odor is present, place beaker in an oven at 230°F (110°C) for a minimum of 1 hour to insure all the HC1 is gone.

4.8 Add 50 ml 1:1 HCl: deionized water to the beaker mix well with a rubber policeman and place on hot plate.

4.9 Heat to boiling.

4.10 After sample boils, remove from heat and filter through a Whatman #42 filter paper into a 400 ml beaker.

4.11 Wash the sides and bottom of the 250 ml beaker with hot water. Using a rubber policeman, remove all residue from the sides and bottom of the beaker and transfer onto the filter paper. Wash filter paper 5 times with hot water until the yellow color in the filter paper is no longer visible.

4.12 Transfer filter paper to a porcelain crucible.

4.13 Place crucible in oven at 230° F (110° C) until filter paper is dry (approximately 1 hour).

4.14 Ignite sample in crucible on a Meker cone burner until the carbon of the paper is completely consumed.

4.15 Transfer crucible to a dessicator and cool. (The crucible is hot.)

4.16 Weigh crucible. Record the weight.

4.17 Brush residue from crucible.

4.18 Reweigh crucible. Record weight.

5 Calculations

5.1 % of Silica = $\frac{\text{wt of residue}}{\text{wt of sample}} \times 100$

wt. of residue = wt. of porcelain crucible + residue – wt. of porcelain crucible

5.2 Record to the nearest 0.1%

Virginia Test Method – 114

Calibration and Verification of
Nuclear Moisture-Density Gauges – (Soils Lab)

August 1, 2001

1. Scope

1.1 This method covers the procedure for calibration of nuclear moisture-density gauges as performed by the Virginia Department of Transportation.

1.1.1 To be calibrated and accepted by the Department as a moisture-density gauge, the gauge must be designed for and/or equipped with the following:

1.1.1.1 Shall use the backscatter method for moisture determination and the backscatter and/or the direct transmission method for density determination. The source rod shall have a "safe" locking position to insure shielding of the radioactive source located in its tip. The gauge shall have at least four direct transmission positions, to include the 2", 4", 6" and 8" (51 mm, 102 mm, 152 mm, 203 mm) depth positions.

1.1.1.2 Shall have internal rechargeable Ni-Cad (or equivalent) battery packs, with an automatic charger using AC or DC current for charging.

1.1.1.3 All basic functions shall be accessed through keypad entry.

1.1.1.4 Shall have memory capabilities with a minimum of 64K 256K of internal and 512K external ROM. Memory storage shall be capable of storing at least 200 complete test station records. A means to transfer data to a printer or a computer hard drive shall be provided.

1.2 This procedure involves the handling of equipment containing hazardous (radioactive) materials. This procedure does not address the safe handling of the gauge. See gauge manufacturer's literature (MSDS) for appropriate safety and health practices prior to the use of a nuclear moisture-density gauge.

1.3 This procedure is necessary as a consequence of the affects of aging on the electronics and the decay of the cesium source.

2. Referenced Documents

2.1 Refer to these documents if needed for gauge operations:

2.1.1 Virginia Test Methods, VTM-10

2.1.2 American Society for Testing and Materials, ASTM D 2922.

2.1.3 American Association of State Highway and Transportation Officials, AASHTO T 310.

2.1.4 Code of Federal Regulations, 10 CFR 20.1101,10 CFR 20.12, 10 CFR 20.1301, 10 CFR 20.1302.

2.1.5 Virginia Test Methods, VTM-81.

2.1.6 Virginia Department of Transportation, Road and Bridge Specifications.

3. Apparatus

3.1 Nuclear moisture-density gauge to be used in the field to determine density and/or moisture content of soil, aggregate or asphalt concrete.

3.2 Standard Calibration and Verification Blocks

3.2.1 Five (5) density Calibration blocks of known, constant and homogenous densities accurate within ± 0.2% (ASTM D 2922), which cover the entire range of densities expected to be encountered in the field. The Calibration blocks may be engineered of any material meeting the aforementioned criteria; however, it is recommended that they consist of magnesium, laminated magnesium/aluminum or aluminum. To account for the siliceous and calcareous nature of the native rock and soil of Virginia, one of the calibration blocks shall be engineered of granite and one of limestone. Calibration blocks shall have surface dimensions of no less than 24 in. (610 mm) long by 28 in. (711 mm) wide (unless smaller dimensions can be used without encountering an influence from the surrounding environment) and a depth of no less than 2 in. (51 mm) greater than the maximum source rod depth or a minimum depth of 9 in. (229 mm) for the backscatter method (ASTM D 2922).

3.2.2 Density Verification block(s) engineered with a known, constant and heterogeneous assigned density accurate within ± 0.5% (AASHTO T 310-00). The density shall be within the typical range of material encountered in the field. **Blocks used for the calibration of the nuclear gauges shall not be used to verify their calibration.** Verification blocks shall conform to the dimensions of Part B of AASHTO T 310.

3.2.3 Three (3) Moisture Calibration blocks of known, constant and homogeneous equivalent moisture content, which cover the entire range of moisture contents expected to be encountered in the field. Moisture Calibration blocks shall be engineered from materials containing chemically bound hydrogen that can be maintained at a constant, homogenous hydrogen content. Standards shall conform to the dimensions and minimum clearances specified in Part 3.2.1 (above).

3.2.4 Calibration, Verification and Moisture blocks shall be protected from variations in density and moisture. The blocks may be placed adjacent to each other; however, a minimum clearance of 3.0 ft. (1 m) from walls or other structures and 30.0 ft. (9 m) from another radioactive source shall be maintained (unless otherwise specified by the manufacturer). Blocks of soil and concrete that are stable and generate reproducible results are difficult to prepare and maintain, and are therefore not recommended.

3.3 Software capable of calculating the calibration curve or equivalent coefficients utilizing the method described herein and reporting the necessary gauge parameters, graphs and data.

4. Procedures

4.1 Density Calibration and Verification

4.1.1 Verify or reproduce calibration curves or equivalent coefficients at least every 24 months, after all repairs and initially when gauge is received from the manufacturer. Thin-lift gauges shall be verified or re-calibrated at least every 12 months (VDOT Road and Bridge Specifications. Section 315.05(e).

4.1.2 Gauge precision shall be verified prior to the calibration and verification procedures; gauges shall meet the precision requirements for stability and drift of the manufacturer's specifications before calibration and verification is performed.

4.1.3 An existing calibration is considered as being verified if a sufficient number of counts at each measurement depth on one or more of the native material Standard blocks and a Verification block shows the existing calibration to be accurate within ±2.0 lbs/ft^3 (±32.0 kg/m^3)at each measurement depth.

4.1.4 Taking into account the chemical composition of the Standard block material, assigned densities shall be used for metallic blocks. This shall be done by multiplying the true, known (actual) density by a mass attenuation factor (consult manufacturer). Material types, actual densities and assigned densities shall be reported as part of the calibration data.

4.1.5 The computation method used in establishing the calibration curve or equivalent coefficients shall be the same as that used by the gauge to determine density. Test procedures used for obtaining calibration count rate data shall be the same as that used to obtain count rates or density in the field.

4.1.6 Sufficient data shall be taken at each depth on each density Standard block to ensure a measured count precision of at least 50% of the precision required in the field.

4.1.7 The calibration curve for each source rod depth shall be parallel to the best-fit curve of the three non-native material Standard blocks with assigned densities and an equal distance from the calibration points of both the limestone and granite Standard blocks. Equivalent coefficients shall define such a line when input into the equation used by the gauge to calculate density.

4.1.8 The gauge shall be calibrated so as to produce a calibration response within ±1.0 lbs/ft^3 (±16.0 kg/m^3) of the assigned densities of the Standard Calibration blocks.

4.1.9 Calibrations using historic calibration curve data have been found to be satisfactory. Calibration curves derived using historic data shall be parallel to the historic curve and shall pass through the new calibration point(s). Equivalent coefficients shall define such a line when input into the equation used by the gauge to calculate density. Calibrations are performed using the following steps:

4.1.9.1 Turn on the gauge by pressing the “ON” button at the bottom of the display panel.

4.1.9.2 After a few seconds, the gauge performs a self-test for 300 seconds, when it is complete, press any key, and the gauge will enter into the "ready" mode.

4.1.9.3 Refer to the manufacturer's manual to clear the gauge's memory and to prepare for re-entering the parameters needed to perform the calibration.

4.1.9.4 Perform a statistical stability and drift test. The stability test is performed to ensure that the gauge's electronics are functioning properly~~,~~ and the drift checks the long-term drift in the gauge readings. Refer to the gauge manufacturer's manual for detailed information on performing these tests procedures.

4.1.9.5 Place the reference block on top of the limestone Calibration block. With the gauge in the safe position, place the gauge on the reference block between the raised edges with the right side of the gauge firmly seated against the metal butt plate on the block. Initiate performance of Standard Counts. Once the gauge has performed four standard counts, do not turn the gauge off, but review the results and assure that all four counts are within tolerances for moisture and density. If counts are not within tolerance, clear the memory and repeat the procedure.

4.1.9.6 Providing the stability, drift and Standard Count tests are acceptable; begin collecting data on each of the five Calibration blocks. All data shall be recorded on the calibration worksheet. Please note that at the start of the calibration procedure four moisture counts have to be taken on the magnesium block along with the density counts. Two counts in the backscatter position and two in the 4" (102 mm) position for the moisture counts. Record the results on the calibration worksheet in the table titled "Moisture Calibration" in the counts column under the label Mg which stands for magnesium.

4.1.9.7 Begin by taking two one-minute counts on the magnesium Calibration block in the backscatter position; record both moisture and density on the calibration worksheet. The next set of counts will be in the 4" (102 mm) position, again recording both moisture and density. Repeat the procedure for the 6″ (152 mm) position, but this time just record the density counts. Repeat the procedure again in the 8" (203 mm) position and record the density counts. Repeat this same procedure for the remaining four Calibration blocks.

4.1.9.8 Obtain the average count on each Calibration block for backscatter and each depth of direct-transmission data collected and record on the worksheet.

4.2 Moisture Calibration and Verification

4.2.1 An existing calibration is considered as being verified if a sufficient number of counts on one or more of the Moisture Calibration blocks shows the existing calibration to be accurate within ±1.0 lbs/ft^3 (±16.0 kg/m^3). Moisture Calibration blocks may be used for verification.

4.2.2 The computation method used in establishing the calibration curve or equivalent coefficients shall be the same as that used by the gauge to determine moisture. Test

procedures used for obtaining calibration count rate data shall be the same as that used to obtain count rates or moisture in the field.

4.2.3 Sufficient data shall be taken on each moisture Calibration block to ensure a measured count precision of at least 50% of the precision required in the field.

4.2.4 The calibration curve shall be the best-fit line of the three Calibration Standard block equivalent moistures. Equivalent coefficients shall define such a line when input into the equation used by the gauge to calculate moisture.

4.2.5 The gauge shall be calibrated so as to produce a calibration response within ±1.0 lbs/ft^3 (±16.0 kg/m^3) of the equivalent moistures of the Moisture Calibration blocks. The equivalent moisture content of each Standard block shall be reported as part of the calibration data.

4.2.6 Take four one-minute counts for the moisture calibration. These counts are performed with the gauge in the backscatter position.

4.2.7 Record the results on the calibration worksheet.

4.2.8 Obtain the averages for each of the Moisture Calibration blocks and record on the worksheet.

5. Results of Density and Moisture Calibrations

5.1 Once all of the calibration data has been averaged, connect the serial cable and printer to the port on the gauge print out the stability and drift data for the density and moisture.

5.2 Obtain the averages for the density and the moisture from the data on the printout.

5.3 Record the averages on the calibration worksheet. Note: the calibration worksheet is now complete.

5.4 Enter all the data averages from the calibration worksheet into the computer program.

5.5 Once the computer has processed the data, print out the results. The printout contains the constants to be entered into the gauge’s memory.

5.6 Follow the manufacturer’s instructions for entry to input the constants into the gauge’s memory.

6. Reports

The statistical stability and drift tape, calibration worksheet and the computer program data sheet are permanent records to be filed in the gauge’s folder listed by the gauge's serial number.

Virginia Test Method – 115

Viscosity of Epoxy Resins – (Chemistry Lab)

April 1, 2002

1. Scope

1.1 To establish a consistent method in which to analyze epoxy samples for viscosity.

1.2 The values stated in English 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. Summary of Test

2.1 Epoxy resin is mixed for three minutes then placed on a Brookfield Viscometer. The instrument measures the viscosity in centipoises and this is converted to poises.

Virginia Test Method – 120

Method of Test For Measurement of Permeability of Bituminous Paving Mixtures Using a Flexible Wall Permeameter - (Asphalt Lab)

October 6, 2005

1. Scope

1.1 This test method covers procedures for determining the relative permeability (also referred to as coefficient of permeability) of water-saturated laboratory compacted specimens or field cores of compacted asphalt concrete mixtures using a flexible wall falling head permeameter.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards

D 4867 Effect of Moisture on Asphalt Concrete Paving Mixtures

2.2 AASHTO Standards:

T 312 Preparing and Determining the Density of Hot-Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

T 283 Resistance of Compacted Bituminous Mixture to Moisture Induced Damage

T 166 Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens

T 275 Bulk Specific Gravity of Compacted Mixtures Using Paraffin-Coated Specimens

T 209 Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures

3. Summary of Test Method

3.1 A falling head permeability test is used to determine the rate of flow of water through a saturated specimen. Water from a graduated standpipe is allowed to flow through the saturated asphalt concrete mixture specimen and the time interval to reach a known change in head is recorded. The coefficient of water permeability of the compacted paving mixture is then determined based on Darcy's Law. Two methods of testing and analysis are the regression method and the single-point check.

4. Significance and Use

4.1 This test method provides an indication of the water permeability of water-saturated samples. It applies to one-dimensional, laminar flow of water.

4.2 It is assumed that Darcy's Law is valid and that the permeability is essentially unaffected by hydraulic gradient. The validity of Darcy's Law may be evaluated by measuring the hydraulic conductivity of the specimen at three hydraulic gradients. If all measured values are similar (i.e. within approximately 25%), then Darcy's Law may be taken as valid.

5. Apparatus

5.1 Permeameter – See Figure 2. The device shall meet the following requirements:

5.1.1 A graduated cylinder, having an inner diameter of 31.75 ± 0.50 mm (1.25 ± 0.02 in.), graduated in millimeters and capable of dispensing approximately 500 ml (17 oz.) of water.

5.1.2 A sealing tube using a flexible latex membrane 0.635 mm (0.025 in.) thick and capable of confining asphalt concrete specimens up to 152.4 mm (6.000 in.) in diameter and 80.0 mm (3.15 in.) in height.

5.1.3 A cap assembly for supporting the graduated cylinder and expanding an o-ring against the sealing tube. The opening in the cap shall be of the same diameter as the outer diameter of the graduated cylinder mentioned previously in 5.1.1. The underside of the cap assembly should be tapered at an angle of 10 ± 1° (see Figure 2.)

5.1.4 A pedestal plate for supporting the asphalt concrete specimen and expanding an o-ring against the sealing tube. The opening in the pedestal plate should have a minimum diameter of 18 mm (0.71 in.). The top side of the lower cap should be tapered at an angle of 10 ± 1° (see Figure 2).

5.1.5 O-rings of sufficient diameter and thickness for maintaining a seal against the sealing tube.

5.1.6 A frame and clamp assembly for supplying a compressive force to the cap assembly and pedestal plate necessary to expand the o-rings.

5.1.7 An air pump capable of applying 103 kPa (15 psi) pressure to the specimen as well as vacuum to evacuate the air from the sealing tube/membrane cavity.

5.1.8 A pressure gauge with range 0 to 103 kPa (15 psi) with ± 2% accuracy.

5.1.9 Quick connects for both vacuum and pressure lines.

5.1.10 An outlet pipe, 50.8 mm (2.0 in.) long with an inside diameter of 18 mm (0.71 in.).

5.1.11 Valve positioned upstream of the outlet pipe.

NOTE 1: A device manufactured by the Karol-Warner Company has been found to meet the above specifications (See Figure 2).

5.2 Vacuum container, Type E, described in T209.

5.3 Vacuum pump, specified in T 209.

5.4 Manometer or Pressure Regulator, specified in ASTM D 4867.

5.5 Spacer, described in AASHTO T 283.

5.6 Balance, meeting the requirements specified in T166.

5.7 Water bath, meeting the requirements specified in T166.

5.8 Stopwatch, or other timing device capable of measurements to at least the nearest 0.1 s and accurate to within 0.05% when tested over intervals of not less than 15 min.

5.9 Meter stick, capable of measuring to the nearest 1 mm (0.5 in.).

5.10 Caliper, capable of measuring to the nearest 0.1 mm (0.01 in.) for measuring specimen dimensions.

5.11 Thermometer, calibrated thermometer capable of measuring the temperature of water to the nearest 0.1^{o}C (0.2^{o}F).

5.12 Graduated Cylinder, 100 ml minimum capacity with 1 ml or smaller graduations.

5.13 Saw, with diamond impregnated blade for wet cutting of specimens to the desired thickness. Dry cut type saws shall not be used.

5.14 Sealing Agent (petroleum jelly), to produce a watertight seal between the specimen and the flexible wall membrane of the permeameter

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5.15 Spatula, for applying the petroleum jelly sealant to the sides of the specimen.

5.16 Electric fan, for drying the wet cut specimens.

6. Reagents

6.1 Supply of clean, non-aerated tap water at room temperature. Water should be stored in a container (5 gal. (20 L) Minimum) for at least 12 hours. Caution: A faucet screen can tend to aerate tap water.

7. Preparation of Test Specimens

7.1 Laboratory prepared specimens:

7.1.1 Specimens shall be prepared in accordance with AASHTO T 312.

7.1.2 Specimens shall be compacted to the required thickness (Table 1) and densities by setting the gyratory compactor in height mode.

NOTE 2: Thinner samples may need additional plates prior to the compaction process. Also recommend inserting a paper disk between plates for buffer to avoid additional wear. Please contact manufacturer for recommendations

7.1.3 REGRESSION METHOD

It is recommended that 3 sets of specimens composed of 3 specimens per set be made in the range of air void contents believed to encompass a range of permeabilities of 50×10^{-5} cm/sec to 500×10^{-5} cm/sec.

7.1.4 SINGLE-POINT CHECK

Compact 5 specimens with an average air void content equal to or greater than 7.5%. The range of air voids for individual specimens should be equal to or less than 1.0%.

NOTE 3. If a single point check is going to be used for rollover mix design approval, then volumetric data for the day of production, the day prior and the following day must be submitted in addition to permeability data.

7.1.5 For some mixes compaction in thin lifts might be difficult. If approximately 7.5% air voids can not be attained specimens may be compacted in a thicker lift (75 $\pm$ 12mm) (3 ± 0.5 in.) and sawed a single time with a wet saw to the required thickness. The bottom surface should be discarded.

7.1.6 After compaction, specimens shall be allowed to cool to room temperature.

7.1.7 Using a caliper, measure the height and diameter to the nearest 0.5 mm (0.02 in.). Individual height measurements shall be taken at four different locations equidistant around the specimen. The diameter shall be 151 $\pm$ 3 mm (6 ± 0.1 in.)measured in two perpendicular directions.

7.1.8 Determine the bulk specific gravity of the specimen in accordance with AASHTO T 166. Sawn specimens shall be dried in accordance to AASHTO T 275, Method A,

Note 1, to a constant mass. Once the dry mass has been obtained, the bulk specific gravity may be calculated.

Table 1. Required average specimen heights matching mixture nominal maximum size aggregate

Nominal Maximum Aggregate Size, in. (mm)	Specimen Height, in. (mm)
3/8 (9.5)	1.5 ± 0.1 in. (38.1 ± 2)
½ (12.5)	1.5 ± 0.1 in. (38.1 ± 2)
¾ 19.0	2.0 ± 0.1 in. (50.8 ± 2)
1 (25.0)	2.5 ± 0.1 in. (63.5 ± 2)
1 ½ (37.5)	3.0 ± 0.1 in. (76.2 ± 2)

7.2 Roadway cores:

7.2.1 Separation of individual pavement layers or removal of tack coat and underlying pavement that would otherwise affect test results may require wet sawing. Prior to wet sawing, the specimen should be soaked in an ice-water bath for a minimum of twenty minutes. Layers can also be separated by hammer and chisel if approved by the engineer.

7.2.2 Wash the test specimen thoroughly with water to remove any loose, fine material produced by the sawing.

7.2.3 Determine the bulk specific gravity of the specimen in accordance with AASHTO T 166. For roadway cores that require no petroleum jelly, the final dry weight shall be measured after completion of the permeability measurements. The specimen shall be dried in accordance with AASHTO T275, Method A, Note 1 to a constant mass. Once the dry weight has been obtained, the bulk specific gravity may be determined.

7.2.4 Using the caliper, measure and record the height and diameter of the specimen to the nearest 0.5 mm (0.02 in.) or better. Individual height measurements shall be taken at four different locations and the two diameter measurements shall be taken perpendicular to each other. The four individual height measurements shall not vary by more than 5 mm (0.2 in.). The diameter of the specimen shall not be less than 148.0 mm (5.827 in.) nor greater than 154.0 mm (6.063 in.).

8. Saturation of Test Specimens

8.1 Place the specimen in a horizontal or vertical position in the vacuum container. If the horizontal position is used it shall be supported above the container bottom by a spacer. Fill the container with water at room temperature so that the specimens have at least 25 mm (1.0 in.)of water above any surface.

8.2 Remove trapped air and saturate the specimen by applying increased vacuum gradually until the residual pressure manometer reads 90 ± 2 mm of Hg. Maintain this residual pressure for 15 ± 2 minutes.

8.3 At the end of the vacuum period, release the vacuum by slowly increasing the pressure. Allow the specimen to stand undisturbed for a minimum of 5 minutes. The specimen

may be tested after this time or quickly transferred to another container where it will remain submerged until ready for testing.

9. Permeameter Setup

9.1 With the permeameter completely assembled (with a specimen of the size to be tested), use the meterstick to measure a distance of 20 ± 1 cm (8 ± 0.5 in.) from the top of the specimen and place a mark onto the standpipe. This mark will be designated as the lower timing mark.

NOTE 4: Complete assembly is important since the springs of the cap assembly must be fully compressed in order to insure an accurate distance measurement.

9.2 Using the meterstick, establish a mark on the graduated cylinder at a distance of 63.0 ± 0.1 cm (25 ± 0.05 in.) from the lower timing mark. This shall be designated as the upper timing mark. Additional timing marks may be established at intermediate intervals (e.g. at 1.0 cm or 0.25 in. intervals) in order to expedite the testing of mixtures having low permeability.

NOTE 5: If the permeameter's graduated cylinder has manufacturer established timing marks, then steps 9.1 – 9.2 should be done to verify that the timing marks have been properly positioned.

10. Testing Procedure

10.1 Disassemble the permeameter specimen cylinder from the permeameter base.

10.2 Connect the pressure line of the permeameter to the vacuum side of the pump. Using the pump, apply a vacuum to the flexible wall to remove entrapped air and collapse the membrane to the inside diameter of the cylinder. This will facilitate loading of the specimen.

10.3 With the flow control valve open, fill the outlet pipe with water until the taper in the base plate pedestal overflows.

10.4 For laboratory compacted specimens, it is necessary to apply a thin layer of petroleum jelly to the sides of the specimen to achieve a satisfactory seal between the membrane and the specimen. This shall be accomplished using a spatula or similar instrument. Sealant shall be applied ONLY to the sides of the specimen. Remove the specimen from the vacuum container filled with water, apply the petroleum jelly sealant to the sides, and then quickly place the specimen on the pedestal of the permeameter. If specimens have been sawn the sawn surface should be placed on the bottom plate of the permeameter. For roadway core specimens, remove the specimen from the vacuum container filled with water, and then quickly place the specimen on the pedestal of the permeameter.

NOTE 6: Petroleum jelly shall not be used on roadway cores.

10.5 Expeditiously reassemble the permeameter making sure that all connections and clamps are tightened.

10.6 Disconnect the pressure line from the vacuum side of the pump and connect it to the pressure side.

10.7 Apply a confining pressure of 96.5 ± 7.0 kPa(14 ± 1 psi).

NOTE 7: Watch for fluctuations in confining pressure since these may be the result of insufficient seal or a hole in the flexible membrane. Care should be exercised to ensure that the confining pressure remains constant throughout the test.

10.8 Fill the permeameter graduated cylinder until water begins to flow from the outlet tube. Exercise care when filling to minimize the incorporation of air bubbles.

10.9 Close the flow control valve.

10.10 Carefully lean the permeameter from side to side to allow the escape of any entrapped air. Continue this operation until all entrapped air has been removed.

10.11 Fill the graduated cylinder above the upper timing mark (h1).

10.12 Commence the water flow by opening the flow control valve of the permeameter. Allow the water to flow through the specimen from the upper timing mark to the lower timing mark to help ensure that all air is removed from the apparatus and specimen.

10.13 Refill the graduated cylinder and start the timing device when the bottom of the meniscus of the water reaches the upper timing mark. Allow water to flow until the water level reaches the lower timing mark (h2). Once the water level reaches the lower timing mark, stop the timing device and close the valve. Record the elapsed time to the nearest second.

10.14 Saturation of the specimen and removal of air may require several test runs. Therefore, steps 10.11 – 10.13 must be repeated if three consecutive time measurements differ by more than ten percent (10%) of the average of the three times. The average of the last three permeability results that meets the time criteria listed above is the permeability of the specimen.

NOTE 8: If the test time is approaching ten minutes during the first test run without the water reaching the lower timing mark, then the test may be terminated at the nearest cm mark corresponding to ten minutes and the water level at this time recorded. In this case, the test should be conducted one additional time by allowing water to flow for approximately ten minutes and recording the water mark at this time with the average of the two elapsed time measurements being recorded for use in calculating the permeability.

10.15 Measure and record the temperature of the permeate water in the system to the nearest 1.0º F (0.5º C).

10.16 After three successful runs meeting the repeatability criteria of 10% have been performed release the pressure from the permeameter, remove the clamp assemblies, upper cap and specimen. Wipe clean any excess sealant off of the latex membrane.

NOTE 9: Before running road cores you should replace the latex membrane to ensure no sealant will damage the road core or affect subsequent mixture test results.

11 Calculation

11.1 The coefficient of water permeability, k, is determined using the following equation:

$$k = \frac{al}{At} \ln\left(\frac{h_1}{h_2}\right)$$

Where,

k = coefficient of water permeability, cm/s
a = inside cross-sectional area of inlet standpipe, cm^2
l = thickness of test specimen, cm
A = cross-sectional area of test specimen, cm^2
t = average elapsed time of water flow between timing marks, s
h_1 = hydraulic head on specimen at time t_1, cm
h_2 = hydraulic head on specimen at time t_2, cm
ln = natural logarithmic function

11.2 Correct the calculated permeability to that for 68° F (20° C) , k_{20}, by multiplying k by the ratio of the viscosity of water at the test temperature to the temperature of water at 68° F (20° C), R_T, from Table 2, as follows

$$k_{20} = R_T k$$

12. Report

12.1 Report the following information:

12.1.1 Specimen identification,
12.1.2 Mixture type/description,
12.1.3 Sample type (i.e. lab prepared or roadway core),
12.1.4 Sample air voids,
12.1.5 Water temperature,
12.1.6 Regression Method - Coefficient of water permeability is reported to the nearest whole unit x 10^{-5} cm/s. Plot Log Permeability vs. Percent Air Voids for the lab specimens. EXCEL can be used to plot Log Permeability vs. Percent Air Voids in order to determine whether the predicted permeability at 7.5% air voids is equal to or less than 150 x 10^{-5} cm/sec (Figure 1). An exponential trendline available under EXCEL is used to determine the permeability.
12.1.7 Single-Point Check – Coefficient of water permeability is reported to the nearest whole unit x 10^{-5} cm/sec. Also, report the average air voids and average permeability of the 5 specimens. The average permeability must be less than 150 x 10^{-5} cm/sec.
12.1.8 Volumetric Data – For the Single-Point Check, when using plant produced material, volumetric data for that day's production, the previous day's production, and the following day's production should be submitted.

NOTE 10: An EXCEL spreadsheet can be provided by VDOT to assist in calculating and reporting the permeability data.

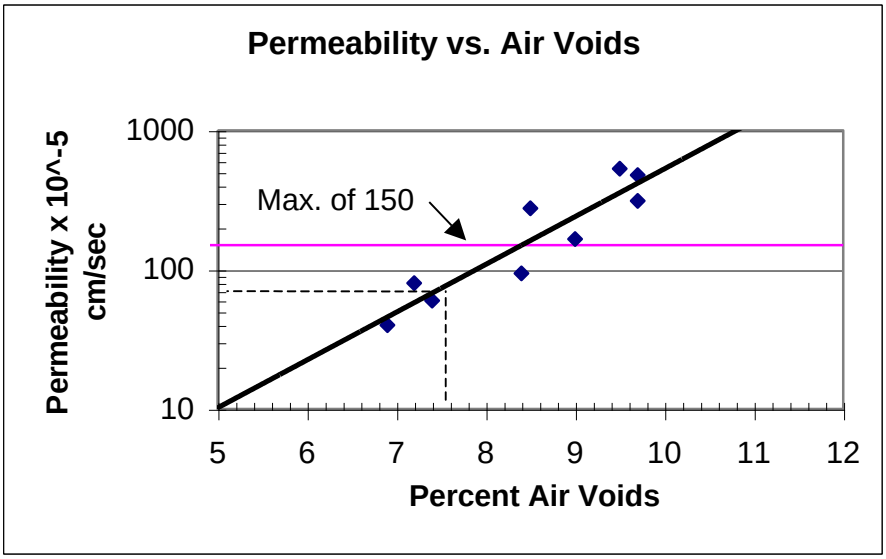
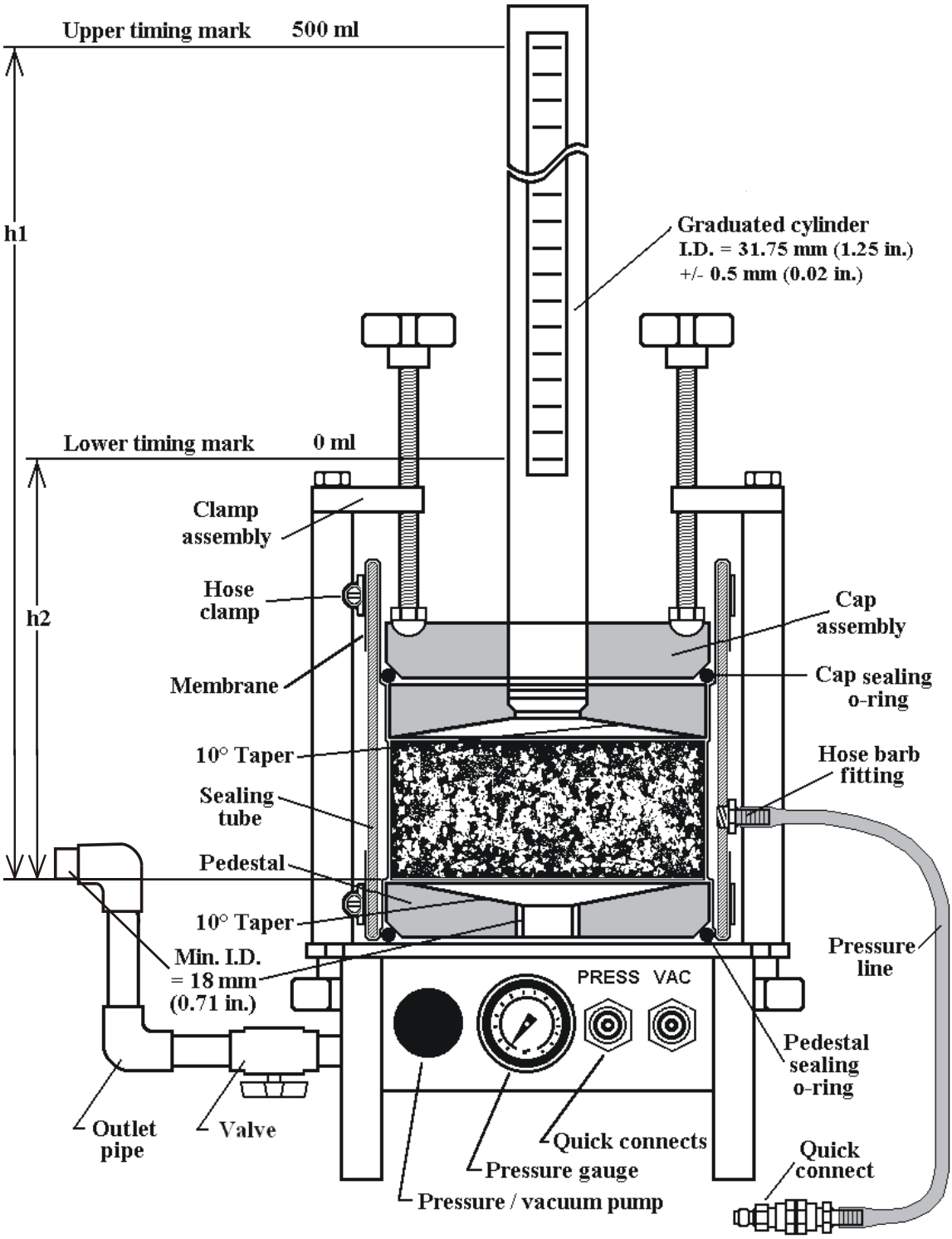


Figure 1. Typical plot of laboratory permeability data

TABLE 2. Correction Factor, R_T, for Viscosity of Water at Various Temperatures

Temperature, °C	R_T	Temperature, °C	R_T
15.0	1.135	25.0	0.889
15.5	1.121	25.5	0.879
16.0	1.106	26.0	0.869
16.5	1.092	26.5	0.860
17.0	1.077	27.0	0.850
17.5	1.064	27.5	0.841
18.0	1.051	28.0	0.832
18.5	1.038	28.5	0.823
19.0	1.025	29.0	0.814
19.5	1.013	29.5	0.805
20.0	1.000	30.0	0.797
20.5	0.988	30.5	0.789
21.0	0.976	31.0	0.780
21.5	0.965	31.5	0.772
22.0	0.953	32.0	0.764
22.5	0.942	32.5	0.757
23.0	0.931	33.0	0.749
23.5	0.921	33.5	0.741
24.0	0.910	34.0	0.733
24.5	0.900	34.5	0.725

Figure 2 – Water Permeability Testing Apparatus (not to scale).



Virginia Test Method – 121

Sample Preparation and Calculations for Flat and Elongated Testing by ASTM D 4791 – (Asphalt Lab)

April 17, 2007

1. Scope

1.1 *This test method covers a procedure for securing an aggregate test sample, reducing the sample to test size and performing the appropriate calculations for flat and elongated testing. The sample may be drawn from an aggregate stockpile or the aggregates from an ignition oven sample*. AASHTO testing procedures allow multiple methods of reducing samples to test size. These multiple methods when used in various combinations may affect the variability between laboratory test results in flat and elongated particle testing. This test method serves as a guide in obtaining the most representative sample for testing flat and elongated particles and *performing the required calculations*.

1.2 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards:
D 4791 Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

2.2 AASHTO Standards:
T 2 Sampling of Aggregates
T 27 Sieve Analysis of Fine and Coarse Aggregates
T 30 Mechanical Analysis of Extracted Aggregate
T 248 Reducing Samples of Aggregate to Testing Size

2.3 *Virginia Test Methods:*
VTM 102 Determination of Asphalt Content From Asphalt Paving Mixtures by the Ignition Method

2.4 *Virginia Transportation Research Council:*
VTRC 06-R10 Comparison of Alternative Devices to Determine Aggregate Shape, McGhee, Rorrer and Deeds, 2005

3. Summary of Test Method

Stockpile Sample

3.1 A small representative aggregate stockpile is created with power equipment from a large production stockpile. This small mini-stockpile is then sampled at multiple locations to obtain the appropriate sized field sample based on the nominal maximum aggregate size of the aggregate in the stockpile. This field sample is then reduced using mechanical splitters to obtain a laboratory sample large enough to perform a sieve analysis.

Ignition Oven Sample

3.2 The testing of aggregate recovered from plant or laboratory produced hot mixed asphalt (HMA) for flat and elongated particles may also be desired, in this case follow the sampling procedures as outlined in VTM 102 and perform the sieve analysis in accordance with AASHTO T-30.

3.3 Once the sieve analysis is complete, on a stockpile or ignition oven sample, the material retained on each sieve larger than the No. 4 (4.75 mm) sieve is then further reduced to obtain particles that are measured to determine the amount of flat and elongated particles. The weight of the flat and elongated particles is expressed as a percentage of the material retained on and above the No. 4 (4.75 mm) sieve.

4. <u>Sampling Procedure</u>

Stockpile Sample

4.1.1 Locate a dry level area free of contamination.

4.1.2 With power equipment create a small stockpile for sampling by drawing material from various levels and locations in the main stockpile. With the blade of the loader bucket back drag the mini-stockpile to produce a level surfaced stockpile of a uniform thickness

4.1.3 A minimum of four representative increments of material should then be sampled from this mini-stockpile using a square-nosed shovel to create a field sample. The size of the field sample should meet the requirements of AASHTO T2.

4.1.4 The field sample shall be reduced/split down to appropriate size for gradation testing in accordance with AASHTO T248, Method A - Mechanical Splitter.

4.1.5 The test sample for gradation testing shall meet the minimum requirements for sample size as set forth in AASHTO T27. The test sample size should be large enough so that there is enough material retained on the ¾”, ½”, 3/8” and No. 4 (19.0, 12.5., 9.5, and 4.75 mm) sieves to perform the flat and elongated test, i.e. there are at least approximately 100 particles on each sieve retaining 10 percent or more of the material. This usually will require a Gilson shaker.

<u>Note 1:</u> Using 8” or 12” (200 or 300 mm) diameter sieves when a full size Gilson shaker is not available may require that several sieving operations be performed to properly complete the sieve analysis process.

<u>Note 2:</u> Great care shall be taken to avoid over loading of individual sieves, especially when using 8” or 12” (200 or 300 mm) diameter sieve nests to perform sieve analysis.

4.1.6 The sieve analysis/gradation shall be performed on the sample according to AASHTO T27 requirements.

Ignition Oven Sample

4.2 Aggregates retained on the sieves during the testing of HMA in accordance with VTM 102 and AASHTO T 30 (ignition oven extraction and Mechanical Analysis of Extracted Aggregate respectively) may be used for flat and elongated testing in accordance with the following procedures.

_____Reducing to Test Size

4.3.1 Flat & Elongated particle testing in accordance with ASTM 4791 shall be performed on each size fraction greater than and including the No. 4 (4.75 mm) sieve that contains more than 10 percent by weight of the total aggregate. The material for each size fraction meeting these criteria shall be obtained from the material separated during the sieve analysis process.

4.3.2 A representative sample of approximately 100 particles shall be obtained from each size fraction (¾", ½", 3/8" and No. 4 sieve) (19.0, 12.5., 9.5, and 4.75 mm sieve) in accordance with AASHTO T248, Method A - Mechanical Splitter. In lieu of counting the particles, the following table will provide a guide for the necessary weight required for each individual size fraction to ensure approximately 100 are obtained through the sample reduction process:

Size/Fraction	Weight Range
-1-1/2" x +1" (- 37.5 mm x +25.0 mm)	
-1" x +¾" (- 25.0 mm x +19.0 mm)	1200 – 1500 g.
-3/4" x +1/2" (- 19.0 mm x +12.5 mm)	350 – 700 g.
-1/2" x +3/8" (- 12.5 mm x +9.5 mm)	160 –300 g.
-3/8" x +#4 (- 9.5 mm x +4.75 mm)	50 – 120 g.

Note 3: The table above references materials with Specific Gravity ranges of 2.65 to 3.00. The purpose of the table is to reduce the opportunity for counting of particles, which may lead to some selective choosing of particles for the test.

Note 4: *When less than 100 particles of aggregate are retained on a sieve during AASHTO T30, but still represent more than 10 percent of the total sample, then no further reduction is required and all retained particles for that sieve shall be tested.*

5. <u>Procedure</u>

5.1 Each size fraction of approximately 100 particles shall then be tested for *flat and elongated particles of aggregate* according to ASTM D 4791, using the *length to thickness* procedure.

5.2 On proportional caliper devices similar to that shown in ASTM D 4791, set the larger opening equal to the maximum dimension *(length)* of the particle. The particle is flat and elongated for the set ratio if the particle when orientated to measure the *thickness* can pass completely through the smaller opening of the caliper. Care should be taken to ensure that the proportional caliper used to measure F & E is properly calibrated.

5.3 *On the vertical digital calipers w/ horizontal plates as described in VTRC 06-R10, the particle's flat and elongated ratio will be determined by the software when the length and thickness are measured between the two plates.*

5.4 Upon completion of particle measurements, the number of particles actually measured for each size fraction should be counted and recorded.

5.5 All calculations and documentation shall be according to ASTM D 4791 requirements.

6. Calculations

6.1 Calculate the percentage of flat and elongated particles to the nearest 0.1% in each size fraction from the No.4 (4.75 mm) sieve upward. The calculation is to be done on the basis of mass of the flat and elongated particles, not the number of particles.

6.2 The weighted average for the sample will be reported. Size fractions not tested (those representing less than 10% of the sample) will be assigned the same percentage of flat and elongated particles as the next smaller or next larger size, or use the average of the next smaller and larger sizes, if both are present.

6.3 Report the total percentage of flat and elongated particles to the nearest 0.1%.

6.4 Examples of a blank worksheet, a completed worksheet with detailed calculations and a completed worksheet as it should be submitted follow on the next four pages.

Virginia Department of Transportation
Flat & Elongated Test

ASTM D4791

Sample ID: _____ Project # _____ Job Mix # _____
District: _____ Location: _____ Producer: _____
Sample # _____ Mix Type: _____ Plant: _____
Lot # _____ Sample Date: _____ Technician: _____
Date Tested: _____

GRADATION					FLAT AND ELONGATED TESTING										
						5:1 Ratio			3:1 Ratio			2:1 Ratio			
			A	B	C	D	E	F	D	E	F	D	E	F	
U.S. Stand Sieve No.	Weight (g)	Percent Passing	Percent Retained	+ No.4 (4.75mm) % Retained	Weight Total Particles Tested (g)	Weight (g)	Percent	Weighted Average	Weight (g)	Percent	Weighted Average	Weight (g)	Percent	Weighted Average	
1 1/2in. (37.5mm)															
1 in. (25.0 mm)															
3/4 in. (19.0 mm)															
1/2 in. (12.5 mm)															
3/8 in. (9.5 mm)															
No.4 (4.75 mm)															
No. 8 (2.36 mm)					**Totals**										
No. 16 (1.18 mm)															
No. 30 (600 microns)															
No. 50 (300 microns)															
No. 100 (150 microns)															
No. 200 (75 microns)															
Pan															
Total															

Weight of original sample. _____ g

Weight after washing. _____ g

1) $\text{Col. B} = \left[\dfrac{\text{Col. A}}{\left(\dfrac{\text{Sum of \% retained} \geq \text{No. 4 (4.75 mm) sieve}}{100} \right)} \right]$

2) Col. C is the Total Weight of the ≈ 100 Particles

3) Col. D is the Weight of the Failed Particles

4) $\text{Col. E} = \left[\left(\dfrac{\text{Col. D}}{\text{Col. C}} \right) \times 100 \right]$

5) $\text{Col. F} = \left[\left(\dfrac{\text{Col. B}}{100} \right) \times \text{Col. E} \right]$

6) F & E Value = Sum of Col. Total

Aggregate Type	Total No. Particles	No. Particles Failed (5:1)	No. Particles Failed (3:1)

Comments: _____

Copies To:
District Materials (1)
Central Office Materials (1)
Prime Contractor (1)
VTRC (1)

Flat & Elongated Test

ASTM D4791

Sample ID:		Project #		Job Mix #	
District:		Location:		Producer:	
Sample #		Mix Type:		Plant:	
Lot #		Sample Date:		Technician:	
Date Tested:					

GRADATION						FLAT AND ELONGATED TESTING								
						5:1 Ratio			3:1 Ratio			2:1 Ratio		
			A	B	C, Meas.	D, Meas.	E	F	D, Meas.	E	F	D, Meas.	E	F
U.S. Stand Sieve No.	Weight Retained	Percent Passing	Percent Retained	+ # 4 % Retained	Weight Total Particles Tested (g)	Weight	Percent	Weighted Average	Weight	Percent	Weighted Average	Weight	Percent	Weighted Average
37.5mm, 1 1/2 in.		100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
25.0 mm, 1 in.		100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
19.0 mm, 3/4 in.		100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
12.5 mm, 1/2 in.	34.1	98.3	1.7	**1.9**										
9.5 mm, 3/8 in.	516.8	72.4	25.9	**28.4**										
4.75 mm, No. 4	1270.1	8.8	63.6	**69.7**										
2.36 mm, No. 8	162.6	0.7	8.1		**Totals**	Total 5:1 % F & E =			Total 3:1 % F & E =			Total 2:1 % F & E =		
1.18 mm, No. 16	3.0	0.6	0.2											
600 microns, No. 30	0.5	0.5	0.0											
300 microns, No. 50	0.6	0.5	0.0											
150 microns, No. 100	0.7	0.5	0.0											
75 microns, No. 200	1.5	0.4	0.1											
Pan	1.5		0.4											
Total	1991.4		100.0											

Weight of original sample. 1997.8 g

Weight after washing. 1991.3 g

SAME FOR BOTH 3:1 AND 5:1

SUM OF + #4 AND LARGER SIEVES = 91.2

Or, 100 - % Passing 4.75 MM = 100 - 8.8 = 91.2

+ #4 % RETAINED CALCULATIONS:

1/2" 1.7 / 91.2 X 100 = **1.9%**

#4 63.6 / 91.2 X 100 = **69.7%**

3/8" 25.9 / 91.2 X 100 = **28.4%**

Flat & Elongated Test

ASTM D4791

Sample ID:		Project #		Job Mix #	
District:		Location:		Producer:	
Sample #		Mix Type:		Plant:	
Lot #		Sample Date:		Technician:	
Date Tested:					

GRADATION						FLAT AND ELONGATED TESTING								
						5:1 Ratio			3:1 Ratio			2:1 Ratio		
			A	B	C, Meas.	D, Meas.	E	F	D, Meas.	E	F	D, Meas.	E	F
U.S. Stand Sieve No.	Weight Retained	Percent Passing	Percent Retained	+ #4 % Retained	Weight Total Particles Tested (g)	Weight	Percent	Weighted Average	Weight	Percent	Weighted Average	Weight	Percent	Weighted Average
37.5mm, 1 1/2 in.		100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
25.0 mm, 1 in.		100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
19.0 mm, 3/4 in.		100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
12.5 mm, 1/2 in.	34.1	98.3	1.7	**1.9**	0.0				0.0	6.0 *	0.1			
9.5 mm, 3/8 in.	516.8	72.4	25.9	**28.4**	255.7				15.3	6.0	1.7			
4.75 mm, No. 4	1270.1	8.8	63.6	**69.7**	76.9				15.4	20.0	13.9			
2.36 mm, No. 8	162.6	0.7	8.1		**Totals**	Total 5:1 % F & E =			Total 3:1 % F & E =		15.7	Total 2:1 % F & E =		
1.18 mm, No. 16	3.0	0.6	0.2											
600 microns, No. 30	0.5	0.5	0.0											
300 microns, No. 50	0.6	0.5	0.0											
150 microns, No. 100	0.7	0.5	0.0											
75 microns, No. 200	1.5	0.4	0.1											
Pan	1.5		0.4											
Total	1991.4		100.0											

Weight of original sample. 1997.8 g

Weight after washing. 1991.3 g

3:1 RATIO

% F & E CALCULATIONS:

3/8"	15.3 / 255.7	X 100 =	**6.0%**
#4	15.4 / 76.9	X 100 =	**20.0%**

WEIGHTED AVERAGES:

1/2"	1.9 / 100	X 6.0 =	**0.1%**
3/8"	28.4 / 100	X 6.0 =	**1.7%**
#4	69.7 / 100	X 20.0 =	**13.9%**

This is the assumed value for the particles retained on the ½" sieve based on the test results for the particles retained on the 3/8" sieve; in accordance with section 6.2 of this method.

Virginia Department of Transportation
Flat & Elongated Test

ASTM D4791

Sample ID: _____ Project # _____ Job Mix # _____
District: _____ Location: _____ Producer: _____
Sample # _____ Mix Type: _____ Plant: _____
Lot # _____ Sample Date: _____ Technician: _____
Date Tested: _____

GRADATION					FLAT AND ELONGATED TESTING										
						5:1 Ratio			3:1 Ratio			2:1 Ratio			
			A	B	C	D	E	F	D	E	F	D	E	F	
U.S. Stand Sieve No.	Weight (g)	Percent Passing	Percent Retained	+ No.4 (4.75mm) % Retained	Weight Total Particles Tested (g)	Weight (g)	Percent	Weighted Average	Weight (g)	Percent	Weighted Average	Weight (g)	Percent	Weighted Average	
1 1/2in. (37.5mm)		100.0	0.0	0.0			0.0	0.0		0.0	0.0				
1 in. (25.0 mm)		100.0	0.0	0.0			0.0	0.0		0.0	0.0				
3/4 in. (19.0 mm)		100.0	0.0	0.0			0.0	0.0		0.0	0.0				
1/2 in. (12.5 mm)	34.1	98.3	1.7	1.9	0.0	0.0	0.0	0.0	0.0	6.0	0.1				
3/8 in. (9.5 mm)	516.8	72.4	25.9	28.4	255.7	0.0	0.0	0.0	15.3	6.0	1.7				
No.4 (4.75 mm)	1270.1	8.8	63.6	69.7	76.9	0.0	0.0	0.0	15.4	20.0	14.0				
No. 8 (2.36 mm)	162.6	0.7	8.1		**Totals**			0.0			15.8				
No. 16 (1.18 mm)	3.0	0.6	0.2												
No. 30 (600 microns)	0.5	0.5	0.0												
No. 50 (300 microns)	0.6	0.5	0.0												
No. 100 (150 microns)	0.7	0.5	0.0												
No. 200 (75 microns)	1.5	0.4	0.1												
Pan	1.5														
Total	1991.4		99.6												

Weight of original sample. 1997.8 g

Weight after washing. 1991.3 g

1) $\text{Col. B} = \left[\dfrac{\text{Col. A}}{\left(\dfrac{\text{Sum of \% retained} \geq \text{No. 4 (4.75 mm) sieve}}{100} \right)} \right]$

2) Col. C is the Total Weight of the ≈ 100 Particles

3) Col. D is the Weight of the Failed Particles

4) $\text{Col. E} = \left[\left(\dfrac{\text{Col. D}}{\text{Col. C}} \right) \times 100 \right]$

5) $\text{Col. F} = \left[\left(\dfrac{\text{Col. B}}{100} \right) \times \text{Col. E} \right]$

6) F & E Value = Sum of Col. Total

Aggregate Type	Total No. Particles	No. Particles Failed (5:1)	No. Particles Failed (3:1)
1/2 in. (12.5 mm)	0	0	0
3/8 in. (9.5 mm)	107	0	8
No.4 (4.75 mm)	97	0	21

Comments: _____

Copies To:
District Materials (1)
Central Office Materials (1)
Prime Contractor (1)
VTRC (1)

7. Report

6.1 Identify the coarse aggregate tested.

6.2 Grading of the aggregate sample showing percent retained on each sieve.

6.3 The dimensional ratios used in the flat and elongated test.

6.4 Percentage calculated by mass for the flat and elongated particles for each size fraction tested.

6.5 The number of particles in each size fraction tested.

6.6 The number of flat and elongated particles in each size fraction tested.

6.7 The weighted average percentages of the various size fractions tested.

6.8 The total weighted average percentage Flat and Elongated for the sample tested.

Virginia Test Method – 122

Friction Testing

September 12, 2007

1. Scope

1.1. This document describes the test method for measuring the skid resistance of a paved surface. Unless otherwise specified, testing will be conducted using a full-scale standard smooth tire. Testing will include (but are not limited to) the following programs: wet accident reduction program (WARP), special requests, and Interstate and Primary Inventory Testing.

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 determines the applicability of regulatory limitations prior to use.

2. Apparatus

2.1. Test equipment shall be configured to meet the specifications of ASTM E-274, "Standard Test Method for Skid Resistance of Paved Surfaces Using a Full-Scale Tire".

2.2. Test tires used for testing shall meet the requirements of ASTM E-524, "Standard Specification for Standard Smooth Tire for Skid-Resistance Tests".

2.3. The safety equipment shall include a light bar mounted on the roof of the vehicle. For the operator, a safety vest, hardhat and proper shoes.

3. Significance and Use

3.1. This test method provides a means of measuring skid resistance on WARP, Special Request and Primary/Interstate Inventory testing.

3.1.1. Skid Number is determined from the resulting force or torque and is reported as Skid Number (SN). The SN is determined from the force required to slide the locked test tire at a stated speed, divided by the effective wheel load (Coefficient of Friction), and multiplied by 100 (SN).

3.1.2. Calculations

3.1.2.1. A Seasonal Correction value will be used to adjust for the variances in climatic conditions:

SKID CORRECTION FACTORS
Monthly Correction
For Seasonal Changes

Month	Correction Factor
January	-3.7 skid numbers
February	-3.7 skid numbers
March	-3.1 skid numbers
April	-1.7 skid numbers
May	-0.7 skid numbers
June	-0.3 skid numbers
July	NO ADJUSTMENT
August	NO ADJUSTMENT
September	-0.6 skid numbers
October	-1.7 skid numbers
November	-3.1 skid numbers
December	-3.7 skid numbers

3.1.2.2. Speed will be adjusted to and reported at 40 miles per hour using the following procedure:

Add .48 mph for every mph OVER 40.0 mph. This is then added to the Skid Number.

43.1 mph
` -40.0 mph
3.1 x .48 = 1.49 ADD 1.49 to skid number

Subtract .48 mph for every mph UNDER 40.0 mph. This is then subtracted from the skid number.

40.0 mph
-37.6 mph
2.4 x .48 = 1.15 SUBTRACT 1.15 from skid #.

4. Restrictions on Testing

4.1. Ambient temperature will be at a minimum of 40^0 Fahrenheit and rising but not greater than 100^0 Fahrenheit.

4.2. Pavement surface shall be free of debris.

4.3. Pavement surface shall be free of standing water.

4.4. Vehicle test speed will be conducted at 40 mph as traffic conditions allow. Vehicle test speeds shall not exceed the posted speed limit.

5. Testing

5.1. WARP Testing

5.1.1. Identify the site limits (Beginning and ending mile point) and locate a starting node using the HTRIS straight-line diagram prior to data collection.

5.1.2. Each site is to have a minimum of three tests prior to and after the referenced site, as maintenance jurisdiction boundaries allow. These run-In and run-out tests are to insure any questionable areas have been accurately identified. These tests shall have an individual SN value grater than 24.0 prior to proceeding.

5.1.3. Where possible, tests shall be conducted within 200 ft. of a stop light or stop sign intersection.

5.1.4. For all routes, testing shall be at a minimum frequency of one test for every 1.0 mile. The tests shall be conducted in the travel lane and in the direction as identified on the Potential Wet Accident Hotspots (PWAH) report.

5.2. Special Request Testing

5.2.1. Identify the site limits.

5.2.2. HTRIS straight line diagram (or its successor) shall be used to identify a start node.

5.2.3. Tests (minimum requirement) will be performed at 0.2 mile intervals ... For sites less than 1.0 mile, testing shall be conducted a minimum of 0.10 of a mile.

5.2.4. One test will be conducted on every Bridge Deck crossed within the test site parameters.

5.2.5. Test values that fall below a maintenance value of 20.0 shall be reported to the District pavement contact.

5.3. Interstate / Primary Inventory Testing

5.3.1. Tests shall be conducted within Jurisdictional parameters as set forth in the HTRIS Straight –Line diagram.

5.3.2. Testing shall be performed at 0.20 mile intervals and one on every bridge deck crossed. For areas having SN under 20.0, frequency shall be increased to a minimum of one test for each 0.050 mile so identification of the area below 20.0SN can be obtained.

5.3.3. Parameters of test values falling below a maintenance value of 20.0 SN shall be reported to the District Pavement Contact as soon as possible.

6. Quality Control

6.1. Quality control procedures are set forth in the VDOT Friction Testing Standard Operating Procedures.

7. References

7.1. ASTM E274 - Standard Test Method for Skid Resistance of Paved Surfaces Using a Full-Scale Tire.

7.2. ASTM E524 – Standard Specification for Standard Smooth Tire for Pavement Skid Resistance Tests.

7.3. VDOT Standard Operating Procedure – Friction Testing

7.4. ICC (International Cybernetics Corp.) Users Manual – Friction Software

<u>Virginia Test Method – 123**</u>**

Post Installation Inspection of Buried Storm Drain Pipe and Pipe Culverts – (Soils Lab)

June 25, 2010

SCOPE

For all roadway projects that are constructed by private contractors for VDOT and for all roadway projects constructed by others that are or will be proposed to be accepted into the VDOT highway system, a visual/video camera post installation inspection is required on all storm sewer pipes and for a selected number of pipe culverts in accordance with the instructions contained in this VTM and Section 302.03 of the VDOT Road and Bridge Specifications. The video camera inspection is to be conducted with a VDOT representative present.

The inspection can be conducted manually if adequate crawl/walking space and ventilation is available to safely conduct the inspection and the individual(s) conducting the inspection have undergone training on working in confined spaces in accordance with VDOT's current Safety Policy and Procedure #8 Confined Space Entry Policy and Procedure - General, or the inspection can be conducted with a video camera. If the inspection is to be conducted with a video camera, the video camera shall have fully articulating lenses that will provide a 360 degree inspection of the pipe/culvert, including each joint and any deficient areas of the pipe/culvert, as well as a means to measure deformations/deflections of the pipe (items such as a laser range finder or other appropriate device for taking such measurements as specified herein and approved by the Engineer).

If the inspection is conducted manually, the person performing the inspection may use a standard video camera or a digital camera to document any observed deficiencies. If the mandrel test is to be performed to mechanically measure deformations/deflections of the pipe/culvert, the mandrel used shall be a nine (or greater odd number) arm mandrel, and shall be sized and inspected by the Engineer prior to testing. The diameter of the mandrel at any point shall not be less than the allowable percent deflection of the certified actual mean diameter of the pipe or culvert being tested. The mandrel shall be fabricated of metal, fitted with pulling rings at each end, stamped or engraved on some segment other than a runner with the nominal pipe/culvert size and mandrel outside diameter. The mandrel shall be pulled through the pipe or culvert by hand with a rope or cable. Where applicable, pulleys may be incorporated into the system to change the direction of pull so that inspection personnel need not physically enter the pipe, culvert or manhole.

A copy of the Storm Sewer/Culvert Inspection Report (inspection report)including any video tape/Digital Video Recording (DVD)/digital photographs shall be provided to the VDOT Inspector within two business days of the completion of the inspection and made part of the project records. Additionally, a copy shall be furnished to local VDOT Asset Management personnel to document the pipe/culvert condition at that point in time. The video tape/DVD/digital photographs should be of such clarity, detail and resolution as to clearly show the conditions of the interior of the pipe/culvert and detect any defects within the pipe or culvert as specified herein. Post installation inspections shall be conducted no sooner than 30 days after completion of installation and placement of final cover (except for pavement structure).

PROCEDURES

The post installation inspection shall be conducted in accordance with the requirements of Section 302.03(d) of the Road and Bridge Specifications and the instructions included herein. The inspection

report shall identify the location of the pipe/culvert being inspected with respect to the project site. The inspection report shall identify the location of the inspection access point of the pipe/culvert being inspected with respect to the plans (e.g., north/south/east/west end of the pipe/culvert, manhole/drop inlet/junction box structure number, etc.). The location of any deficiencies within the pipe/culvert shall be noted in the inspection report by identifying the distance from the inspection access point. If no deficiencies are noted, an *"*OK*"* entry shall be made in the report under the remarks column for each section of pipe/culvert inspected.

Where deficiencies are found, a video recording is to be used to identify the deficiency in addition to it being noted on the report form. The video camera system shall be capable of capturing clear images. The camera system shall have a titler/keyboard for data entry and an audio microphone for verbal descriptions; both a textual note on the video/images and a verbal description shall be used to note deficiencies. The camera system shall have a locator system for locating the position of the camera, and a footage counter on the cable reel. The location and description of the deficiency should be added to the recording by the use of an audio microphone. When deficiencies are noted that require remedial actions, the contractor's proposed remediation measures shall be noted in the report form.

The Department shall review the post construction inspection report including any proposed remediation measures and communicate its findings to the Contractor within 10 days of receiving the report. Where the Department agrees with the proposed remediation measures, the contractor shall be notified of such approval and authorized to begin such work. Where the Department disagrees with the proposed remediation measures or where the Department identifies additional deficiencies that require remedial action, the contractor shall be notified of such findings and requested to submit a supplemental remediation plan. Pipes or culverts that require~~d~~ coating should have the coating inspected. Cracks (longitudinal and circumferential) shall be noted in the inspection report and photographed (if not videoed) and digitally scanned to allow for accurate measurement. Spalls and slabbing locations shall be photographed (or videoed) and noted in the report.

Upon completion of the corrective measures, the remedial locations are to be re-inspected prior to final acceptance of the project by the same test methods noted herein. Re-inspection shall be made within 10 days of correction except where sections of pipe/culvert have been replaced re-inspection shall not occur sooner than 30 days after replacement of pipe/culvert and final cover (except for pavement structure).

DEFICIENCIES

Deficiencies may include, but are not limited to, the following:

1. Crushed, collapsed or deformed pipe/culvert or joints.
2. Alignment defects would include sags in the longitudinal profile and invert heaving.
3. Improper joints that can allow leaking of water or infiltration of backfill or surrounding soils.
4. Misaligned joints that can cause debris accumulation.
5. Pipe/culvert that has been penetrated by guardrail or other posts or improper backfill materials or methods.
6. Debris, construction or other materials in the pipe/culvert or structures.
7. Coating material shall be free of cracks, scratches and peeling.
8. Cracks (longitudinal and circumferential).
9. Spalls and slabbing.
10. For metallic and plastic pipes/culverts, localized buckling, bulging, cracking at bolt holes (metallic only), flattening, or racking, as well as the applicable points noted above.

REPORTS

The attached form is to be used to report the inspection findings. Proposed remedial actions, if required, can be attached on separate pages.

Storm Sewer/Culvert Inspection Report

Video Camera/Visual Inspection

Project Description _____

_____

_____

Camera Owner _____

Camera Operator _____

Date _____

VDOT Inspector _____

Weather Conditions _____

Test Section Number	Storm Sewer	Culvert	Pipe Material	Size	Description/ Location Test Section (e.g., From Structure ID to Structure ID)	Description of Access	Total Length Tested	Any Flow in Pipe	Any Deficiency Y/N	Comments

Virginia Test Method – 124

Evaluation of Wet Retroreflective Pavement Markings – (Chemistry Lab)

July, 2008

1. Scope

1.1 This test method is used to determine the wet retroreflectivity properties of horizontal pavement markings. This test method may include one or all of the following:

A. Visual evaluation of pavement markings at night under rain/wet conditions.

B. Instrumental measurement of pavement markings in the lab and/or field using ASTM E 2176, (Standard Test Method for Measuring the Coefficient of Retroreflected Luminance of Pavement Markings in a Standard Condition of Continuous Wetting) with modifications noted in Section 3B.

C. Instrumental measurement of pavement markings in the lab and/or field using ASTM E 2177, (Standard Test Method for Measuring the Cofficient of Retroreflected Luminance of Pavement Markings in a Standard Condition of Wetness).

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

2. Referenced Documents

ASTM Standards

E 2176 Standard Test Method for Measuring the Coefficient of Retroreflected Luminance of Pavement Markings in a Standard Condition of Continuous Wetting.

E2177 Standard Test Method for Measuring the Coefficient of Retroreflected Luminance of Pavement Markings in a Standard Condition of Wetness.

E1710 Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer.

3. Test Method Guidelines

A. Visual Evaluation of Installed Pavement Markings at Night Under Rain Conditions.

Visual evaluation of pavement markings should be used to supplement instrument measurement methods and will be made on test locations established by the Materials Division. Pavement markings must be clearly retroreflective when subjected to continuous rain conditions in the field. Rain conditions may be natural or simulated. Pavement marking products should be compared against an “acceptable” Wet Reflective Standard for adequate wet-night retroreflectivity. The standard should be 10 feet in length and viewed from a distance of 30 m from the vehicle.

Procedures:

1. Natural Rain Condition Evaluation

Natural rain conditions are defined as a steady rain rate (typical of the average rain rate for the area) that will continuously cover the marking and Standard throughout the evaluation period.

1. Ensure the right edge line is safely protected in an approved lane closure.
2. Place the approved Wet Reflective Standard next to the edge line to be evaluated. The Standard should be placed parallel to the edge line separated by one inch. The standard should be as flat as possible and can be secured to the road, if needed.
3. Position the vehicle 30 meters from the standard, centered in the right lane.
4. Using a rain gauge, record the rain rate.
5. From the drivers position, with the headlights on low and the windshield wipers on medium speed, compare the right edge line with the standard.
6. Passing or Failing Guidelines – The edge line must be as bright or brighter than the Standard to pass.

2. Simulated Rain Condition Evaluation

Simulated rain conditions are defined as a steady spray rate from a garden sprayer or equivalent that is typical of the average rain rate for the area that will continuously cover the marking and Standard throughout the evaluation period.

a. Ensure the right edge line is safely protected in an approved lane closure.
b. Place the approved Wet Reflective Standard next to the edge line to be evaluated. The Standard should be placed parallel to the edge line separated by one inch. The standard should be as flat as possible and can be secured to the road, if needed.
c. Position the vehicle 30 meters from the standard, centered in the right lane.
d. Position the spray equipment and nozzle such that the 10 foot Standard and adjacent edge line will receive a continuous and even spray during the evaluation.
e. Using a rain gauge, record the spray rate.
f. From the drivers position, with the headlights on low, compare the right edge line with the standard.
g. Passing or Failing Guidelines – The edge line must be as bright or brighter than the Standard to pass.

B. Instrumental measurement of pavement markings in the lab and/or field using ASTM E 2176, (Standard Test Method for Measuring the Coefficient of Retroreflected Luminance of Pavement Markings in a Standard Condition of Continuous Wetting) with modifications noted below:

1. **Lab Measurements:**

a. Samples should be 4 feet long and affixed to a 4 foot aluminum blank (approximately 0.1 inches thick and 6 inches wide).

Note: An alternate waterproof material that is structurally sound may be used in place of aluminum.

b. The 4 foot sample should be angled to a 3% cross-slope using a 3/16 inch spacer on one side.

c. The external beam retroreflectometer (LTL-X or equivalent per ASTM E 2176) should be positioned on the end of the 4 foot sample.

d. The sprayer should be positioned in a holder at a height of 18 +/- 0.5 inches from the sample.

e. The spray nozzle should be an iSpray 1/8 HH-1.5 Full Cone Nozzle or equivalent.

f. The center of the spray pattern should be positioned at the center of the measurement area for the instrument being used.

g. Measurements should be made and recorded at the following flow rates:
Approx 9.3 "/Hour = 800 +/- 80 ml/minute
Approx 2.0 "/Hour = 170 +/- 17 ml/minute

2. **Field Measurements:**

a. The pavement marking to be tested should be representative of the marking in the general area.

b. All measurements are to be made in the direction that drivers will view the markings.

c. If possible, select an area that represents a typical VDOT road design (longitudinally flat with a 3 % cross-slope).

d. Record the longitudinal and cross-slope (%) of the area to be tested.

e. The external beam retroreflectometer (LTL-X or equivalent per ASTM E 2176) should be positioned on the pavement marking.

f. The sprayer should be positioned in a holder at a height of 18 +/- 0.5 inches from the pavement surface.

g. The spray nozzle should be an iSpray 1/8 HH-1.5 Full Cone Nozzle or equivalent.

h. The center of the spray pattern should be positioned at the center of the measurement area for the instrument being used.

i. If possible, avoid taking measurement when road winds modify the spray pattern. Use a wind shield if necessary.

j. Measurements should be made and recorded at the following flow rates:
Approx 9.3 "/HR = 800 +/- 80 ml/minute
Approx 2.0 "/HR = 170 +/- 17 ml/minute

k. Take measurements at intervals agreed upon by the VDOT Engineer and pavement marking manufacturer.

C. Instrumental measurement of pavement markings in the lab and/or field using <u>ASTM E 2177, (Standard Test Method for Measuring the Cofficient of Retroreflected Luminance of Pavement Markings in a Standard Condition of Wetness).</u>

This Standard Test Method should be followed as written.

4. Quality Control Requirements

1. Ensure the instruments are maintained and calibrated in accordance with the manufacturer's instructions.

2. Quality control samples should be used to ensure accuracy and precision.

3. QC samples should be representative of the anticipated range of test samples.

4. Test the applicable quality control standards and record results.
   QC samples should be tested in the lab and field before testing any product.
   Ensure results are within allowable range (+/- 10%) prior to testing any product.

5. Reproducibility of test results should be evaluated periodically between test labs using stable reference samples.

6. Visual Wet Reflective Standards should be representative of an "acceptable" and agreed upon level of visual wet retroreflectivity.

Virginia Test Method – 125

Evaluation of Pavement Markings - Field Testing – (Chemistry Lab)

June 1, 2011

1. Scope

1.1 This test method is used to evaluate pavement marking performance on an approved test facility (simulated or actual roadway). Evaluations may be for initial product approval or for newly installed markings for final acceptance.

Pavement markings include edge lines, skip lines, legends, symbols and cross walks. This method defines the sampling criteria such as the length of evaluation sections and the number of measurements needed to adequately evaluate pavement marking performance.

This performance to include, but not be limited to, Retroreflectivity (Dry and Wet), Color (Day and Night), and Durability.

1.2 1.2 This test method may involve testing pavement markings on an in-service road. Proper safety procedures should be utilized when testing pavement markings on a road with traffic, including, proper lane closures, safety vehicles, and personnel safety devices (safety vest, hard hat, safety shoes).

2. Referenced Documents

ASTM Standards

D 7585/D7585M-10, Standard Practice for Evaluating Retroreflective Pavement Markings Using Portable Hand-Operated Instruments.

E1710, Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer

D6628-03 (Reapproved 2010), Standard Specification for Color of Pavement Marking Materials

E313, Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates

Virginia Test Method - 94, Quality Control Testing of Pavement Markings

3. Test Method Guidelines

Sampling and testing should be carried out in accordance with ASTM D 7585 with the following exceptions for Pavement Marking Lines 2 Miles or Less:

Three evaluation sections shall be tested within the 2 mile project. Evaluation sections will be randomly chosen in the first, middle, and last section of the pavement marking area. Measurements within each evaluation section shall be made with a sample size of at least 20 for skip lines and 20 for edge lines as seen in Figure 1 and Figure 2 of D7585.

Data Averaging – Each evaluation section of at least 20 measurements for the edge lines and 20 measurements for the skip lines shall be averaged separately and compared against the specification.

For Example:

First Section	Middle Section	Last Section
Edge Line Average = X	Edge Line Average = X	Edge Line Average = X
Skip Line Average = X	Skip Line Average = X	Skip Line Average = X

Variability of Test Data – VDOT reserves the right to exclude outlier data that prevents averaged data from being representative of the pavement markings.

Testing Frequencies and Schedules

Testing frequencies are established to adequately access the performance of the pavement marking. Typical frequencies are at installation and after 3, 12, 24, or 36 months.
However, exact testing frequencies may not always be met due to variations in weather, personnel availability, equipment, and road closure availability.

4. Quality Control Requirements

1. Ensure measurement instruments are maintained, calibrated, and used in accordance with the manufacturer's instructions.

2. Instruments are stored in the laboratory under controlled conditions. Instruments and quality control samples should be allowed to equilibrate to the environmental conditions where they will be used prior to calibration and measurement.

3. Quality control samples should be read and the results should be within acceptable ranges prior to analyzing pavement markings.

Virginia Test Method - 126

Test Method for Non-Tracking Time of Tack (Laboratory)

1. Scope

1.1. This test method covers a laboratory procedure for determining the non-tracking time of tack materials. This method uses a metal cylinder with rubber O-rings as a wheel. The wheel is rolled down a ramp over freshly applied tack material. The elapsed time from placement to no tack transfer is the non-tracking time. Key variables to be controlled during testing are film thickness, temperature, humidity, and air flow.

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. Referenced Documents

2.1. ASTM D 711 Standard Test Method for No-Pick-Up time of Traffic Paint

2.2. ASTM D 823 Standard Practices for producing films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels

3. Apparatus

3.1. Refer to ASTM D 711 for specifications for the wheel and ramp used in this test method

Figure 1: Tracking/Pickup Device

3.2. Refer to ASTM D 823, Practice C, Motor Driven Blade Film Applicators

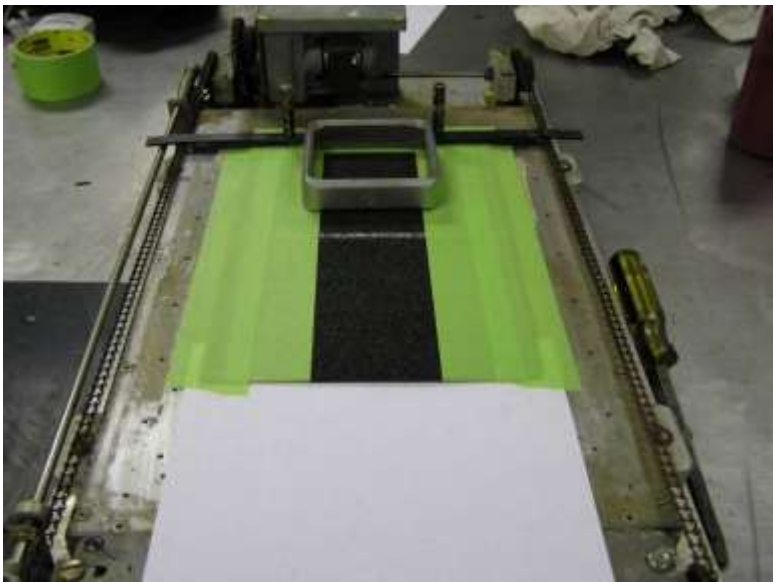


Figure 2: Drawdown Device

4. Procedure

4.1. Prepare a test stripe at least 3 inches in width of the tack material to be tested by a mechanical spreader on roofing paper using the 0.8 mm thickness setting.

4.2. Allow material to dry for 20 minutes

4.3. Butt roofing paper against ramp. Then place a white sheet of paper against the opposite side of the roofing paper. Position wheel so that the rubber ring rolls an area of the film at least 1 inch from the edge of the test stripe. Remove the wheel from its rest, hold against the rest as a start point, then free roll the wheel down the inclined ramp, over the tack (ensuring entire circumference of wheel has rolled through tack) and finally over the white paper.

4.4. Using the following table as a guide, assign a visual rating from 0 to 10:

	g visible
	O-ring entire length of paper or both O-rings for ½ length of paper
	king along the length of paper.

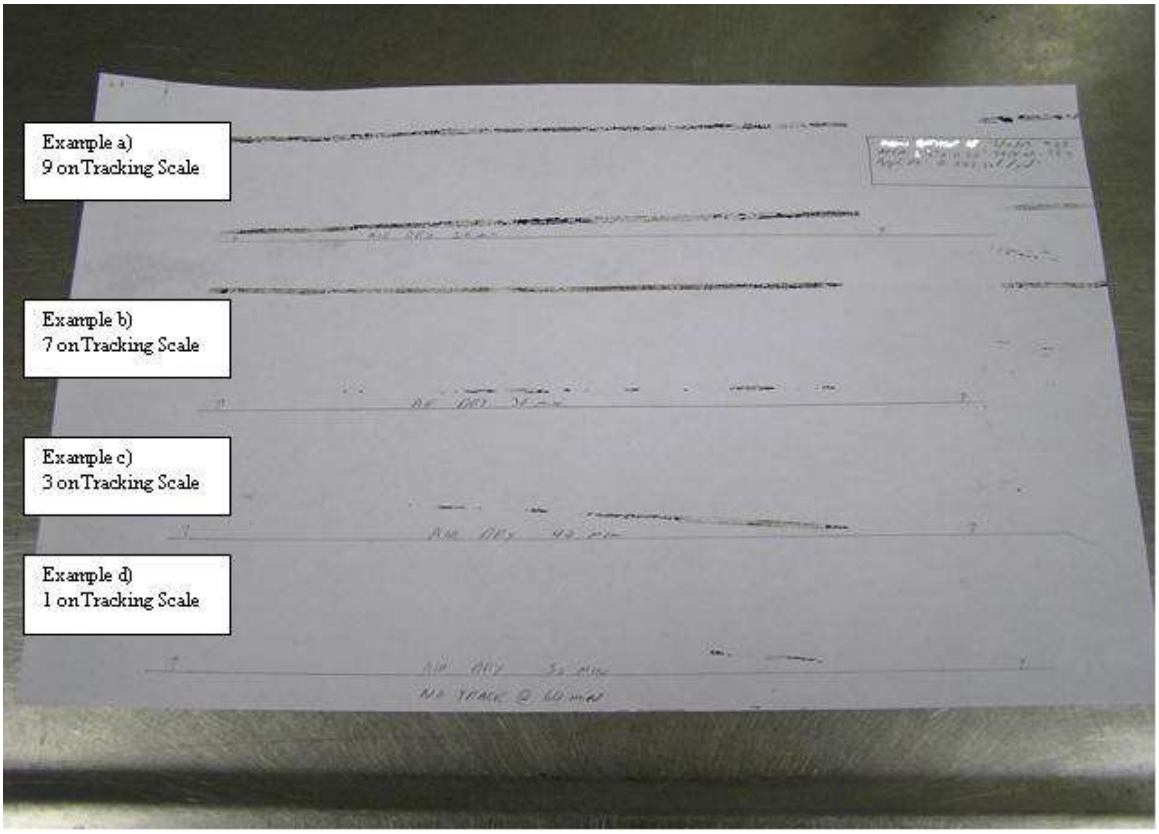


Figure 3: Examples of Tracking Scale

4.5. Repeat steps 4.1 through 4.4

5. Report

Report the product name along with average result from 2 runs. Photograph or white paper from test should be included for verification. Photocopies will not be acceptable for verification of results.

Virginia Test Method - 128

Test Method for Bond Strength of Asphalt Layers (Laboratory)

1. Scope

1.1. This test method covers a laboratory procedure for determining the shear and tensile strength of the bond between layers of asphalt concrete materials. The shear strength test uses a jig specially designed to operate within a Marshall device for compression loading and subjects the interface between the layers to a guillotine-like operation of destructive loading. The tensile strength test involve affixing plates to the top and bottom of specimens, threading eye bolts through the plates, placing in a universal testing machine, and pulling the plates away from one another until the bond at the interface ruptures. Both test procedures use a 4-inch diameter field-cored or laboratory-prepared specimen.

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. Referenced Documents

2.1. ASTM D 6927, Standard Test Method for Marshall Stability and Flow of Bituminous Mixtures

3. Apparatus

3.1. Refer to ASTM D 6927 for specifications for the Marshall Compression Device.

3.2. Figure 1 is an image of the shear testing jig. The fixed component of the device is the heavy vertical plate with a 4-in hole in the center and four evenly spaced guide blocks, which stick out from the plane of the plate and surround the left end of the specimen. The 4-in hole in the fixed plate aligns with a similar hole on the moving side of the device (shown to the right of the image). The specimen is oriented such that the layer interface is centered in a ¼-in slot between the left and right plate. The round plate on the end of the threaded rod (oriented horizontally and centered on the specimen) is

opposite a similar plate on the back (right) side of the specimen and compressed against a heavy spring. These two plates constrain the specimen during testing.

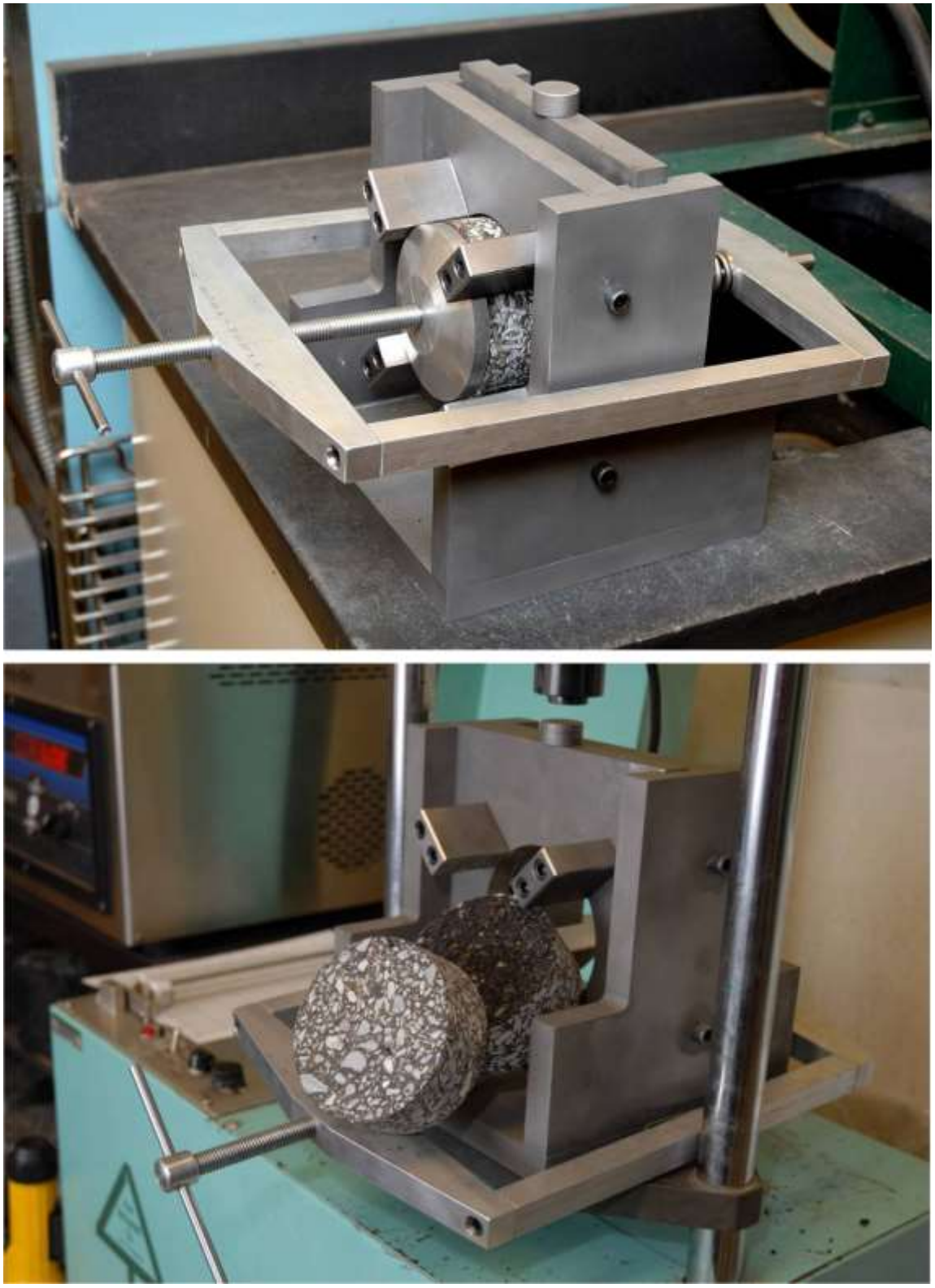


Figure 4: Guillotine-Style Shear-Testing Adapter for Marshall Device

3.3. Figure 2 is a picture of a specimen that has been readied for a bond tensile strength test. The equipment necessary to conduct the tension tests include circular steel plates with threaded holes in the center, eye bolts that will thread into those holes, and a universal testing machine (UTM) with capacity to apply a 1,200 lb/minute load of sufficient magnitude to break an asphalt-to-asphalt bond.

Figure 5: Specimen Ready for Tension Test

4. Procedures – Note that all tests to be run at standard laboratory temperature of 70º F.

4.1. Shear Strength Test

4.1.1. Acquire (via coring) or prepare a 4-inch diameter specimen with desired layer interface at approximately the middle of the specimen section.

4.1.2. Place the specimen in the shearing jig device such that the layer interface is centered in the ¼-inch slot between the left and right plates of the jig.

4.1.3. Place the jig with specimen in the Marshall device.

4.1.4. Load the cylindrical cap on the top of the jig with the Marshall device until the interface shears apart. The loading rate is as prescribed in ASTM D 6927, 2.0 ± 0.15 in/min.

4.1.5. Calculate the total load on the interface – the load applied by the compression device plus the weight of the movable portion of the jig.

4.2. Calculate the shear strength of the interface - the maximum total load achieved divided by the nominal surface area of the specimen.

Shear strength = (F+J)/A

Area =Pi*(d^2)/4

F = Failure load
J = Jig Weight
A = Area
d = specimen diameter
Pi = 3.141593

4.3. Tensile Strength Test

4.3.1. Establish sound material at the top of the upper layer and bottom of the lower layer of the specimen using a wet-saw. These cuts also provide an opportunity to locate the interface of interest at the approximate center of the composite specimen.

4.3.2. Clean and dry the cut surfaces and affix the circular steel plates with epoxy.

4.3.3. After allowing the epoxy to set overnight, thread the eye bolts into the center of the plates and place in the UTM for testing.

4.3.4. Apply a tensile load to the fully-mounted specimen (rate of 1,200 lb/min) until failure is achieved.

4.3.5. Calculate the tensile strength of the interface - the maximum load divided by the nominal surface area of the specimen.

Pull strength = (F-(W/453.6))/A

Area =Pi*(d^2)/4

F = Failure load
W = Weight of Top of broke off specimen
A = Area
d = specimen diameter
Pi = 3.141593

5. <u>Report</u>

Report the product name along with average result from 3 sets of tests – 3 each of shear and tension.

Virginia Test Method – 129

Test Method for Comparative Qualitative Corrosion Characterization of Steel Bars Used in Concrete Reinforcement (Physical Lab)

May 2, 2014

1. Scope

1.1 This test method (the Florida Tombstone Test) provides a means to compare the differences between the corrosion behavior of corrosion-resistant chromium alloyed reinforcing steels (CRR) to carbon steel when exposed to chlorides. This test method is a low maintenance test procedure that allows for the penetration of chlorides from the surface of the concrete to the reinforcing steel through multiple sides of a test sample.

2. *Referenced Documents*:

ASTM standards:

- A 615, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
- C 39, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
- C 138, Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
- C 192, Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.
- C 876, Standard Test Method for Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete

Other Documents:

- Virginia Department of Transportation. Virginia Test Method 112: Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration. http://www.virginiadot.org/business/resources/Materials/bu-mat-VTMs.pdf. Richmond, 2007.
- Hartt, W.H., Powers, R.G., Lysogorski, D.K., Liroux, V., and Virmani, Y.P. Corrosion Resistant Alloys for Reinforced Concrete. FHWA-HRT-07-039. Federal Highway Administration, Turner-Fairbank Highway Research Center, McLean, VA, 2007.
- Sharp, S.R., Lundy, L.J., Nair, H., Moen , C.D., Johnson, J.B., and Sarver B.E. Acceptance Procedures for New and Quality Control Procedures for Existing Types of Corrosion-Resistant Reinforcing Steel. FHWA/VCTIR 11-

R21. Virginia Center for Transportation Innovation and Research, Charlottesville, VA, 2011.

*3. **Apparatus:***

3.1 Immersion tank: A suitable immersion tank made of heavy duty fiberglass or plastic tank that is resistant to sodium chloride solution, impact resistance and can be easily repaired if a specimen damages the tank. For example, the two fiberglass tanks shown in Figure 1 are 28 by 30 by 48 inches tall and hold 30 specimens each.

Figure 1. Tombstone Test Setup. The 3% saltwater storage tank is located in the lower left corner, with the tombstone immersion tanks adjacent to the saltwater storage tank, and the data acquisition system above the tombstone tanks (top of picture).

3.2 Sample spacers: A sample spacer holds the specimens in an upright position and provides a means of adding stability to specimens since the height of the specimen is much greater than the width. This item is not required for testing, but should be considered to reduce the chance of damaging the specimens. The spacer must be resistant to saltwater and moisture. An example is shown in Figure 3.

3.3 Sample booster: The sample booster provides a means of lifting specimens out of residual salt water during dry periods of the wet/dry exposure cycle. It must be resistant to saltwater and moisture, as well as impact resistant or easily repaired if specimen strikes the booster material. An example of a sample booster is shown in Figure 2 and Figure 3.

Figure 2. Close-up of 1" plastic square tube that functions as a sample booster

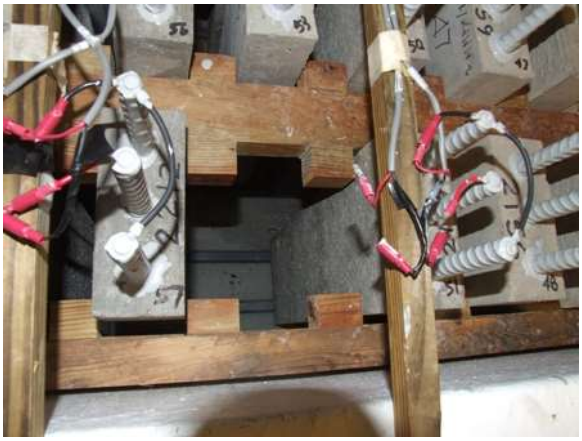


Figure 3. Picture of sample spacers (upper wooden slots) and sample boosters (lower plastic rails)

3.4 Salt solution: The salt solution is a 3% by weight sodium chloride solution. The solution volume needed depends on the size of the immersion tank. To calculate the quantity of solution required, the volume of the bottom 6 inches of the tombstone specimens plus the height of the sample booster must be considered in conjunction with the other two dimensions of the ponding tank.

3.5 Data Acquisition System (DAS): The DAS will be used to monitor the voltage across a 1-ohm resistor on each block. Therefore, it is important that the DAS have sufficient channels for the number of tombstones being tested. In addition, the DAS must have high impedance terminals and, for DC voltage measurement, a maximum resolution of 1 μV at 20 mV and measurement accuracy integral time 1.67 ms ± (0.1% of rdg. + 25 digits) at 20 mV, all at standard operating conditions.

4. Preparing Test Specimens

4.1 Test Specimen Details:

For each set of test bars to be evaluated, control bars will be prepared and tested in conjunction with the bars being evaluated. The control bars will include the following alloy types:

1) 316LN (UNS S31653),
2) either XM-28 (UNS S24100) or type 304 (UNS S30400)
3) MMFX2
4) and A615 Grade 60 black bar

The bars will be #5 with each bar and tested in an as-received condition. Each test specimen, or tombstone, will consist of three bars of a single type of reinforcing steel embedded in a concrete block made in accordance with a VDOT A4 concrete mix design (VDOT Road and Bridge Specifications, Section 217), except that the concrete shall not contain mineral admixtures and the coarse aggregate will be a No. 8 in accordance with the VDOT Road and Bridge Specifications, Section 203. A trial concrete batch should be prepared and five 4-inch specimens cast; 3 for compressive strength (ASTM C31/ASTM C39) and 2 for permeability (cured and tested in accordance with VTM 112). The compressive strength should be greater than 4000 psi and the permeability should be greater than 5000 coulombs to qualify the trial batch concrete as acceptable for use. The tombstone specimens have the dimensions 2 ½" x 6 ½" x 21 ½" as shown in Figure 4. These dimensions will ensure rapid corrosion test results for an embedded steel type test. After the tombstone specimens have been cast and cured for 28-days, the exposed ends of the bars will be cleaned to expose the base metal, and after making the electrical connections, a two part epoxy, such as a 100% solids high build epoxy, will be applied to the bars and top of the specimens. The bars embedded in concrete, as shown in Figure 4, with the exposed bar ends connected and epoxy applied, is considered a "Test Specimen", which is also known as a Florida tombstone test specimen or simply a tombstone. The three (3) bars of each type steel in the Test specimen must come from the same lot/heat and the chemical composition of the bars should be determined or verified using VTM 130. Other bar configurations are possible. See the discussion in the report by Hartt, et al.

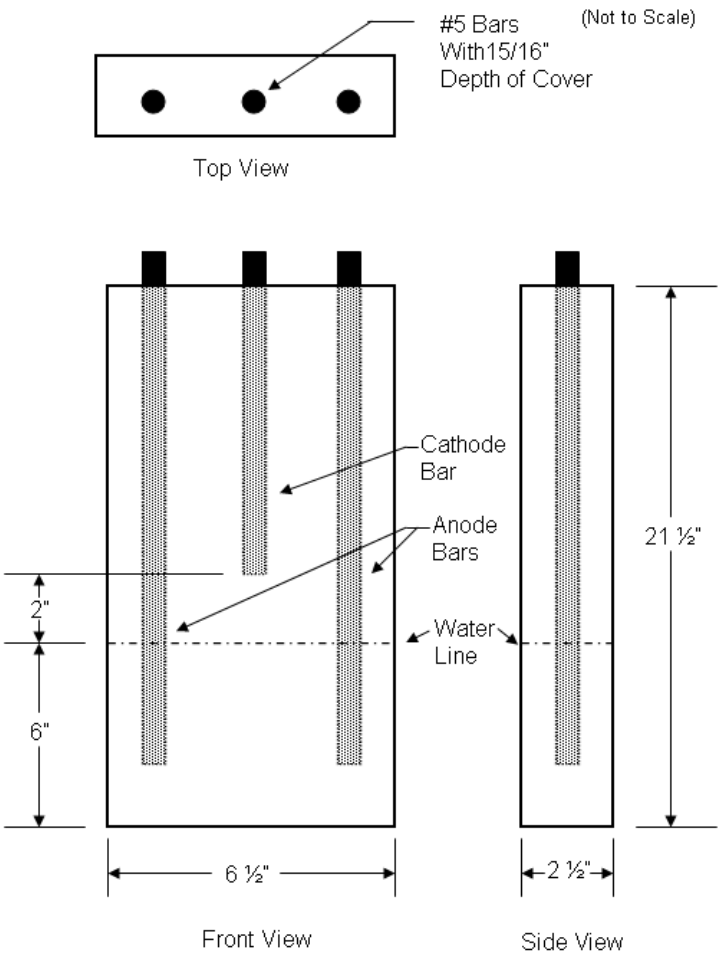


Figure 4. Illustration of tombstone specimens with sample dimensions

4.2 Test Specimen Preparation: The test specimens are prepared as follows:

4.2.1 Tombstone molds - An illustration of a tombstone mold is shown in Figure 5. These molds have two regions. The upper mold region does not receive concrete and is used to align and secure the bars prior to casting. The lower mold region is where the concrete is placed to embed the steel bars.

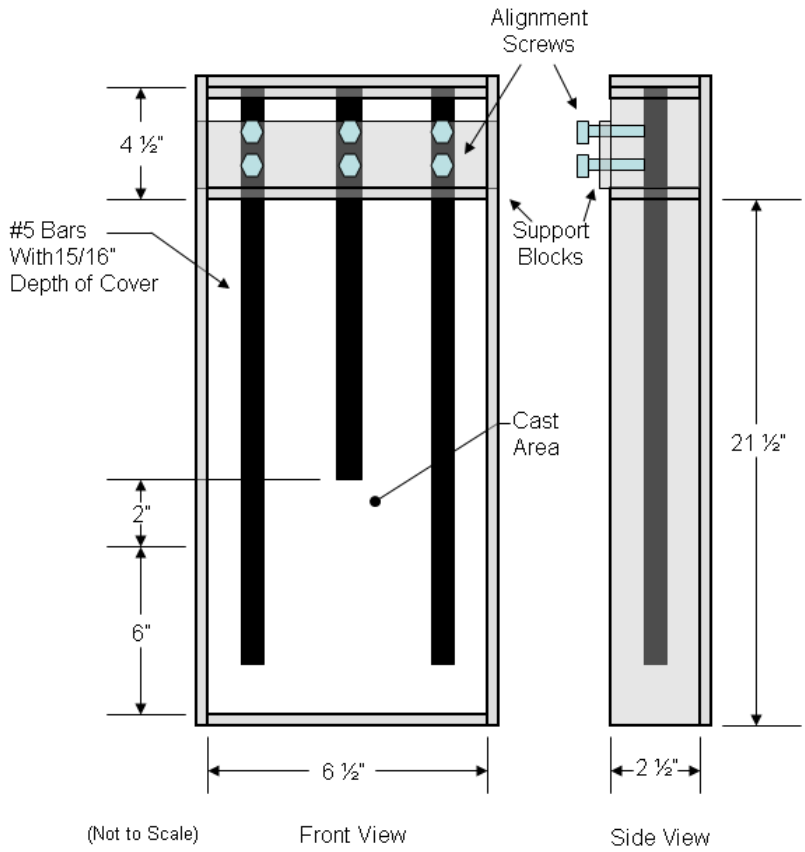


Figure 5. Illustration of forms used to cast tombstone specimens

4.2.2 Casting tombstone - Place a single type of reinforcing steel in the tombstone molds, adjust the bar heights to ensure the concrete cover will be consistent and cover all bolt hardware and exposed form edges with tape, as shown in Figure 6.

Thoroughly mix the concrete before placement. Cast concrete specimens ensuring good consolidation around the rebar. The concrete can be placed in a single lift and consolidated by vibrating the entire form. In addition to casting tombstone specimens, five 4-in cylinder specimens should also be cast for 28-day compressive strength (3 cylinders per ASTM C31/ ASTM C39) and permeability (two cylinders per VTM 112) to confirm the concrete quality. The compressive strength should be greater than 4000 psi and the permeability should be greater than 5000 coulombs. After casting, specimens should be allowed to cure 28 days in accordance with ASTM C31 before performing any additional work on the specimens.

Figure 6. Photograph of tombstone molds that are ready for concrete casting phase

5. ***Experimental Procedure:***

5.1 Connections and Wiring - After the specimens have properly cured, remove specimens from the curing room and clean the exposed bar ends to remove any rust and ensure quality electrical contact between the rebar and the wire. To make connection between embedded rebar, stranded copper wire (size range: #10 - #16) will be used. Solderless connectors will be used to couple the blocks to the data acquisition system (examples shown in Figure 7) and to connect the wire to each rebar. A rivet will be used to join the solderless connector and the rebar. A hole, slightly larger than the rivet, is drilled into the end of each piece of rebar and the rivet is used to secure the solderless connector to the rebar. The size of the rivet is not as important as the fit between the rivet and the ring style solderless connector. A size 3/16" rivet, which is shown in Figure 8, has been used successfully. A 1-Ohm resistor is placed in series between the electrically connected anode bars and cathode bar, as shown in Figure 9.

Figure 7. Examples of solderless connectors that can be used

Figure 8. A 3/16" rivet positioned through a ring style solderless connector, which will be used to connected the wires to each rebar specimen

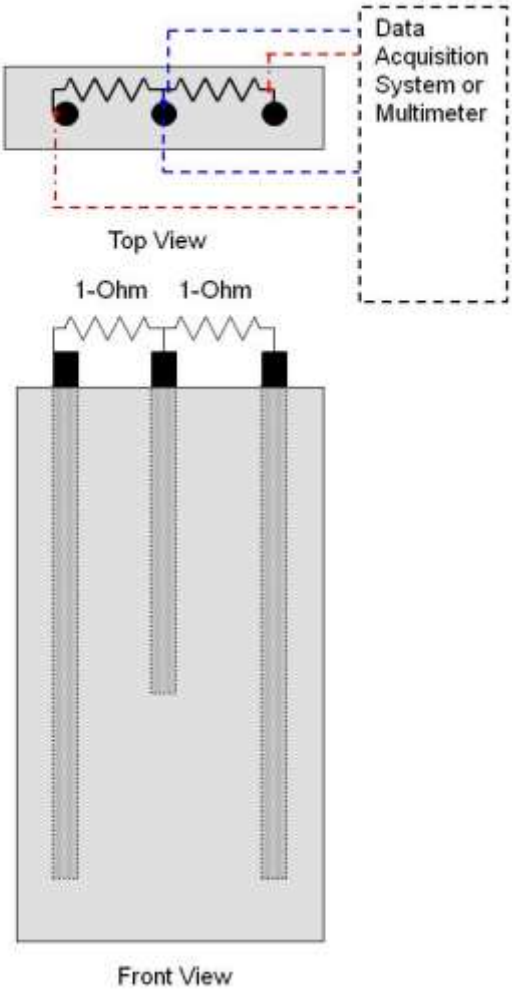


Figure 9. Illustration of tombstone wire connections

5.2 Place Tombstone in Tank - With the sample boosters and spacers placed appropriately, carefully lower each tombstone specimen into the immersion tank until the bottom six inches of each specimen is covered with solution. If several tombstone specimens are cast, it is advantageous to mark the top of each specimen with a unique marking or to create a key above the immersion tank to help in identifying each specimen.

5.3 Connect Leads - The distance between each tombstone and the data acquisition system are measured and two lead wires are cut and uniquely labeled. One wire from each pair is then connected on each side of the resistor and then wired to the data acquisition system.

5.4 Ponding Cycles:

5.4.1 Initial Ponding Cycle - During the first immersion cycle (three days ponded, four days dry), pond the samples in water (no salt). The water level in the tank should be six inches above the bottom of each specimen. During this first cycle, check for leaks, faulty wire connections, computer or data acquisition hardware/software issues, and any other potential equipment related problems.

5.4.2 Subsequent Ponding Cycles - During the second immersion test cycle and until completion of the test, use the 3% salt solution. The salt solution level in the tank should be six inches above the bottom of each specimen. The test cycle is three days ponded with salt water and four days dry. Terminate the test process at conclusion of a complete ponding and drying cycle upon detection of concrete cracking, visible corrosion product bleed-out or if half-cell potential exceeds -0.35 V.

Note: When evaporation of the 3% salt solution occurs, add tap water to bring the solution back to the original volume. Check the specific gravity to ensure the solution is maintained at 3% NaCl. The specific gravity should be approximately 1.0214 at 68 °F.

5.5 Monitoring Test Specimens: Monitor macro-current using DAS and compare values to previous values to determine if macro-current is trending away from zero which is an indication of macro-current activity. Activity is typically indicated by macro-current activity greater than 0.01 mA (or 0.01 mV measured across a 1 ohm resistor).

5.5.1 Activity Detected - After macro-current activity is detected, begin monitoring half-cell current using a voltmeter.

5.5.2 Using a silver/silver chloride electrode, place the electrode in tank. Measure voltage following ASTM C876, with the silver/silver chloride

electrode being used in place of copper/copper sulfate (CSE). The Half-Cell electrode should not be left in tank for a prolonged period of time.

5.5.3 Terminate exposure if the half-cell value is more negative than -.35 V vs. CSE and record macro-cell and half-cell values upon termination. Begin Autopsy.

5.6 Autopsy – Test specimens are evaluated according to the following:

5.6.1 *Carefully remove concrete from rebar and visually evaluate bar condition.*

5.6.2 *Collect samples of concrete adjacent to bar for total chloride and pH analysis.*

5.6.3 *Compare the percent corroded surface area to qualifier bar values.*

5.6.4 *Record any evidence of pits and the depth of pits.*

5.6.5 Record any other unusual observations.

6. ***Report:***

6.1 Record all data on Table A1 and rank each bar according to the [Cl]/[OH] ratio.

6.2 Bar acceptance is based on ranking in accordance with the following:

6.2.1 Bars that rank the same as or worse than carbon steel are considered a LEVEL 0 Bar (No Corrosion Resistance).

6.2.2 Bars that rank better than carbon steel and similar to ASTM A1035 bars are considered a LEVEL 1 CRR (Improved Corrosion Resistance).

6.2.3 Bars that rank similar to a duplex stainless steel but worse than a 316LN stainless steel are considered a LEVEL 2 CRR (Moderate Corrosion Resistance).

6.2.4 Bars that rank equal to or better than a 316LN stainless steel are considered a LEVEL 3 CRR (High Corrosion Resistance).

Table A1. Summary of Tombstone Test Data

Bar Type	Start Test, Date	Half Cell Above Threshold		Micro-Current Above Threshold		% Surface Area Corroded	Number of Pits	Average Pit Depth, mm	Chloride Concentration, lbs/yd^3	pH	[Cl-]/[OH-]	Rank Highest to lowest Resistance (1=best)
		Date	Value	Date	Value							
Carbon Steel												
ASTM A1035												
UNS S24100												
UNS S31653												
Test Bar #1												
Test Bar #2												
Test Bar #3												
Test Bar #4												
Etc.												

Virginia Test Method – 130

Alloyed Steel Identification Testing With X-Ray Fluorescence Analyzer – (Physical Lab)

May 2, 2014

1. Scope

This method is used to determine the chemical composition of alloyed steel using a field-ready, handheld X-Ray Fluorescence (XRF) analyzer.

2. Apparatus

A commercially-produced, field-ready, handheld XRF is required.

2.1. System Requirements:

- Equipment is fully calibrated and ready for use upon receipt.
- Unit must be portable, self-contained and operate on a battery pack.
- Hand-held unit weighs less than 5 pounds.
- Unit is robust and reliable.
- Easy to operate.
- Requires minimum start-up time.
- Easy to read, integrated, color display screen (coupled PDA devices are not acceptable).
- Capable of operating in a temperature range of 20 °F to 110 °F.
- Capable of storing up to 10,000 test results.
- Radioactive isotope excitation is not acceptable (Does not contain a radio-isotope source).
- CE and RoHS compliant.
- Standard analytical range minimum of 20 elements.
- Operator can easily add or modify allow grades in the grade library.
- Provides a best-fit alloy analysis per known alloy grades in library.
- Ability to check calibration – calibration check either external or internal to instrument.
- Ability to check consistent instrument response.
- Analyzes metals to detect major alloys such as stainless steels 316, 304, MMFX, 2201, 2202, 2203, 2204, 2205, ASTM A955, AASHTO MP13 and ASTM A1035.
- Minimum pre-programmed 200 alloy identification library with element specifications. Capacity for additional 100 alloy grades.
- Ability to create user calibrations.
- Capable of determining the alloy of 3/8 inch reinforcing steel bar without changing the shape of steel bar.
- Voltage and current shall adjust automatically to optimize range of elements measured.
- Radiation exposure on user's hand with safety shutter open shall not exceed 0.09 mR/hour.

2.2. Power Requirements

- Unit must be capable of operating with an included AC power supply attachment (110-120 volts, 60 hertz).
- The unit must be able to perform in continuous operation using a single battery pack for a minimum of 4 hours.

2.3. Computer/Software Requirements

- All software to calibrate, analyze and display data is included; vendor shall provide free software upgrades for life of the model instrument.
- Data entry shall accommodate user-defined inputs that are fully integrated with system downloading and reporting software.
- Allows download of data easily to PC – comes with the cables and software (including software license) for downloads to PC.
- Downloaded data is compatible with Microsoft software operating systems and products; downloaded date shall also be tamper proof, legally defensible.

2.4. Accessories and additional items to be provided

- Include two rechargeable battery packs and battery charger – charger operates on 110-120 volts, 60 hertz.
- Durable carrying case.
- Operating manuals.
- A NIST certified reference standard of 304 or 316 stainless steel sample provided to verify calibration of equipment.
- If equipped with clear sheathing material to protect the detector, include extra window material to replace window sheathing at least 10 times.

NOTE: Follow all safety precautions as recommended by the manufacturer and any governing agencies when operating the XRF.

3. Test Specimens

The test specimen can be hot-finished or cold-finished bars including rounds, squares, hexagons and hot-rolled or extruded shapes like angles, tees and channels. The test surface of the steel bar should be clean and free of corrosion, mill scale or other debris. The metal surface may be prepared by grinding, polishing or lathing. If there is a cut end of the test specimen that is of sufficient dimension, this area can be used for the surface test area. All test specimens must have a relatively flat surface of greater diameter than the XRF's aperture. As needed, refinish the surface(s) of the test specimens to obtain accurate readings. Note: If the tested surface area is not clean, the test results may be erroneous. Also, if checking stainless steel bars, test the side of the bar and the end of the bar. If the bar is clad with stainless steel, the bar on the interior will be an A615 bar and the cladding will be a grade of stainless steel.

4. Procedure

4.1 Turn on the XRF and allow sufficient time (approximately five minutes) for instrument warm-up prior to taking measurements.

4.2 Analyze a standard reference material (typically a block supplied by the manufacturer) and compare the results with the standard reference calibration certification. If the test results for the elements of interest are within tolerance of the calibration certification, proceed with the analysis. Otherwise, contact the manufacturer for recommended repair.

4.3 Place the small opening in the front of the analyzer on the prepared test surface using alignments marks on the instrument case. Some instruments have a camera and, if so equipped, move the instrument such that the test surface consumes the camera viewing area as much as possible. For alloy identification, a 20-second analysis time is typically sufficient. However, the XRF may identify the alloy within a few seconds. The accuracy of the XRF is improved significantly by increasing the analysis time. Analysis times over 2 minutes are rarely needed for alloy identification.

5. Report

5.1 The XRF analysis may provide the following:

5.1.1 Alloy type
5.1.2 Percent confidence of alloy identification
5.1.3 Percent of elements detected
5.1.4 The confidence limit per element detected

5.2 The chemical composition of the steel shall conform to the requirements specified in the contract. The elements displayed with acceptable tolerances may be used to generate a laboratory report. Attached is a report that may be used to document verifying the alloy of reinforcing steel in the field.

Virginia Department of Transportation

Materials Division

Field Test Report for Chemical Analysis of Steel using an X-Ray Fluorescence (XRF) Analyzer

Date - _____

Project No. - _____

Location of Steel being tested - _____

Materials Office Location - _____

Alloy of steel being tested (from Mill Test Report or Mill Certification) - _____

Alloy of steel specified on the project - _____

Quantity of Steel represented - _____

Lot Numbers of Steel represented - _____

Tested alloy of steel - _____

Number of Steel Pieces Tested - _____

Number of Steel Pieces Compliant with specified alloy - _____

Status of Testing (Passing/Failing) - _____

Analyst (printed) - _____

Signature of Analyst - _____

Comments -

_____

_____

_____

_____

_____

_____

Virginia Test Method – 131

Procedure for Ultrasonic Testing of Anchor Rods – (Structures)

December 2, 2014

1. Scope

1.1 This test method outlines the procedure for ultrasonically determining discontinuities in anchor rods by the pulse echo method, using straight beam longitudinal waves induced by direct contact of the search unit with the material being tested.

2. Referenced Documents

2.1 ASTM Standards

E114-10 Ultrasonic Pulse Echo Straight Beam Testing by the Contact Method

3. Personnel

3.1 Personnel shall be qualified in accordance with ASNT SNT-TC-1A Level II and certified by VDOT Materials Division

4. Equipment

4.1 **Instrumentation:** Krautkramer Ultrasonic Pulse Echo Flaw Detector, Model USL58 or equivalent.

4.2 **Transducer:** 0.50 inch diameter, 5.0 Mhz Straight Beam Unit

4.3 **Couplant:** Glycerin/cellulose gum with water added for desired consistency, or equivalent.

4.4 **Reference Standard:** Reference standard material and anchor rod material should be acoustically similar.

4.5 Equipment shall be qualified in accordance with AWS D1.5 Section 6, Part C

5. Calibration

5.1 The ultrasonic unit shall be calibrated for distance on a reference standard of sufficient length and diameter to simulate the anchor rod being inspected. Sensitivity should be adjusted to a gain setting of at least 20 dB greater than that required for an 80% back-reflection from the end of the calibration standard.

5.2 Unless otherwise specified, the initial pulse and at least one back-reflection shall appear on the screen of the CRT while testing for discontinuities in material having parallel surfaces.

5.3 As a minimum, the calibration shall be checked each time there is a change in operators, when new batteries are installed, when search units are changed, when operating from

one power source is changed to another power source, or when improper operation is suspected.

6. Testing Surface

6.1 Surfaces shall be uniform and free of loose scale and paint, discontinuities such as pits, gouges, dirt or other foreign material which can affect test results. It may be necessary to grind the top surface of the anchor rod smooth and level to insure proper acoustic coupling and transmissions.

7. Scanning

7.1 Apply a layer of couplant, hold the search unit in hand and move slowly over the top surface of the anchor rod.

7.2 Scanning level shall be 20dB above the calibration level as noted in 5.1.

7.3 Evaluate the first 10 inches of the anchor rod by setting the instrument range for 10" of material thickness. If there are no indications noted, reset the instrument range for 50" of material thickness. Attempt to confirm the back-reflection of the rod to determine the length of the rod and evaluate any indications in the length of the rod beyond the 10" test.

8. Reports

8.1 The inspector shall furnish, within 14 calendar days of the test, a report of the testing that shall include the following information: District, County, Route, Sign Structure Number, Instrument Description (Make and Model), Search Unit description (Type, Size, Frequency), Pertinent instrument settings necessary to duplicate test, Operators Name, Date of Test, and The pertinent Anchor Rod Identification Number as noted on the report (anchor rod diameter, total length of anchor rod if obtainable by back-reflection).

9. Acceptance

9.1 Any indications that are above 10% FSH at the prescribed scanning level shall be noted on the report, and reported to the Bridge Safety Inspection Engineer within 24 hours. The Department will make a final decision concerning the suitability of the anchor rod.

10. Painting of Anchor Rods

10.1 The top of the anchor rods that were ground to bare metal for inspections purposes, should be totally cleaned of couplant and painted with a zinc-rich paint.

Richmond, VA 23219

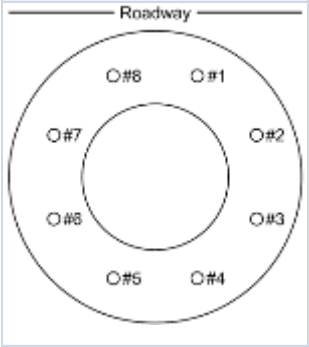
Structure Number:	0010051	Instrument:	USL-58
City/County:	Accomack	db Reference Level:	41
Structure Type:	Sign Structure	db Scanning Level:	53
Date:	9/29/2013	Transducer Diameter:	0.5"
Inspector(s):	U.T. Inspector	Transducer Frequency:	5.0 Mhz
Location:	On SR-175W (Chincoteague Rd.) at Main Street		

Number of Bolts:	8
Bolt Diameter:	1"
Base Plate Shape:	Round

Base Plate Location:	Single

Note: 1st bolt always to the right of center of pole when looking from the structure towards the roadway.

Base Plate and Bolt Layout



Anchor Bolt (#)	Approx. Bolt Length[1] (inch)	Anchor Bolt Projection (inch)	Depth of Indication[2-3] (inch)	Indication Rating[4] (%)	Accept	Reject[5]
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

Notes: [1]*ND = Not Detected* [2]*NRI = No Relevant Indication*
[3]*CNT = Could Not Test (include reason in "Other Comments")*
[4]*___%FSH (Full Screen Height); ___dB (report only if reject criteria is met)*
[5]*Any indication above 10% FSH at scanning level*

Comments:

Authorized Signature

<u>Virginia Test Method – 132**</u>**

Test Methods and Physical Requirements for Packaged Materials to be Used in Concrete Repairs – (Physical Lab)

April 8, 2016

1. SCOPE

This document establishes the physical requirements and test methods to determine conformance to criteria for repair to hydraulic cement concrete class A3, A4 and A5 used in precast, pavement, sidewalks, concrete bridge decks, super- and sub- structures and miscellaneous concrete. Test results will be used to populate list 31.

1.1 Packaged, dry mortar materials are defined as containing aggregate of which less than 5% by weight of the total mixture is retained on the 3/8 inch sieve.

1.2 This specification does not include bitumens, epoxy resins and polyesters as the principle binder.

2 APPLICABLE DOCUMENTS

2.1 ASTM Standards

C 31 Practices for Making and Curing Concrete Test Specimens in the Field
C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens
C 109 Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)
C 157 Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
C 187 Standard Test Method for Amount of Water Required for Normal Consistency of Hydraulic Cement Paste.
C 192 Practices for Making and Curing Concrete Test Specimens in the Laboratory
C 305 Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency
C 470 Specification for Molds for Forming Concrete Test Cylinders Vertically
C 511 Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
C 617 Practice for Capping Cylindrical Concrete Specimens
C 807 Test Method for Time of Setting of Hydraulic Cement Mortar by Modified Vicat Needle
C 882 Bond strength of epoxy resin used with concrete by slant shear.

C 928 Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs
C1231 Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders

2.3 Virginia Test Method (VTM)

VTM 112 Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

3. REQUIREMENTS

3.1 Requirements for class A3, A4 and A5 concrete repair materials are identified in the following Tables I, II and III.

3.2 The repair material will be placed on the approved list into the table in which all the requirements of the class of concrete are met.

3.3 Any repair material, in a higher class of concrete, can be used for repair in a lower class of concrete.

3.4 Specimens are moist cured unless specified otherwise by the manufacturer.

TABLE I

Physical Requirements for Repair of A3 Concrete Items

Test A Setting Time (minutes)

Initial Setting Time	reported for information
Finial Setting Time	reported for information

Test B Compressive Strength (min. psi)

2, 4, 6 hrs.	24 hrs.	28 days
Reported for information	2000	3000

Test C Bond Strength (min. psi)

7 days	1000

Test D Freeze-Thaw (max. %)

Loss after 25 cycles of freezing and thawing in 10% calcium chloride solution	8

Test E Length Change (max. %)

Maximum allowable change after 28 days in water, based on length at 3 hours.	± 0.15
Maximum allowable change after 28 days in air, based on length at 3 hours.	± 0.15

Test F Permeability (max. coulombs)

Rapid Chloride Ion Permeability at 28 days	3500

TABLE II

Physical Requirements for Repair of A4 Concrete Items

Test A Setting Time (minutes)

Initial Setting Time	reported for information
Finial Setting Time	reported for information

Test B Compressive Strength (min. psi)

2, 4, 6 hrs.	24 hrs.	28 days
Reported for information	2500	4000

Test C Bond Strength (min. psi)

7 days	1000

Test D Freeze-Thaw (max. %)

Loss after 25 cycles of freezing and thawing in 10% calcium chloride solution	8

Test E Length Change (max. %)

Maximum allowable change after 28 days in water, based on length at 3 hours.	± 0.08
Maximum allowable change after 28 days in air, based on length at 3 hours.	± 0.08

Test F Permeability (max. coulombs)

Rapid Chloride Ion Permeability at 28 days	2500

TABLE III

Physical Requirements for Repair of A5 Concrete Items

Test A Setting Time (minutes)

Initial Setting Time	reported for information
Finial Setting Time	reported for information

Test B Compressive Strength (min. psi)

2, 4, 6 hrs.	24 hrs.	28 days
Reported for information	2500	5000

Test C Bond Strength (min. psi)

7 days	1000

Test D Freeze-Thaw (max. %)

Loss after 25 cycles of freezing and thawing in 10% calcium chloride solution	8

Test E Length Change (max. %)

Maximum allowable change after 28 days in water, based on length at 3 hours.	± 0.08
Maximum allowable change after 28 days in air, based on length at 3 hours.	± 0.08

Test F Permeability (max. coulombs)

Rapid Chloride Ion Permeability at 28 days	1500

4. SPECIMEN PREPARATION

4.1 Bagged mortar: Mix the dry package material with all the mixing liquid in according to the manufacture recommendations. Follow the manufacturer's recommendations as to the order of addition and mixing times. Mold and cure the specimens in accordance with the individual physical test procedures for mortar.

4.1.1 The sample of package material used to prepare any individual test shall be of such size to yield 10 % excess after molding test specimens.

4.1.2 Use the maximum amount of liquid recommended by the manufacturer on the bag for each test. Base the quantity of water, or other liquid component, or both, added during mixing on the quantity per unit of weight stated, in the directions for use, supplied by the manufacturer.

4.2 Bagged concrete or bagged mortar extended: Mix the dry package material with all the mixing liquid in according to the manufacturer recommendations. Follow the manufacturer's recommendations as to mixing procedures. Mold and cure the specimens in accordance with the individual physical test procedures.

4.2.1 The sample of packaged, dry material used to prepare any individual test shall be at least one whole bag of material. If because of set time mixing a whole bag is impractical, mix partial bag showing mixed weight and amount of water used.

4.2.2 In cases where the material in the bag is mortar that can be extended, the size of stone recommended by the manufacturer will be used and the maximum amount of stone recommended by the manufacturer will be used.

4.2.3 Use the maximum amount of liquid recommended by the manufacturer on the bag for each test. Base the quantity of water, or other liquid component, or both, added during mixing on the quantity per unit of weight stated, in the directions for use, supplied by the manufacturer.

5. CURING

Follow the manufacturer recommendations as to the type of cure to be used.

5.1 Dry or Room Cure The test specimens are left in the molds uncovered in the mixing room in a place free from vibration. The set material in cube form is identified and removed from the mold as necessary. Removed samples shall be kept in the mixing room.

5.2 Damp Cure The test specimens are covered with a damp cloth or towel after the initial set. Plastic sheeting may be placed on the damp cloth to retard drying of the cloth. The set material is identified and removed from the mold as necessary. Curing is for the period specified.

5.3 Moist Cure Immediately upon completion of molding, place the test specimens in the moist closet or moist room. Keep all test specimens in the molds in the moist closet or moist room with their upper surfaces exposed to the moist air, but protected from dripping water. Keep them on the shelves of the moist closet or

moist room for 24 hr. and then immerse the specimens in saturated lime water in storage tanks. Remove samples as required for testing.

6. TEST METHODS

6.1 Test methods for determining conformance to the physical requirements for class A3, A4 and A5 concrete repair materials in section 3 Tables I, II and III are listed below:

Test A — Setting Time: Determine the initial and final setting time in accordance with the Test method for determining setting time of rapid hardening cementitious repair materials. If the mixture contains coarse aggregate, then wet sieve the mixture over a ¼ inch sieve.

Test B — Compressive Strength: Prepare and test three mortar cubes for each age of test using maximum water recommended and cured according to the Test Method for Determining Compressive Strength. If the bagged material has coarse aggregate or can be extended, test three (4" x 8") cylinders at maximum water and maximum stone. Compressive strength test should be performed at 2, 4, 6 and 24 hours as well as at 28 days. The 24 hour and 28 day strength shall meet the requirement for the appropriate class of concrete repair material.

Test C — Bond Strength: Prepare and test three neat test specimens using the maximum amount of water recommended. If the mixture contains coarse aggregate, then wet sieve the mixture over a ¼ inch sieve. Test in accordance with the Method for Determining Bond Strength. The average bond strength of the three (3) (3" x 6") test specimens shall not be less than 1000 psi.

Test D — Resistance to Freezing and Thawing: Prepare and test three cubes in accordance with the Test Method for Measuring Freeze-Thaw. If the mix contains coarse aggregate, then wet sieve the mixture over a ¼ inch sieve. The average percent loss by weight of the specimens shall not be more than 8%.

Test E — Length Change: Prepare and test four beams, two for Air and two for water, using maximum water recommended. Test in accordance with the Test Method for Measuring Length Change. The two air cured bars are averaged together and the two water cured bars are averaged together. The average length change shall be not more than ± 0.08% for class A4 and A5 concrete repair material or ± 0.15 for class A3 concrete repair material. Beams will have a ten inch gauge length using molds 1" x 1" x 11 ¼".

Test F — Resistance to the Penetration of Chloride Ions: Prepare and test two - four inch by eight inch cylinders in accordance with VTM-112, Method A. The maximum coulomb value shall not exceed a value of 1500 coulombs for class A5 concrete repair material, 2500 coulombs for class A4 concrete repair material or 3500 coulombs for class A5 concrete repair material when tested at 28 days.

Test G — Total Chloride Content: The total percent chloride content shall contain no more than 0.10 percent chlorides when tested in accordance with AASHTO T 260. The sample shall be taken from one random bag of material and screened over a

No. 4 sieve before the analysis is performed. Test G applies to all categories of concrete repair materials if the material is cementitious.

Note: Test Methods A, E, F and G are not applicable for non-cementitious materials.

7. REJECTION

7.1 All broken packages shall be rejected.

7.2 Material failing to meet all of the requirements of a given Table shall be rejected.

8. MARKING

8.1 Directions on Product Data sheet must match the directions on the package. All packages shall be clearly marked and contain the following information:

8.1.1 Average time to reach final set.

8.1.2 Directions for use shall include but are not limited to:

8.1.2.1 The maximum amount of water, other liquid component, or both, to be mixed with the package contents.

8.1.2.2 The recommended length of mixing time or sequence of mixing and resting times in minutes.

8.2 Date the material was packaged.

8.3 The yield in cubic feet (or cubic meters) when mixed with the recommended amount of liquid.

8.4 The net weight of each package. The contents of any package shall not vary by more than 2% from the weight stated in the markings.

Test A

TEST METHOD FOR DETERMINING SETTING TIME OF RAPID HARDENING CEMENTITIOUS REPAIR MATERIALS

1. SCOPE

1.1 This test method covers the determination of time of setting of a mortar prepared from prepackaged cementitious repair materials by a modified vicat needle.

1.2 The zero or start time for the purpose of establishing initial and final setting time will be the time of initial contact of mixing liquid with the prepackaged material.

2. APPLICABLE DOCUMENTS

2.1 ASTM Standards

C 109 Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. Cube Specimens)
C 187 Standard Test Method for Amount of Water Required for Normal Consistency of Hydraulic Cement Paste.
C 807 Test Method for Time of Setting of Hydraulic Cement Mortar by Modified Vicat Needle
.

3. APPARTUS

3.1 Tamper and trowel, conforming to the requirements of ASTM C 109.

3.2 Vicat apparatus, conforming to the requirements of ASTM C 187 as modified by ASTM C 807 section 6.2.2.

3.3 Mold conforming to the requirements of ASTM C 187

4. PREPARATION OF TEST SAMPLE

4.1 The cement paste used for the determination of the time of setting is obtained from one of the two following methods:

4.1.1 Paste is used from mortar mix of such size to yield 10 % excess after molding test specimens of dry-packaged material using the maximum amount of water stated in the directions supplied by the manufacturer.

4.1.2 For material that is packaged already extended, record how the material was mixed. Either it was wet sieved or dry sieved. If dry sieved, record how much material and the amount of water was used.

4.2 Paste is placed into mold in a way to ensure good consolidation.

5. TIME OF SETTING DETERMINATION

5.1 Immediately after molding the test sample, bring the 2 ± 0.05 mm needle of the apparatus in contact with the surface of the sample and tighten the setscrew. Set the movable indicator to the upper zero mark on the scale. Release the rod quickly by releasing the setscrew and allow the needle to settle for 30 seconds. If the sample is obviously quite fluid on early readings, the fall of the rod should be retarded to avoid possible damage to the needle. Take penetration tests as often as necessary until the needle reads 25 mm. (Note 1) No penetration test shall be closer than ¼ inch from any previous penetration test or from the inside edge of the mold. Record the results of all penetration tests and by interpolation, determine the time when a penetration of 25 mm is obtained. Record all penetration test results and by interpolation determine the time when a penetration of 25 mm is obtained.

5.2 The difference (in minutes) between the zero or start time (the zero or start time begins when the dry material comes into contact with the liquid) and the 25 mm penetration is the initial setting time. The final setting time is that time when the needle does not visibly sink into the test sample.

5.3 Report the initial setting time and the final setting time to the nearest whole minute.

Note 1: The manufacturer's data should provide some guidance as to what an approximate interval should be.

Test B

TEST METHOD FOR DETERMINING COMPRESSIVE STRENGTH OF RAPID HARDENING CEMENTITIOUS REPAIR MATERIALS

1. SCOPE

1.1 This method of test covers the compressive strength of rapid hardening cementitious material.

2. APPLICABLE DOCUMENTS

2.1 ASTM

C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens
C 109 Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. Cube Specimens)
C 192 Practice for Making and Curing Concrete Test Specimens in the Laboratory
C 470 Specification for Molds for Forming Concrete Test Cylinders Vertically

3. SPECIMEN PREPARATION

3.1 Specimens will be made in accordance with ASTM C 109 or ASTM C 192 and cured in air at 73 ± 5°F for up to 24 hours in molds. Cubes for 28 day strength shall be stripped at 24 hours and stored in lime water at 73 ± 5°F for the remaining time. Cylinders for 2, 4, 6 and 24 hour are to remain in molds with tops until stripped to be broken. Cylinders for 28 day strength shall be stripped at 24 hours and stored in a moist environment at 73 ± 5°F for the remaining time.

3.2 Cubes: If mortar mixture is used, use whole bag or select a representative sample from the bag. Mix a batch of such size to yield 10 % excess after molding test specimens of dry-packaged material using the maximum amount of water stated in the directions supplied by the manufacturer. If mix has coarse aggregate, or is extended, wet sieve material over a ¼ sieve if making cubes.

3.2.1 Use 2 inch cube molds meeting the requirements for *Specimen Molds*, in ASTM C 109 when making cubes.

3.2.2 Break a set of three cubes for each strength determination at each given time (2, 4, 6 and 24 hours and at 28 days).

3.3 Cylinders: Use bagged product containing coarse aggregate premixed in bag or extend bagged product according to manufacturer's directions with recommended coarse aggregate.
.

3.3.1 Use 4 inch by 8 inch cylinder molds meeting the requirements for molds, in ASTM C 470 when making cylinders.

3.3.2 Break a set of three cylinders for each strength determination at each given time (2, 4, 6 and 24 hours and at 28 days).

4. SPECIMEN TESTING

4.1 Cubes shall be tested according to ASTM C 109.

4.2 Cylinders shall be tested according to ASTM C 39.

4.3 All test specimens shall be broken within the permissible tolerance prescribed as follows:

Test Age	Tolerance
2 and 4 hrs.	± 5 min
6 hr.	± 10 min
24 hr.	± 1/2 hr.
28 day	± 12 hr.

5. REPORT

5.1 Report cube strengths as the average of three 2 inch cubes broken at each given time.

5.2 Report cylinder strengths as the average of three 4x8 cylinders broken at each given time.

6. ACCEPTANCE

6.1 To be included on the Approved List, the average strength of three test specimens must comply with the strength requirement for the determined use.

Test C

TEST METHOD FOR DETERMINING BOND STRENGTH OF RAPID HARDENING CEMENTITIOUS REPAIR MATERIAL

1. SCOPE

1.1 This method covers the determination of the bond strength of prepackaged cementitious repair materials to be used in repairing hydraulic cement concrete.

2. APPLICABLE DOCUMENTS

2.1 ASTM Standards

C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens C 305 Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency
C 470 Molds for Forming Concrete Test Cylinders Vertically
C 617 Practice for Capping Cylindrical Concrete Specimens
C 511 Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks used in the Testing of Hydraulic Cements and Concretes
C 882 Bond strength of epoxy resin used with concrete by slant shear.

3. SUMMARY OF METHODS

3.1 A portion of the freshly mixed prepackage product is placed into a 3 by 6 inch cylindrical mold which contains a cured cementitious half cylinder of the dimensions shown in Figure 1. After specified curing of the prepackaged product, the bond strength is performed by determining the compressive strength of the composite cylinder.

4. APPARATUS

4.1 Apparatus to mix portland cement mortar shall be as described in ASTM C 305.

4.2 Specimen Molds: The molds shall be waxed single use molds meeting the requirements of ASTM C 470 for paper molds.

4.3 Dummy Section: A dummy section (Figure 1) shall be machined of a hard material that is not attacked by portland cement mortar. It shall fit the mold and be equal to half the volume of the cylinder, but at an angle of 30 degrees from the vertical.

4.4 Tamping Rod: The tamping rod shall be a round rod of brass, steel or plastic, 3/8 inch in diameter and approximately 12 inches long, having both ends rounded to hemispherical tips.

4.5 Spatula: To be used for rodding pointed section.

4.6 Testing Machine: The testing machine shall be as described in ASTM C39.

4.7 Moist Room: The moist room shall conform to the requirements of ASTM C 511.

5. MATERIALS

5.1 Laboratory made half cylinders shall have a minimum compressive strength of 2500 psi at 28 days.

5.1.1 To make half cylinders, lightly oil the dummy section. Position the dummy section in the mold with the slant side up. Place the molds in their normal vertical position and place a layer of freshly mixed material into the molds to a depth of approximately one inch. Rod this thin layer with the spatula sufficiently to insure that all voids are filled. Place additional mortar into the mold in two layers of approximately equal volume. Rod each layer with 20 strokes using the tamping rod. Distribute the strokes over the cross-section, and make them deep enough to penetrate into the underlying layer. Strike off the surface of the top layer with the trowel, and cover the specimen. A laboratory external vibrator may be used in lieu of rodding to consolidate the mortar. Remove the half cylinder specimens from the molds after one day and cure them for at least 13 additional days in the moisture room.

5.2 Fill a 3 by 6 inch mold without dummy section to check strength of mix. Mortar cylinder shall be a compressive strength calculated on the basis of the normal cross-sectional area of the cylinder (7.07 $inch^2$). Make as many mortar cylinders as needed to determine when mortar has reached desired strength.

6. TEST SPECIMENS

6.1 Remove three standard mortar half-cylinders from the curing room, sandblast or wire brush the elliptical surfaces and then carefully remove the loose surface material. For each prepackaged cementitious material tested, mix ample material to cast three composite bond strength specimens. The prepackaged material should be mixed according to the manufacturer's mixing instructions using maximum water allowed. Place the mortar sections into three cylinder molds and slightly dampen the elliptical surfaces. Place the molds in their normal vertical position and place a layer of freshly mixed material into the molds to a depth of approximately one inch. Rod this thin layer with the spatula sufficiently to insure that all voids are filled. Place additional mortar into the mold in two layers of approximately equal volume. Rod each layer with 20 strokes of the tamping rod. Distribute the strokes over the cross-section, and make them deep enough to penetrate into the underlying layer. A laboratory external vibrator may be used in lieu of rodding to consolidate the mortar. Strike off the surface of the top layer with the trowel, and cover the mold.

6.2 Curing: Demold the testing specimens after 24 hours and cure them 6 additional days in a moist environment at 73 ± 5°F.

7. PROCEDURE

7.1 Capping: Cap all specimens after removal from curing in accordance with ASTM C617.

7.2 Strength Testing: Test the specimens in compression, after capping, in accordance with ASTM C39

8.1 Calculate the bond strength of the bonding system by dividing the load carried by the specimen at failure by the elliptical area of the cylinder (approximately 14.13 $inch^2$).

8. ACCEPTANCE

9.1 To be included on the Approved List, the average strength of three test specimens must comply with the strength requirement for the determined use.

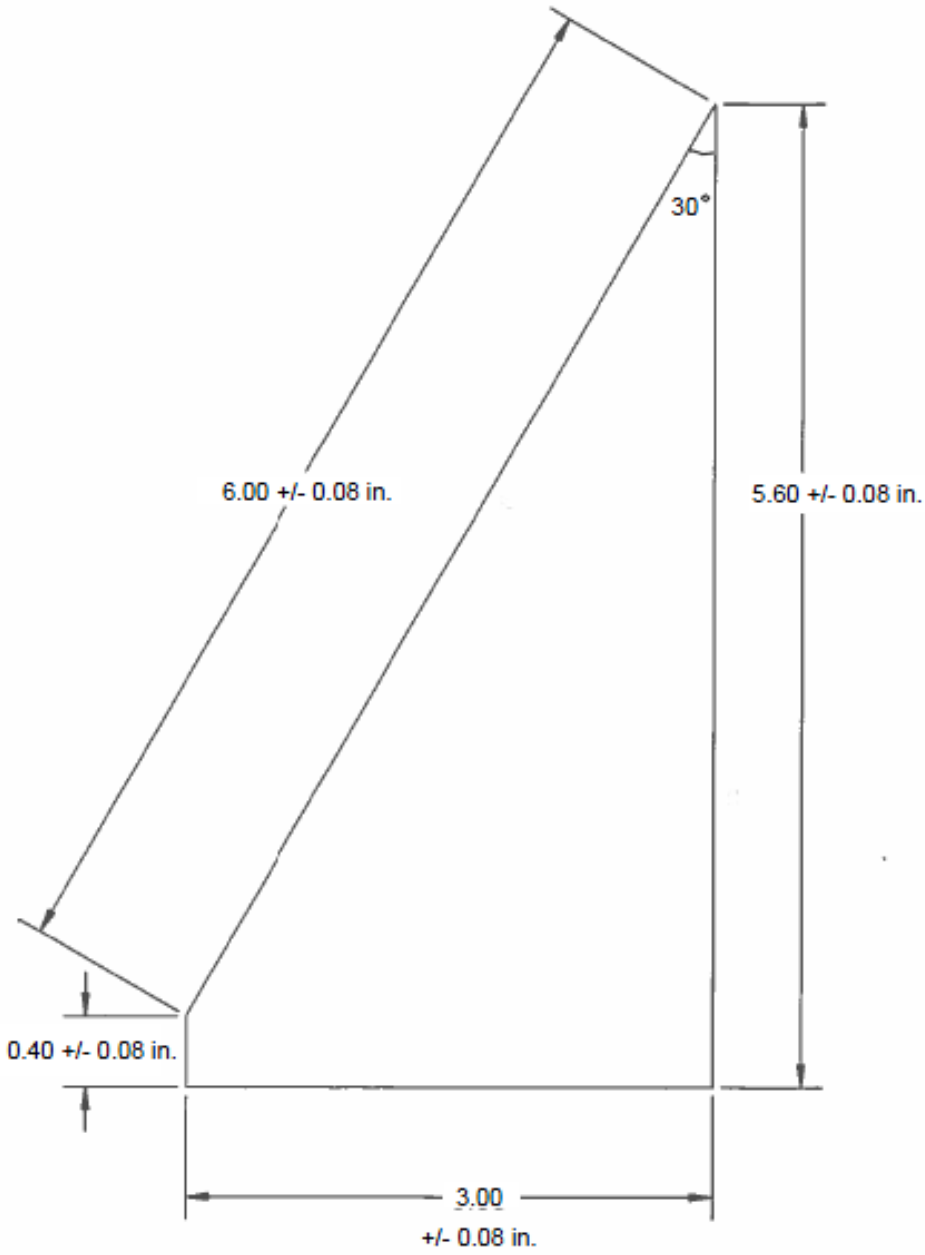


FIG. 1 DUMMY SECTION
FOR 3" x 6" CYLINDER

Test D

TEST METHOD FOR MEASURING FREEZE – THAW RESISTANCE OF RAPID HARDENING CEMENTITIOUS REPAIR MATERIALS

1. SCOPE

1.1 This test method covers the procedure for determining the resistance of 2 inch cube specimens of mortar, to alternate freezing and thawing cycles while immersed in a brine of 10% by weight of calcium chloride (USP or better) in water.

2. APPLICABLE DOCUMENTS

2.1 None

3. APPARATUS

3.1 Container – a suitable container (Note 1) of sufficient size to permit at least 6 specimens to be surrounded on 5 sides by not less than ½ inch of the salt solution at all times during freezing and thawing cycles.

Note 1: A plastic dish pan may be found suitable.

3.2 Freezing Apparatus: The freezing apparatus shall consist of a suitable chamber in which the specified container, (as described above), salt solution and specimens may be subjected to the specified freezing temperature of -10°F. or lower and shall contain the necessary refrigerating equipment for maintaining this temperature range.

3.3 Thawing Area: The thawing area shall be relatively dust-free and shall have a temperature range of 75 ± 15°F. in order to complete the thawing of the test specimens and salt solution within a 7 ± 1 hour period (Note 2 below).

Note 2: Ordinary room temperature usually is sufficient for this purpose, but a 15 watt infra-red lamp may be used to accelerate the thawing. When one of these lamps is used, it shall be placed at a distance of at least 7 inches from the test specimens and salt solution.

3.4 Solution: 10% by mass calcium chloride (USP or better) in water.

4. TEST SPECIMENS

4.1 The specimens are 2 inch cubes made in accordance with Test B of this VTM.

4.2 Specimens shall be cured in air at 73 ± 5°F for 22 ± 2 hours in molds. After the initial 22 ± 2 hour, remove the specimens from the molds and individually identify. Immerse in lime water at 73 ± 5°F for the remainder of the 14-day curing period.

5. PROCEDURE

5.1 At the end of the 14-day curing period (as described in Section 4.2), the specimen shall be removed from the storage tanks, surface dried with the damp cloth or towel, weighed and the weight recorded to the nearest 0.1 g. The specimens shall be protected from loss of moisture at all times by completely covering with a damp cloth or towel.

5.2 Place the specimens at random locations within the container (as described in Section 3 above) and cover with the specified salt solution so that all specimens are surrounded on 5 sides by not less than ½ inch of the solution. (Note 4 below)

Note 4: At no time during the test shall the cubes be covered by less than ½ inch of salt solution.

5.3 Place the container inside the freezing chamber for a period of 16 ± 2 hours. Maintain the temperature of the freezing chamber at -10°F or lower for the freezing period.

5.4 After the 16 ± 2 hour freezing period, remove the container and permit the contents to thaw at a temperature of 75 ± 15°F for a period of 7 ± 1 hour.

5.5 Alternately cycle between freezing and thawing as specified in the two previous paragraphs. At the end of each fifth cycle, during the thawing phase, remove the specimens (one at a time) rinse with clean water to remove all traces of brine, surface dry with a damp cloth or towel and weigh. Record the weight to the nearest 0.1 g and return the specimens to the container. Care shall be taken to prevent loss of moisture during the weighing operation by covering the specimens completely with a damp cloth or towel. When weighting, if a loss greater than the maximum is encountered, testing can be terminated.

5.6 When the sequence of freezing and thawing cycles must be interrupted, store the specimens in a frozen condition.

5.7 The test specimens shall be subjected to 25 cycles of alternate freezing and thawing.

6 CALCULATIONS

6.1 Calculations shall be made upon the completion of each 5 cycles to determine the percent loss during those cycles. Determine the total percent loss at the end of the testing period.

a. Calculate the percent of loss by using the following formula:

$$L = \frac{W - X}{W} * 100$$

Where:

L = Percent Loss
W = Weight of specimen at 0 cycles
X = Weight of same specimen after completion of each testing period (5 cycles, then at 10 cycles, etc., up to and including final cycle).

7 ACCEPTANCE

7.1 To be included on the Approved List, the average percent loss by weight of the specimens shall not be more than indicated for the determined use.

Test E

TEST METHOD FOR MEASURING LENGTH CHANGE OF HARDENED HYDRAULIC CEMENT MORTAR AND CONCRETE.

1. SCOPE

1.1 This test method covers the determination of the length changes that are produced by causes other than externally applied forces and temperature changes in hardened hydraulic cement mortar and concrete specimens made in the laboratory and exposed to controlled conditions of temperature and moisture.

2. APPLICABLE DOCUMENTS

2.1 ASTM

C 157 Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

C 490 Use of Apparatus for the Determination of length change of hardened cement paste, mortar, and concrete.

3. APPARATUS

3.1 Molds and Length Comparator: The molds for casting test specimens and the length comparator for measuring length change shall conform to the requirements ASTM C490. Beams will have a ten inch gauge length using molds that are 1” x 1” x 11 ¼”.

3.2 Tamper: The tamper shall be made of a material such as medium-hard rubber and shall have a cross section of 0.5 in. by 1.0 in. and a convenient length of about 6 in. The tamping face of the tamper shall be flat and at right angles to the length of the tamper.

4. Procedure for Mixing and Preparing Test Specimens

4.1 For material containing no aggregate: Mix a batch of such size to yield 10 % excess after molding test specimens of dry-packaged material using the maximum amount of water stated in the directions supplied by the manufacturer. The test specimen shall be a prism of 1-in. square cross-section and approximately 11¼ in. in length. Two specimens shall be prepared for air curing and two specimens for water curing.

4.2 For material that is packaged already extended, record how the material was mixed. Either it was wet sieved or dry sieved. If dry sieved, record how much material and the amount of water was used.

5. Procedure for Molding Specimens

5.1 Place the mortar in the mold in two approximately equal layers. Compact each layer with the tamper. Work the mortar into the corners, around the gage studs, and along the surfaces of the mold with the tamper until a homogeneous specimen is obtained. After the top layer has been compacted, strike off the mortar flush with the top of the mold and smooth the surface with a few strokes of a trowel.

6. Procedure for Curing of Specimens

6.1 Remove specimens from molds soon after final set.

6.2 Measure bars immediately after removal from the molds and record the length.

6.3 Water Storage—Immerse two specimens in lime saturated water storage at 73 ± 5°F.

6.4 *Air Storage*—Store the specimens in the drying room, (Temperature 73 + 3 °F and relative humidity of 50%), so that the specimens have a clearance of at least 1 inch.

6.5 At 28 days measure the specimens as before and record the length.

7. Procedure for Calculating Length Change

7.1 Length Change—Calculate the length change of each specimen at 28 days after the initial comparator reading as follows:

$$\square \mathbf{Lx} = \frac{\text{CRD- initial CRD}}{G} * 100$$

where:

□Lx = length change of specimen, %,
Initial CRD = Length of the specimen bar when removed from mold
CRD = Length of the specimen bar at 28 days
G = the gage length (10 in.).

7.2 The two air-cured and water-cured bars are measured individually. The average of the two readings for each condition is the reported length change.

8. ACCEPTANCE

8.1 To be included on the Approved List, the average length change of either shall be not outside the limits for the determined use.

Virginia Test Method – 133

Calcium Chloride Analysis of Aggregate – (Soils Lab)

November 20, 2014

1. Scope

This test method is intended to verify the quantity of calcium chloride that has been added to dense-graded aggregate for gravel road stabilization.

Typically a 32% solution of Calcium Chloride is pug- milled into aggregate at the rate of 2.2 gallons per ton. This test method determines the approximate chloride concentration (mg/L) of the aqueous extract of the aggregate. This chloride concentration is converted to a corresponding Calcium Chloride application treatment of the aggregate. See Calibration Section for more details of this test.

2. Precautions and Limitations

Follow the chemical safety precautions included with the HACH Chloride Test Kit.
Ensure weighing scale is calibrated in accordance with manufacturer's instructions.

3. Apparatus

- Plastic (or glass if cleaned of chlorides) 500 ml beaker.
- Metal spatula.
- Graduated cylinder.
- Scale accurate to 0.5 g.
- HACH Chloride Test Kit (Cat. No. 1440-01, 5-400 mg/L).

4. Procedure

a. Obtain a 5-10 lb representative sample of aggregate that has been pug-milled with CaCl2 solution.

b. Mix and quarter the sample.

c. Weigh a 100 g sample of a visually representative gradation of the bulk aggregate sample in the 500 ml beaker.

d. Add 300 ml of deionized (chloride-free) water.

e. Stir for 30 seconds with a clean metal spatula. Wait for the solution to settle, approximately 1 minute.

f. Test the supernate for chloride concentration (mg/L) using the HACH Chloride Test Kit (0-400mg/L), or equivalent. Dilute sample as necessary to prevent exceeding the 400 mg/L maximum concentration. The recommended dilution is 1:1.

g. Refer to Chart 1 – Find the Plant Addition of CaCL2 to Aggregate that

corresponds to the Supernate Chloride concentration from the Chloride Test Kit result. For example, a chloride concentration of 400 mg/L indicates the aggregate calcium chloride plant addition is 1.1 gallons per ton.

5. Interpretation of Test Results

Test results with low chloride concentration (<400 mg/L) indicate aggregate was not treated with enough calcium chloride. Test results with high chloride concentration (>600 mg/L) indicate aggregate was treated with the appropriate amount of calcium chloride.

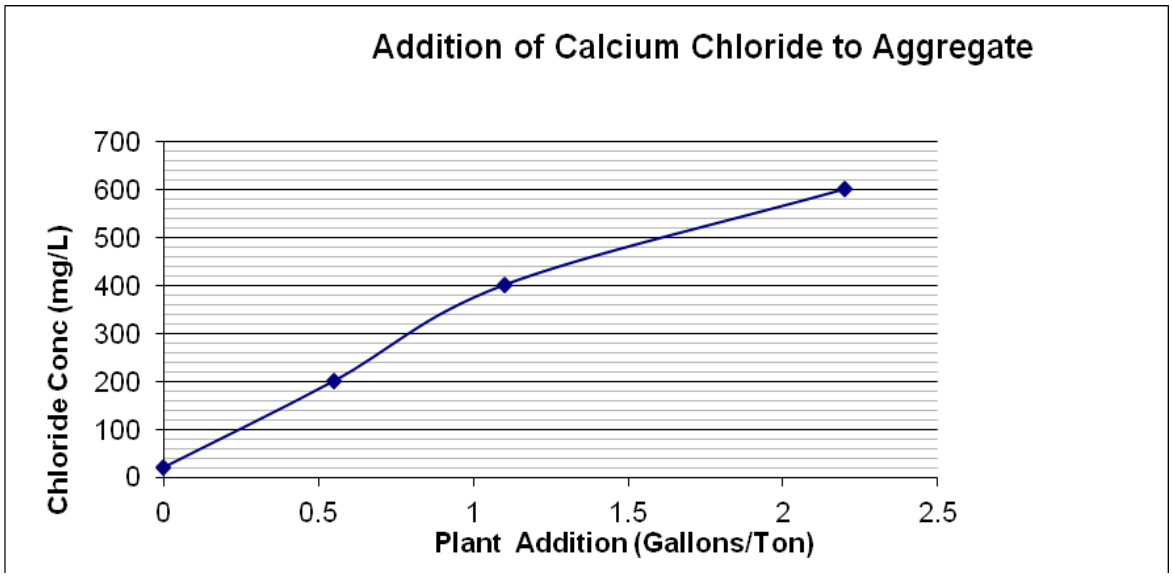
6. Calibration

This test method is an approximate indicator of the calcium chloride quantity added to aggregate. Assumption is made that the chloride concentration is attributable to the calcium chloride salt and no other chloride salt. Aggregate that has not been treated with calcium chloride should be tested to determine the baseline chloride concentration.

A calibration curve is used to determine the relationship between chloride concentration in the supernate and the calcium chloride applied to the aggregate. The calibration curve should be validated periodically with known additions of calcium chloride to aggregate. The test results of the chloride test kit should be validated against other accepted analytical methods, (titration). For best results, it is recommended that the Chloride Test Kit cover the low range of Chloride (0-400 mg/L). If needed, test solutions can be diluted to ensure the chloride concentration is within the 0-400 mg/L range.

Addition of Calcium Chloride to Aggregate

Plant Addition (Gal/Ton)	AVG Chloride Conc (mg/L)
0	20
0.55	200
1.1	400
2.2	600



Virginia Test Method – 134

Bioretention Soil Media Test – *(Soils Lab)*

June 11, 2015

1. Scope

This test method is intended for use with the Virginia DOT Special Provision for Bioretention Soil Media.

- Texture analysis of the mineral soil component (soil fines and fine aggregate); particle size distribution of the fine aggregate; sieving of the soil fines over the 3/8 inch sieve. Must sample 3 times from different parts of each of the stockpiles, blend the samples, and then test and report 1 result for each of the 3 analyses.
- Organic matter content, %, of the bioretention soil media. Must sample 3 times from different parts of the stockpile, blend, and then report 1 result.
- Cation Exchange Capacity (CEC). Must sample 3 times from different parts of the stockpile, blend, and then test and report 1 result.
- Phosphorus (p) adsorption capability. Must sample 3 times from different parts of the stockpile, blend, and then test and report 1 result.
- Bulk density (to obtain conversion factor between tons and cubic yards). Must sample 3 times from different parts of the stockpile, blend, and then test and report 1 result.
- Saturated Hydraulic Conductivity (K_{sat} or K herein) of a simulated standard installation based on the *Mesocosm Testing Protocol for Bioretention Soil Media Testing* by Wetland Studies and Solutions, Inc., Gainesville, VA. Must sample from 6 different parts of the stockpile, maintain the 6 samples separately, 1 for each testing tube, and conduct 1 Mesocosm test, which will result in 6 sets (1 per sample) of hydraulic conductivity measurements.

2. Precautions and Limitations

See individual test descriptions.

3. Apparatus

See individual test descriptions.

4 Procedure

a. Particle Size Distribution and Textural Analysis

Three (3) representative samples of a pug milled mix of the fine aggregate alone (if soil fines alone are comprised of just one (1) graded sand mix, then pug milling shall not be required)shall be collected as per the mini-stockpile method described in VDOT Materials Division Manual of Instructions Section 308.05(a). These three (3) samples shall be blended together. The fine aggregate gradation shall be determined using AASHTO T27

Three (3) representative samples of a pug milled mix of the soil fines alone shall be collected per the mini-stockpile method described in VDOT Materials Division Manual of Instructions Section 308.05(a). These three (3) samples shall be blended together. The soil fines shall be sieved over the 3/8-in sieve to ensure 100% passing. The result shall be reported.

Three (3) representative samples of a pug milled mix of the mineral soil (fine aggregate and soil fines together) shall be collected per the mini-stockpile method described in VDOT Materials Division Manual of Instructions Section 308.05(a). These three (3) samples shall be blended together. A textural analysis shall be completed and reported. AASHTO T88 shall be used to determine particle size distribution, except that the hydrometer reading for sand shall be recorded at 40 seconds and for clay at 120 mins.

b. Organic matter content.

Three (3) representative samples of the bioretention soil media shall be sampled per the mini-stockpile method mentioned above, blended together, and AASHTO T267 Determination of Organic Content in Soils by Loss on Ignition used to determine organic content, except that the sample shall be kept drying for 16 hours minimum in order to achieve drying to constant mass. Organic matter shall be expressed on a dry weight basis and shall not include coarse particulate components.

c. Cation Exchange Capacity (CEC)

Three (3) representative samples of the bioretention soil media shall be sampled per the mini-stockpile method mentioned above, blended together, and the Ammonium Acetate CEC Method (Chapman, 1965) as included in Annex A of this VTM shall be used to test the mix.

d. Phosphorus (P) Adsorption Capability

Three (3) representative samples of the bioretention soil media shall be sampled per the mini-stockpile method mentioned above, blended together, and either the Mehlich I or Mehlich III methods as included in Annex B of this VTM shall be used to test the mix.

e. Bulk Density

Three (3) representative samples of the bioretention soil media shall be sampled per the mini-stockpile method mentioned above, blended together, and tested for bulk density.

A clear, rigid plastic or glass test tube of 12-inch inside diameter and 18-inch height shall be filled with the bioretention soil media, including being placed on a rigid free-draining surface with the same hardware cloth and rebar bottom as in Annex C underneath the sample, and being hydraulically compacted, except that the soil shall be within 1 inch of top of tube prior to compaction.

The entire sample including test tube and hardware fabric and rebar bottom shall be weighed 2 hours after the last of the water for hydraulic compaction has been added. The actual height of soil in the tube shall be measured to the nearest inch just prior to weighing. The sample weight shall be recorded to the nearest pound. The net weight of the sample shall have the weight of the tube and hardware cloth and rebar to the nearest pound subtracted.

The bulk density in pounds per cubic foot (pcf) shall be computed as the net weight of the sample in pounds divided by the volume of the bioretention media after hydraulic compaction in cubic feet. This volume is computed as pi * $(0.5)^2$ * (height of sample in inches measured just prior to weighing/12), and shall be recorded to the nearest 0.1 pcf.

f. Saturated Hydraulic Conductivity (K_{sat} or K herein) by Mesocosm Test

Six (6) representative samples of the bioretention soil media shall be sampled per the mini-stockpile method mentioned above. One mesocosm test shall be done on each sample, resulting in 6 different K values being produced.

The *Mesocosm Testing Protocol for Bioretention Soil Media Testing* by Wetland Studies and Solutions, Inc., Fairfax, VA, included in Annex C, shall be used, including the reporting procedures

Annex A
Cation Exchange Capacity Determination at pH 7 with Ammonium Acetate
(Chapman, 1965)

Advantages of pH 7 Ammonium Acetate CEC:

The pH 7.0 ammonium acetate CEC method has been widely used in the U.S. for decades. Consequently, a large data base exists for soil CEC by this method. Many state agencies have traditionally required CEC to be measured by this procedure.

Disadvantages of pH 7 Ammonium Acetate CEC:

The pH 7.0 ammonium acetate CEC method is more time-consuming than effective CEC but can be readily adapted by most soil testing laboratories. The main problem with this method is that it buffers soil pH at 7.0 causing large overestimates of CEC for many of the acid soils common to the northeast.

Equipment:

1. Buchner funnel filtration apparatus.
2. Balance.
3. 250 and 500 mL Erlenmeyer flasks.
4. Apparatus for ammonium determination (steam distillation or colorimetric).

Reagents:

1. 1 *M* ammonium acetate (NH_4OAc) saturating solution: Dilute, in a chemical hood, 57 mLs glacial acetic acid (99.5%) with ~800 mL of distilled H_2O in a 1 L volumetric flask. Add 68 mL of concentrated NH_4OH, mix and cool. Adjust pH to 7.0 with NH_4OH if needed and dilute to 1 L.
2. 1 *M* KCl replacing solution: Completely dissolve 74.5 g KCl in distilled water and dilute to a final volume of 1 L.
3. Ethanol, 95%

Procedure:

1. Add 25.0 g of bioretention soil media (BSM) to a 500 mL Erlenmeyer flask.
2. Add 125 mL of the 1 *M* NH_4OAc , shake thoroughly, and allow to stand 16 hours (or overnight).
3. Fit a 5.5 cm Buchner funnel with retentive filter paper, moisten the paper, apply light suction, and transfer the BSM. If the filtrate is not clear, refilter through the BSM.
4. Gently wash the BSM four times with 25 mL additions of the NH_4OAc, allowing each addition to filter through but not allowing the BSM to crack or dry. Apply suction only as needed to ensure slow filtering. Discard the leachate, unless exchangeable cations are to be determined. **Note**:

Exchangeable cations can be determined on the leachate after diluting it to 250 mL.

5. Wash the BSM with eight separate additions of 95% ethanol to remove excess saturating solution. Only add enough to cover the BSM surface, and allow each addition to filter through before adding more. Discard the leachate and clean the receiving flask.

6. Extract the adsorbed NH_4 by leaching the BSM with eight separate 25 mL additions of 1 *M* KCl, leaching slowly and completely as above. Discard the BSM and transfer the leachate to a 250 mL volumetric. Dilute to volume with additional KCl.

7. Determine the concentration of NH_4-N in the KCl extract by distillation or colorimetry. Also determine NH_4-N in the original KCl extracting solution (blank) to adjust for possible NH_4-N contamination in this reagent.

Calculations:

CEC (meq/100g) = NH_4-N[+] (mg/L as N) ÷ 14

[+](NH_4-N in extract -NH_4-N in blank)

Note:
If NH_4-N is expressed as mg/L of NH_4, not NH_4N, divide the result by 18 instead of 14 to obtain CEC.

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Annex B
Mehlich I

The Mehlich-1 (M1) extraction method determines the relative bioavailability of ortho-phosphate (PO_4-P) in soils.

Equipment and Apparatus

1. Soil Scoop 4 cm^3

2. Reciprocating mechanical shaker, capable of 180 oscillations per minute (opm)

3. Repipette dispenser, calibrated to 25 ± 0.2 mL, 12 ± 0.1 mL

4. 50-mL plastic extraction erlenmeyer and associated filtration apparatus

5. Whatman No. 1 filter paper or equivalent

6. Pipettes: 0.250 ±0.005 mL, 0.500 ±0.005 mL, 1.00 ±0.01 mL, 2.00 ±0.02 mL, 3.00 ± 0.03 mL

7. 2.5 cm matching spectrophotometer cuvette

8. Spectrophotometer, wavelength 882 nm, automated Flow Injection Analysis (FIA) and/or ICP-AES

Reagents

1. Deionized water, ASTM Type I grade

2. M1 extracting solution (0.05 N HCl and 0.025 N H_2SO_4). Dilute 4 mL of concentrated HCl and 0.7 mL concentrated H_2SO_4 to 1.0 L with deionized water

3. Modified Reagent A (Watanabe and Olsen, 1965)

   a. Ammonium Molybdate: Dissolve 12.0 g. of A.R. [$(NH_4)_6Mo_7O_{24} \cdot 4H_2O$] in 250 mL of deionized water
   b. Antimony Potassium Tartrate: Dissolve 0.291 g. of A.R. antimony potassium tartrate [$K(SbO) \cdot C_4H_4O_6 \cdot ½ H_2O$] in 100 mL of deionized water
   c. Add both of the dissolved reagents to 1,000 mL of 5.76 N H_2SO_4 (160 mL of concentrated sulfuric acid per liter, Self and Rodriguez, 1996) mix thoroughly and add DI water to make 2,000 mL of solution. Modified Reagent A (mixed reagent) last at least four months if it is stored in an opaque plastic bottle.

4. Reagent B, ascorbic/molybdate reagent (Watanabe and Olsen, 1965)

   a. Dissolve 1.32 g. of A.R. ascorbic acid ($C_6H_4O_6$) in 250 mL of modified Reagent A and mix well. This reagent should be prepared as required.

5. Calibrations Standards: From a standard solution containing 1,000 mg L^{-1} of the analytes, prepare 1 L of standards in M1 extracting solution containing the highest concentrations of each element.

Then, prepare 250 mL each of other calibration standards from diluting the most concentrated one. Below is the recommended range of calibration standards:

P	K	Ca	Mg	Na	Fe	Mn	Cu	Zn	B
ppm	ppm	ppm	Ppm	ppm	ppm	ppm	ppm	ppm	ppm
0	0	0	0	0	0	0	0	0	0
10	10	50	10	10	10	2	2	2	2
25	25	100	50	50	25	5	5	5	5
50	50	500	100	100	50	10	10	10	10

Procedure

Extraction

1. Scoop or weigh 5.0±0.1 g (4.0 ±0.1 cm^3) of air dried bioretention soil media (BSM) pulverized to pass 10 mesh sieve (< 2.0 mm) in a 50-mL glass or plastic Erlenmeyer flask.

2. Add 25.0 mL of M1 extracting solution (see comment # 2). Include a method blank.

3. Place extraction flask(s) on reciprocating mechanical shaker for five (5) minutes.

4. Filter suspension immediately into 20 mL plastic scintillation vials; refilter if filtrate is cloudy.

Analysis

For phosphate determination

1. Pipette 1.0 mL aliquot of standard or BSM extract into a 25 mL test tube (see comment #3).

2. Add 12.0 mL of deionized water.

3. Add 2.0 mL of Reagent B (ascorbic/molybdate reagent) and stir on vortex stirrer for 30 seconds.

4. Adjust and operate spectrophotometer in accordance with manufacturer's instructions. Read absorbance at a wavelength of 882 nm after ten (10) minutes of adding the Reagent B. Adjust the 0.000 absorbance using the 0.00 standard. Determine absorbance of a method blank, standards and unknown samples. Calculate phosphorus concentration for blank and unknown samples from standard curve and record phosphorus to the nearest 0.01 mg L^{-1} PO_4-P in extract solution (See Comment #4).

For ICP determination of all analytes

1. Calibrate the ICP using multiple element standards following manufacturer's recommendations in the operation and calibration of the instrument.

2. Analyzing samples. Dilution should be made if a sample has concentrations above the highest standard.

Calculations

1. BSM mass — parts per million

   Report BSM M1 extractable macronutrients to the nearest 0.1 mg kg^{-1} and micronutrients to the nearest 0.01 mg kg^{-1}:

   BSM nutrients mg kg^{-1} = (mg L^{-1} in extract - method blank) × 4

2. BSM volume- parts per million

   Report BSM M1 extractable macronutrients to the nearest 0.1 mg dm^{-3} and micronutrients to the nearest 0.01 mg dm^{-3}

   BSM nutrients mg kg^{-1} = (mg dm^{-3} in extract - method blank) × 4

Analytical Performance

1. The modern ICP can reliably detect macronutrients to 0.1 ppm and micronutrients to 0.01 ppm, which are satisfactory for making fertilizer recommendations. Overall, the repeatability and reproducibility of M1 were within the acceptable range.

1.

Effects of Storage

1. Air-dried BSM may be stored several months without affecting the M1 P measurement.
2. The M1 extraction solution is stable and can be stored for several weeks due to its acidic nature. A specific shelf life is not known.

Safety and disposal

The chemicals used in this procedure pose no safety risk and therefore can be stored and disposed of according to routine laboratory procedures. Some labs may require neutralization before pouring extracted M1 solution into the sink due to low pH.

Annex B (continued)
Mehlich III

Description

Mehlich 3 estimates plant availability of most macro- and micro-nutrients inbioretention soil media (BSM). In the process of extraction, phosphorus is solubilized under different mechanisms.

Equipment and Apparatus

1. BSM scoop calibrated to 2.0 g (1.7 cm^3) and leveling rod

2. 60 mL extraction bottles

3. Automatic solution dispenser

4. Reciprocating shaker

5. ICP-AES and/or spectrophotometer, automated Flow Injection Analysis (FIA) if colorimetric determination of P is needed

6. Reciprocating syringe pump calibrated at 20 mL

Note: The original published method (Mehlich, 1984) is strictly on a volumetric basis (2.5 cc soil – 25 mL of extractant) making no assumptions in soil bulk density. The purpose of this is due to the fact that soils can vary significantly in densities (0.5 to 1.7 g /cc) and erroneous assumptions can lead to large errors in final results obtained.

Reagents

Solutions are made with ASC reagent grade chemicals and distilled water unless otherwise noted.

1. Ammonium nitrate (NH_3NO_3), fw = 80.05, CAS# 6484-52-2

2. Ammonium fluoride (NH_4F), fw = 37.04, CAS# 12125-01-8

3. Nitric acid (HNO_3), 68-70%, fw = 63.02, 15.5N, CAS# 7698-37-2

4. Ethylenediamine tetraacetic acid (EDTA), $(HOOCCH_2)_2NCH_2CH_2N(CH_2COOH)_2$, fw = 292.25, CAS# 60-00-4

5. Acetic acid, glacial [CH_3COOH] fw = 60.05, CAS# 64-19-7

6. Ammonium fluoride-EDTA stock solution (3.75M NH_4F—0.25M EDTA): Dissolve138.9g of NH_4F in 600 mL of deionized water and add 73.06 g EDTA (or 93.06 g of Na_2-EDTA•$2H_2O$), dissolve and dilute to 1000 mL.

7. Mehlich-3 extracting solution (0.2 N CH_3COOH—0.25N NH_4NO_3-0.015N NH_4F-0.013N HNO_3-0.001 M EDTA@pH-2.50 ± 0.05). Dissolve 80.05 g NH_4NO_3 in about 3,000 mL of deionized water. Add 16.0 mL of 3.75M NH_4F -0.25M EDTA stock solution and mix well. Add 46 mL of concentrated glacial CH_3COOH and 3.3 mL of concentrated HNO_3 and bring to 4,000 mL final

volume. The final pH should be 2.50 ± 0.05.

8. Calibrations Standards. From a standard solution containing 1,000 mgL^{-1} of the analytes prepare 1 L of standards in Mehlich 3 extracting solution containing the highest concentrations of each element. Then, prepare 250 mL of other calibration standards from diluting the most concentrated one. Below is the recommended range of calibration standards:

P	K	Ca	Mg	Na	Fe	Mn	Cu	Zn	B
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0	0	0	0	0	0	0	0	0	0
10	10	20	10	10	10	2	2	2	2
25	25	50	25	25	25	5	5	5	5
50	50	100	50	50	50	10	10	10	10

Procedure

Extraction

1. Scoop or weigh 2.0± 0.05 g of air dried BSM pulverized to pass10 mesh sieve (< 2.0 mm) in a 50-mL glass or plastic Erlenmeyer flask.

2. Add 20.0 mL of Mehlich 3 extracting solution. Include a method blank and check samples as determined by the lab.

3. Place extraction flask(s) on reciprocating mechanical shaker (200, 4-cm recips/minute) for five (5) minutes.

4. Filter suspension immediately and collect the extract in 40 mL plastic vials, refilter if filtrate is cloudy.

Analysis

3. Calibrate the ICP using multiple element standards following manufacturer's recommendations in the operation and calibration of the instrument.

4. Analyzing samples. Dilution should be made if a sample has concentrations above the highest standard.

Calculations

3. BSM mass — parts per million

   Report BSM Mehlich 3 extractable macronutrients to the nearest 0.1 mg kg^{-1} and micronutrients to the nearest 0.01 mg kg^{-1}:

   BSM nutrients mg kg^{-1} = (mg L^{-1} in extract - method blank) × 10

4. BSM volume — parts per million

Report BSM Mehlich 3 extractable macronutrients to the nearest 0.1 mg dm^{-3} and micronutrients to the nearest 0.01 mg dm^{-3}

BSM nutrients mg kg^{-1} = (mg dm^{-3} in extract - method blank) × 10

Analytical Performance

2. The modern ICP can reliably detect macronutrients to 0.1 ppm and micronutrients to 0.01 ppm, which are satisfactory for making fertilizer recommendations. The repeatability and reproducibility of M3 for plant available macro- and micro-nutrients were thoroughly evaluated through inter-laboratory studies by Zhang et al. (2009) and Schroder et al. (2010). Overall, the repeatability and reproducibility of M3 were within the acceptable range.

Effects of Storage

3. Air-dried BSM may be stored several months without affecting the M3 P measurement.

4. The M3 extraction solution is stable and can be stored for several weeks due to its acidic nature. A specific shelf life is not known.

Safety and disposal

1. The chemicals used in this procedure pose no safety risk and therefore can be stored and disposed of according to routine laboratory procedures. Some labs may require neutralization before pouring extracted M3 solution into the sink due to low pH.

Annex C

Mesocosm Testing Protocol for Bioretention Soil Media Testing

(from Wetland Studies and Solutions, Inc., Gainesville, VA)

1. Introduction

A mesocosm is an experimental tool that integrates relevant structure and functions of existing or proposed site conditions into a controlled laboratory environment. For purposes of this testing protocol, mesocosms are assembled with a specific soil media profile (i.e. gravel, sand, bioretention soil media (BSM), and shredded hardwood mulch) to assess how the soil profile will function in a full scale bioretention facility under varying conditions. These mesocosms can be utilized to mimic field conditions through exposure to multiple falling head filtration tests that include drying periods of various durations between the tests to simulate multiple rain events. It is recommended that replicate tests on multiple mesocosms be conducted simultaneously in order to capture the range of the variability in the media's filtration rate normally encountered in the field.

If facilities are constructed near roadways or other surfaces that may potentially be treated with de-icing road salt (NaCl), at least one testing cycle should include a road salt brine solution. Sodium (Na) is known to disperse organic matter, silts, and clays and slows infiltration rates when introduced to the media intermittently between freshwater flushes. It therefore has the potential to significantly reduce the filtration capacity of the facility (i.e. reduction of up to 90% has been observed in such tests).

This test is a measure of the overall bowl recession rate (i.e. rate at which the ponded water recedes into the soil). Under saturated conditions, this rate will equilibrate and closely approximate the saturated hydraulic conductivity (k_{sat}) of the soil media. As presented, this test is repeatable and reflects what users will observe in the field.

The remainder of this document outlines the procedures that should be followed in order to construct the mesocosm apparatus, perform the tests, and to analyze/summarize the data.

2. Mesocosm Soil Profile

2.1. Typical Soil Media Profile

Below is the standard typical mesocosm soil profile that shall be used for this testing protocol, unless other design specifications are provided. Refer to Section 2.2 if a specific bioretention facility design is to be used.

6” Design ponding depth
3” Shredded hardwood mulch
36” Bioretention soil media (BSM)
3” ASTM C33 coarse sand
2” Washed VDOT #8 choker stone
8” Washed VDOT #57 aggregate
Rebar grate supporting hardware cloth (See Section 3.1 for specifications)

2.2. Site Specific Mesocosm Soil Profile

If a specific bioretention facility design is to be tested, the typical section provided in Section 2.1 should be revised to match. This will require the following design information be obtained in order to ensure the proper elements are tested:

- Bioretention soil media (BSM) design specifications and depth
- Filter fabric type and brand, if any (Note: Sometimes filter fabric is used in lieu of a gap graded sand/gravel filter. In such cases, the fabric is wrapped on the bottom of the column and held in-place with steel band clamps.)
- Sand and aggregate class sizes and depths, if specified beneath the soil media

3. Required Materials for a Single Mesocosm Test

3.1. Apparatus (Refer to Appendix 1)

- Mesocosm stand
- 12" diameter tube (PVC or clear acrylic), minimum length shall accommodate all media layers of bioretention facility, ponding depth, and 4" for installation of rebar grate at base
- 12" rubber Fernco fittings, as necessary
- Rebar grate to support mesh hardware cloth (required to hold media in-place)
  - Rebar grate: 3-12" lengths of #4 rebar at 3.3" on center (o.c) overlaid and welded with 2-12" lengths of #4 rebar at 4.5" o.c. to create a grid
  - Hardware cloth: 23 gage, galvanized wire with 1/4" mesh opening
- Scale
- Duct tape
- 5 gallon bucket
- Contractor trash bag

3.2. Filter Fabric, Aggregates, and Soil Media (per Section 2)

- Gap-graded sand/gravel filter (i.e. choking layer)
  - ASTM C33 coarse sand
  - #8 choker stone
- #57 aggregate
- BSM or individual components of BSM to manually mix (e.g., sand, soil, organics)
- Shredded hardwood mulch
- Other media or filter fabric[1] as prescribed in design specifications.

Note: All materials shall be obtained from proposed supplier.

3.3. Additional Materials

- Road salt (NaCl) brine solution (i.e. if potential exposure to road salt deicing, See Section 5)
- Hose with mist/spray nozzle attachment
- 12" diameter foam circle with string attachment, at least 1" thick
- Stopwatch
- Record keeping materials

4. Apparatus Set-up

4.1. Secure PVC tube(s) in mesocosm stand with a 5-gallon bucket installed underneath to collect water (Appendix 1). A plastic apron, such as a contractor trash bag, may be attached to the bottom of the PVC tube to guide water into the 5-gallon bucket. An alternate method for securing mesocosms may be employed such that it sufficiently secures the tubes and allows water to flow through unimpeded.

4.2. Install rebar grate and hardware mesh at base of PVC tube (Appendix 1). Grate and mesh shall be installed such that aggregate and media remains in-place without impeding flow.

[1] *Filter fabric is not included in the provided 'typical' standard mesocosm profile. Obtain a minimum 2.5'x2.5' sample for each mesocosm if fabric is specified in the design plans. (Note: If the fabric is not appropriately selected for the BSM particle size distribution clogging can occur, which will likely be observed after repeated tests in the facility.)*

4.3. Fill mesocosms from the bottom up with specified depth of aggregates[2] - #57 aggregate and gap-graded sand/aggregate filter (i.e. choking layer).

4.4. Install BSM in 12" lifts with hydraulic compaction of each lift. Use a flat shovel, or comparable, to smooth each layer (i.e. lift) of media prior to installing additional lifts, as described below:

a. Fill the mesocosm with 12 inch depth of BSM for the first lift, and then use a string to lower the 12" diameter foam circle to rest flat on the top of the BSM. Use the hose with the sprinkler nozzle to sufficiently saturate the lift (e.g., water covers the foam pad and water drips from the bottom of the mesocosm)[3].

b. Prior to installing additional lifts, allow water to drain through the media so that there is no standing water on the surface after the foam is removed. Continue to fill the mesocosm with the additional 2-12" lifts, saturating in between.

c. Re-measure soil media depth. If the depth of soil media has been reduced, add additional soil media to regain the 36" BSM depth and hydraulically compact as noted in Section 4.4.a, b.

4.5. Install shredded hardwood mulch.

4.6. After all medias are in-place, attach a scale to the inside wall of the column. A reading of zero on the scale should correspond to the top of the mulch to represent the ponding depth.

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[2] *In most bioretention facilities the base layer of aggregate is installed as a water retention basin to store water in the pore spaces between the aggregate that has drained through the facility. Over time water is slowly released through a controlled drain opening or into the natural subsoil layers. Depth of these layers can vary drastically from a few inches to several feet. If aggregate storage is proposed, a minimum depth of 6"shall be used in the mesocosm to mimic the field conditions and limit the mesocosm to a manageable height. Aggregate base layers will not impede flow, or alter overall infiltration rate, thus, not required for this test.*

[3] *The sprinkler head and foam circle act as a dissipater to prevent water from separating the fine particles from the soil media and creating a layering of grain sizes as the water draws down. The hardwood mulch top layer will provide similar protection once installed in the mesocosm and in the actual, full scale facility.*

5. Testing Procedures

The general testing procedure is to fill water to the 6" ponding depth and to measure incremental and overall drawdown of multiple cycles after varying drying times[4]. A saltwater brine solution shall be substituted for a minimum of one cycle if the bioretention facility will be exposed to road salt[5].

The step-by-step procedure is as follows:

5.1. Use a sprinkler head attachment on a hose to gently spray water evenly down into the mesocosm until the water level reaches desired maximum ponding depth.

5.2. Record the time when the 6" ponding depth is obtained. Continue recording incremental time and depth measurements until the ponding depth is zero. Generally, a measurement interval that results in a minimum 0.25" drop in head is sufficient (i.e., if the soil drains 0.25" in 30 minutes, measurements may be taken every 30 minutes or less). Be aware, however, that soil particle interaction may speed or slow the filtration rate without warning.

5.3. Once the water has completely penetrated the soil media surface (i.e., water level is at zero), take a final time measurement.

5.4. Repeat Steps 5.1 through 5.3 to perform the second cycle immediately after the first water cycle is complete.

5.5. After the second cycle, allow the mesocosm apparatus to completely drain of water (either through the base of the apparatus or through the underdrain) and dry for a minimum of 36 hours. Then repeat steps 5.1 through 5.3 for the third water cycle.

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[4] *Drying periods between cycles allows the mesocosm apparatus to completely drain of water. This simulates a typical wet/dry cycle that would be seen in a natural environment and confirms if there is a multiple event scenario that may cause performance degradation.*

[5] *Road salt brine shall be prepared by mixing approximately 2.5 kg of road salt into 14 liters of freshwater (i.e. a saturated solution at room temperature).*

5.6. Test cycles shall be performed as follows:

Table 1. Recommended Testing Cycles

Cycle 1 - Freshwater
Cycle 2 - Freshwater
36 hour Drying Period (minimum)
Cycle 3 - Saltwater Brine Solution [1]
Cycle 4 - Freshwater
96 hour Drying Period (minimum)
Cycle 5 - Freshwater
Cycle 6 - Freshwater
36 hour Drying Period (minimum)
Cycle 7 - Freshwater
Cycle 8 - Freshwater

[1] *Potential exposures to road salt (NaCl) from de-icing of roads or other surfaces within the proposed drainage area may affect filtration (See Section 1) and should be tested. If road salt (NaCl) exposure is expected, then a minimum of 1 testing cycle shall use a salt water brine solution. The effect of the brine solution is not immediate, so it should be tested in Cycle 3 to allow sufficient time for it to take effect.*

6. Success Criteria

Mesocosm filtration test results of BSM are considered acceptable when the mean overall infiltration rate for each cycle is between 1 and 8 in/hr. If the rate from any particular cycle is outside this acceptable range, but returns to within the acceptable range during the following cycle or after a drying period and, the overall mean infiltration rate from all cycles is within range, then the BSM shall still be considered acceptable.

7. Results

Results shall be summarized and reported as follows:

- Cycle Data. Data for each wet cycle shall be recorded in the blank Cycle Data Worksheet provided as Appendix 2a. Data will include time, elapsed time, depth, and incremental infiltration rate. Overall infiltration rate shall also be included.

- Mesocosm Test Result Summary. Once all wet/dry cycles are done, the summary table and graph as provided in Appendices 2b and 2c, shall be completed. This summary reports the overall infiltration rate of each cycle, along with BSM composition, media depths and sources, wet cycles (i.e. road salt brine (Na) or freshwater), and length of drying cycles. The accompanying graph shall also be prepared to illustrate any variability. If multiple mesocosms are tested, a report may be compiled using these summary sheets.

- Summary of Multiple Mesocosms. When comparing results from multiple mesocosms, a bar graph with error bars shall be used to illustrate level of variability (Appendix 2d).

8. List of Appendices

Appendix 1. Mesocosm Apparatus
Appendix 2. Blank Forms

Appendix 1. Mesocosm Apparatus

Figure 1. Example mobile mesocosm apparatus for three (3) mesocosm tubes. Five (5) gallon buckets are installed underneath to collect water draining from mesocosms.

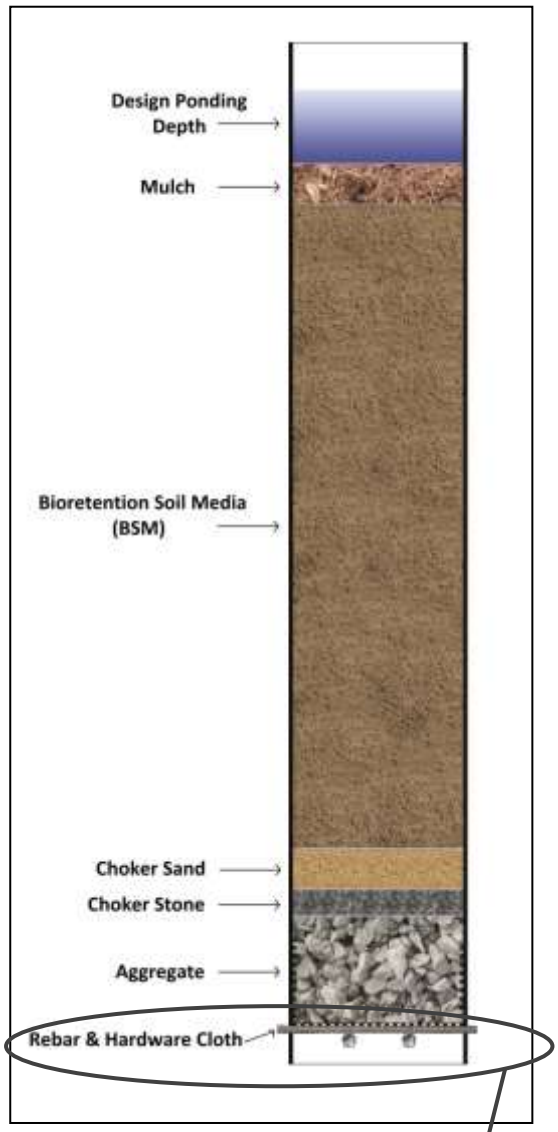


Figure 2. Typical Mesocosm Profile

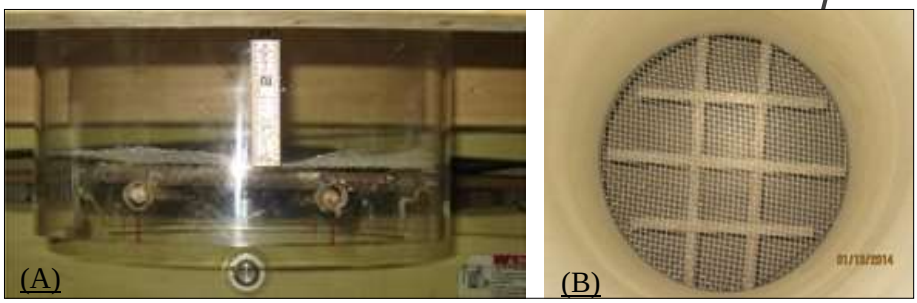


Figure 3. Rebar grate & hardware mesh (A) looking at holes drilled into clear pipe to secure grate (B) view of grate and mesh from top of mesocosm tube.

Appendix 2. Blank Forms

Appendix 2a. Example Cycle Data Worksheet

Date:	mm/dd/yyyy	**Start Time:**	HH:mm
Test Number:	1, 2, 3, etc.	**End Time:**	HH:mm
Performed By:			

Media Source:	Example Company, Inc.
Media Depth (in):	36
Flood Depth (in):	6

Time	Interval Time (hrs)	Elapsed Time (hrs)	Depth (in)	Infiltration Rate (in/hr)
6:19 AM	0	0.00	**6**	
6:34 AM	0.25	0.25	3	--
6:49 AM	0.25	0.50	0.25	11.00
6:52 AM	0.05	0.55	0	5.00

Overall Infiltration Rate (in/hr):	**10.91**
Infiltration Rate Acceptable?	**Yes**

Appendix 2b. Example Mesocosm Test Result Summary

Sample XYZ
Example Test #

Results Summary:

Cycle Number	Date	Overall Infiltration Rate (in/hr):	Infiltration Rate Acceptable?
Cycle 1	2/19/2014	10.9	Yes
Cycle 2	2/19/2014	3.8	Yes
36-hour Drying Period [2]			
Cycle 3	2/21/2014	7.5	Yes
Cycle 4	2/21/2014	4.2	Yes
96-hour Drying Period [2]			
Cycle 5	2/23/2014	5.1	Yes
Cycle 6	2/23/2014	2.4	Yes
36-hour Drying Period [2]			
Cycle 7	2/25/2014	0.9	No
Cycle 8	2/25/2014	1.0	Yes

Minimum Infiltration Rate:
1-2 inches/hour

Soil Media Composition [1]:
X% Sand
X% Topsoil
X% Organic Matter

Fresh Water Cycles
Salt Water [3] Cycles

[1] Media obtained from Example Company on DATE.

[2] Drying periods between cycles were used to allow the mesocosm apparatus to completely drain of water. This simulates a typical wet/dry cycle that would be seen in a natural environment.

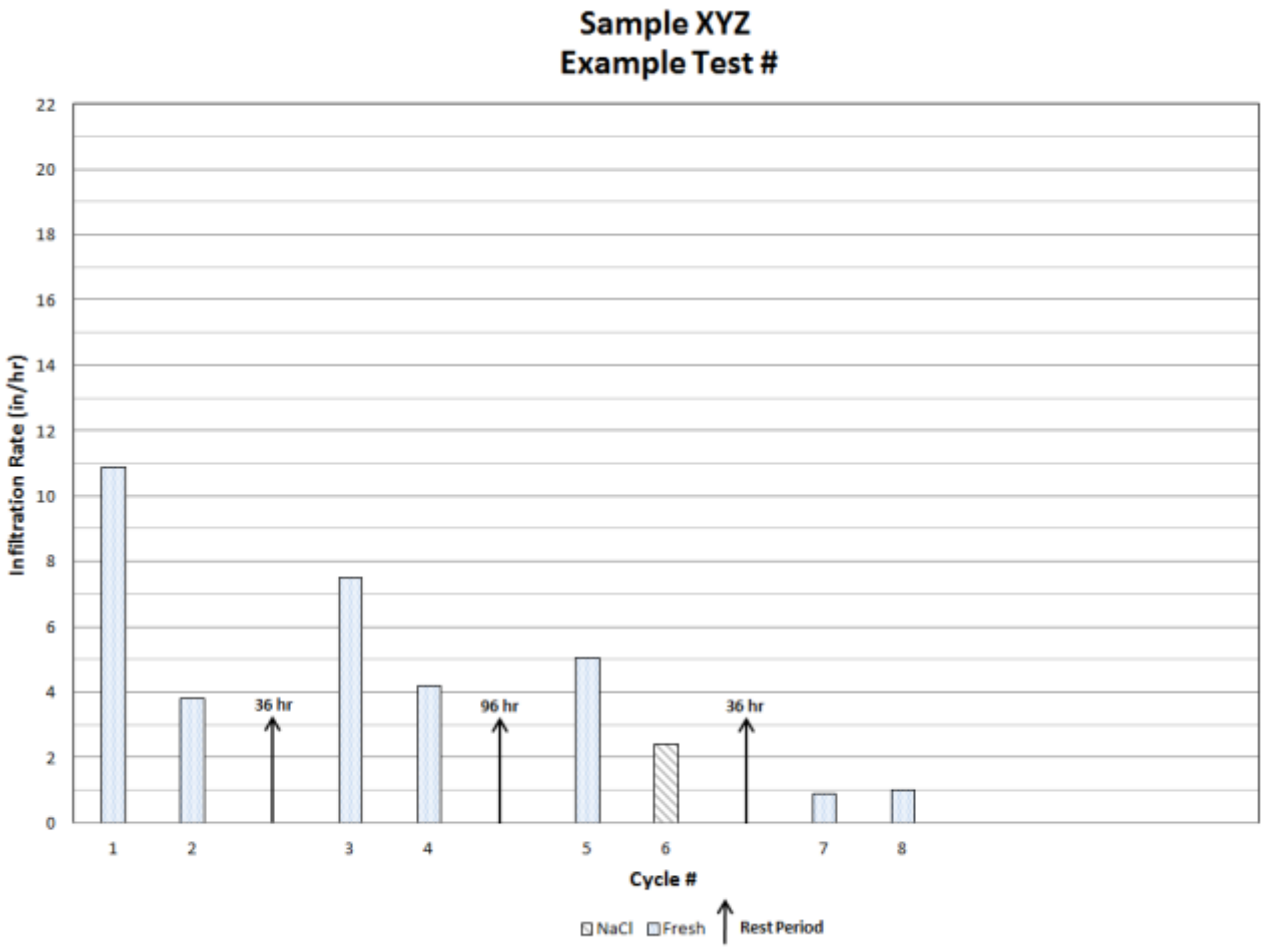
[3] Road salt was collected from Example Company (Town, VA) on DATE. Salt was mixed at a concentration of 2.52 kg of road salt into 14 liters of water to make brine solution.

Mesocosm Profile:

Material	Depth	Source
Ponding Depth	6"	Example Company, Inc
Mulch	3"	Example Company, Inc
Soil Media	36"	Example Company, Inc
Coarse Sand	3"	Example Company, Inc
Choker Stone (#8)	2"	Example Company, Inc
Aggregate (#57)	8"	Example Company, Inc

source filepath

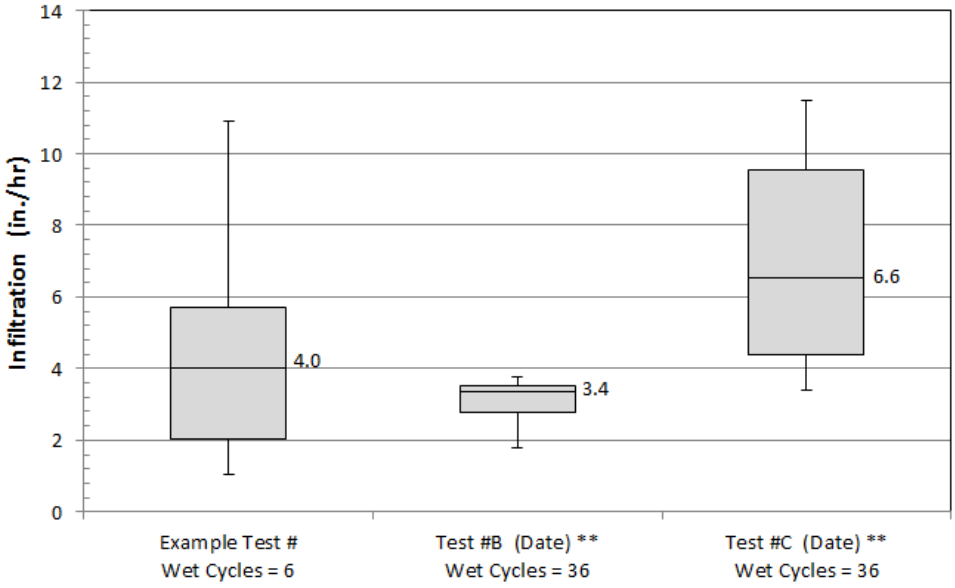
Appendix 2c. Example Mesocosm Test Result Summary Graph



Appendix 2d. Example Overall Summary Graph

Sample XYZ

Overall Summary *



* On the graphs, the gray boxes represent the middle 50% of each data set, as measured by the upper and lower quartiles. The median value is labeled and identified as the thin line in each gray box.

** Refer to the report dated DATE for Test #B and Test #C results. Results are provided herein for comparison only to testing that is presented in this report.

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<u>Virginia Test Method – 137**</u>**

Test Method for Measurement of Tack Application in the Field – (Asphalt Lab)

February 29, 2016

1. Scope

1.1. This test covers the procedure for determining the application rate in gallons per yard squared of bituminous material (tack).

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. Balance, Class G2, in accordance with AASHTO M 231

2.2. Suitable weighing box or shield for balance

2.3. Metal plate, approximately 1 ft x 1 ft; or other approved apparatus with known area and consistent weight

2.4. Tack distributor with accurate volume readings.

3. Procedure

3.1. Method A: Tack Plate Method

3.1.1. Record the plate area (square feet) from known value for plate or measuring dimensions.

3.1.2. Weigh the plate to determine the mass of just the plate.

3.1.3. Place plate at a stratified random location in lane ahead of tack distributor; have distributor continue normal spraying pattern over plate. If plate area or weight is altered besides the emulsion sprayed on plate surface (i.e. due to distributor tires) then test should be restarted.

3.1.4. After distributor has passed and tack applied to the plate, remove the test plate from the pavement, with care to not allow tack material to fall off of the top plate surface, and weigh immediately, no later than 3 minutes, prior to tack breaking.

3.1.5. The weight of the sprayed emulsion is calculated by subtracting the weight of the plate from the weight of the plate + asphalt

3.1.6. Determine the residual asphalt content from supplier. This information is found on the product Technical Data Sheet.

3.2. Method B: Tack Yield Calculation Method

3.2.1. Measure the temperature of the tack, and the length (ft) and width (ft) of the lane area to be tacked for paving.

3.2.2. Before the distributor begins spraying tack, take a reading from the distributor's gauge in gallons.

3.2.3. Once the distributor has tacked the entire area measured and no other paving surfaces outside of the measured area, take a final reading from the distributor's gauge in gallons.

3.2.4. Determine the difference in the initial and final distributor readings. This value is the amount of tack placed in gallons.

3.2.5. Determine the residual asphalt content from supplier. This information is found on the product Technical Data Sheet.

4. Calculations

4.1. Method A: Tack Plate Method

To determine the Sprayed Emulsion Application Rate, use the following equation:

$$Sprayed\ Emulsion\ Application\ Rate\ \left(\frac{gal}{SY}\right) = \frac{Wt.of\ Sprayed\ Emulsion\ (lb)\ \times\ 9}{Plate\ Area\ (ft^2) X\ 8.4}$$

4.2. Method B: Tack Yield Calculation Method

To determine the Sprayed Emulsion Application Rate, use the following equation:

$$Sprayed\ Emulsion\ Application\ Rate\ \left(\frac{gal}{SY}\right) = \frac{Gallons\ of\ tack\ placed\ \times K \times\ 9}{Length\ (ft) X\ Width\ (ft)}$$

Where:

$K\ (temperature\ correction\ factor) = 0.00025 \times (60 - T) + 1$

T = Temperature of tack material when measured (°F)

4.3. Additional calculation can be done if the residual asphalt application rate is needed.

$$Residual\ Asphalt\ Application\ Rate\ \left(\frac{gal}{SY}\right) = Sprayed\ Emulsion\ Application\ Rate\ \left(\frac{gal}{SY}\right) \times Residual\ Asphalt\ Content\ (from\ supplier)$$

5. Report

5.1. Report the Sprayed Emulsion Application Rate to the nearest 0.01 gal/sy^2 (Method A)and the total quantity (Method B) on TL-143.

Virginia Test Method – 138

Test Method for Grout Segregation – (Physical Lab)

October 16, 2015

1. Scope

1.1. This test covers the procedure for indicating the presence of bleeding, segregation, or soft grout in hydraulic-cement grout.

1.2. This test follows ASTM C1090 *(Standard Test Method for Measuring Changes in Height of Cylindrical Specimens of Hydraulic-Cement Grout)*, with the exception of the preparation of the test specimen and the height change measurement. This test method is a modified version of the wick-induced bleed test and requires a 9-inch piece of strand and a 4x8-in cylinder and evaluates the grout's ability to show bleeding, segregation, or soft grout instead of expansion.

2. Apparatus

2.1. 4x8-in plastic cylinder with lid with 0.625-in diameter hole in the center of the lid

2.2. 9-in section of strand with a 0.6-in diameter. Tape ends of strand with 0.5-in wide strip of duct tape to keeps wires together.

3. Procedure

3.1. Place 9-in strand in the center of the cylinder.

3.2. Sample grout and pour grout into cylinder, keeping the strand positioned in the center of the cylinder at all times.

3.3. Tap the sides of the cylinder lightly with a small hammer to consolidate the grout.

3.4. Strike off the grout at the top of cylinder.

3.5. Place the cap on the cylinder.

3.6. Tap the sides of the cylinder lightly again with a small hammer as needed to consolidate the grout around the strand.

3.7. Let the cylinder set for twenty-four hours.

3.8. After twenty-four hours, remove the cap and investigate for bleed water, segregation of grout, and soft unset grout.

4. Results

4.1. If the grout surface is hard, and there is no evidence of bleed water, segregation of grout, or soft unset grout, then the specimen passes.

4.2. If the grout surface exhibits bleed water, segregation of grout, or soft unset grout, then the specimen fails, and the grout is not accepted for use.