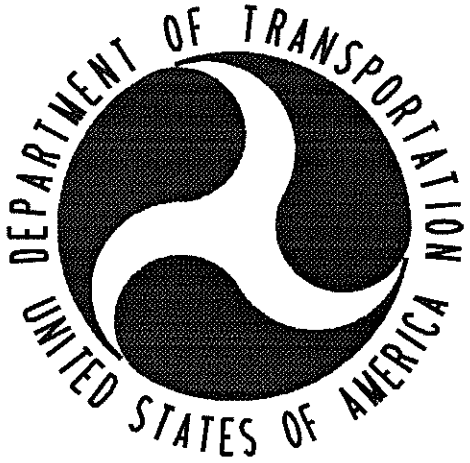
SAMPLING AND TESTING METHODS

FEDERAL LANDS HIGHWAY (FLH)
FIELD MATERIALS MANUAL



APPENDIX A - FLH TEST PROCEDURES
APPENDIX B - MODIFIED AASHTO TEST PROCEDURES

EFFECTIVE DATE: FEBRUARY 10, 1997

APPENDIX A - FLH TEST PROCEDURES
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Standard Method of

Determining the Thickness of Compacted Asphalt Concrete Paving Mixture Specimens

FLH Designation: T 501-96

1. SCOPE

1.1 This test method covers determination of the thickness of compacted asphalt paving mixture specimens.

2. SIGNIFICANCE AND USE

2.1 The thickness of a compacted asphalt paving mixture is often used as a construction check to insure that the proper quantity of material has been placed on a project and to correct strength measurement on constant diameter specimens with varying heights.

3. APPARATUS

3.1 Any of the following apparatus may be used to measure the thickness of test specimens to the nearest millimeter:

3.1.1 A metal tape or rule.

3.1.2 A set of calipers.

3.1.3 A measurement jig or other device, fabricated in such a manner that it is capable of measuring specimen thicknesses in accordance with this procedure.

4. TEST SPECIMENS

4.1 Test specimens shall be laboratory compacted or from compacted asphalt pavements.

4.2 Pavement test specimens shall be taken with a core drill, diamond or carborundum saw, or by other suitable means.

4.2.1 Thickness measurements shall not be made on any specimen that has been distorted or cracked in removal from the pavement, from laboratory compaction molds, or in storage prior to measuring.

4.2.2 Specimens shall be free of foreign material such as seal coat, foundation material, soil, paper, or foil.

4.2.3 Where desirable, specimens may be separated from other layers by shearing or other suitable means, provided a well defined construction plane is achieved.

5. PROCEDURE

5.1 Thickness of specimens with relatively plane horizontal surfaces or layers with well defined, uniform lines of demarcation may be measured with a tape, rule, or calipers in accordance with the following:

5.1.1 Measure the thickness of the specimen or layer using any of the apparatus described in section 3.1. Make thickness measurements approximately perpendicular to the upper plane of the specimen. Measure between upper and lower surfaces, between a well-defined construction demarcation line and either the upper or lower surface, or between two well-defined construction demarcation lines.

5.1.2 Make three measurements at approximately the third points on the periphery of cores or at the approximate midpoint of each of the four sides of rectangular, sawed specimens. Record the average of these measurements as the thickness of the specimen.

5.2 The average thickness of specimens with relatively plane horizontal surfaces may be measured by means of measurement jig or other suitable device, provided the device yields results consistently within ± 1 millimeter of those obtained in accordance with Section 5.1.

NOTE 1—Specimens cut from the pavement with hand-held or power-operated chisels should be trimmed by abrasion or diamond sawing to remove any distorted areas prior to measuring.

6. REPORT

6.1 Report the thickness of the specimen as the average thickness determined by any of the procedures described in sections 5.1 through 5.2. Report the mean of measurements to the nearest millimeter.

6.2 Indicate on the report which of the two procedures was used to determine the thickness; that is, measurement by tape, rule, or calipers (5.1), or by measurement jig (5.2).

7. PRECISION

7.1 No measurement precision data are presently available for this test method.

Standard Method of

Determining the Flow of Grout Mixtures Using a Flow Cone

FLH Designation: T 502-96
(U.S. Corps of Engineers Test Method CRD-C 79)

1. SCOPE

1.1 This method of test covers the procedure to be used both in the laboratory and in the field for determining the flow of grout mixtures by measuring the time of efflux of a specified volume of grout from a standardized flow cone.

2. APPARATUS

2.1 *Flow Cone.* The flow cone shall conform to the dimensions and other requirements indicated in Figure 1.

2.2 *Stop Watch.* A stop watch having 0.20 second increments or less.

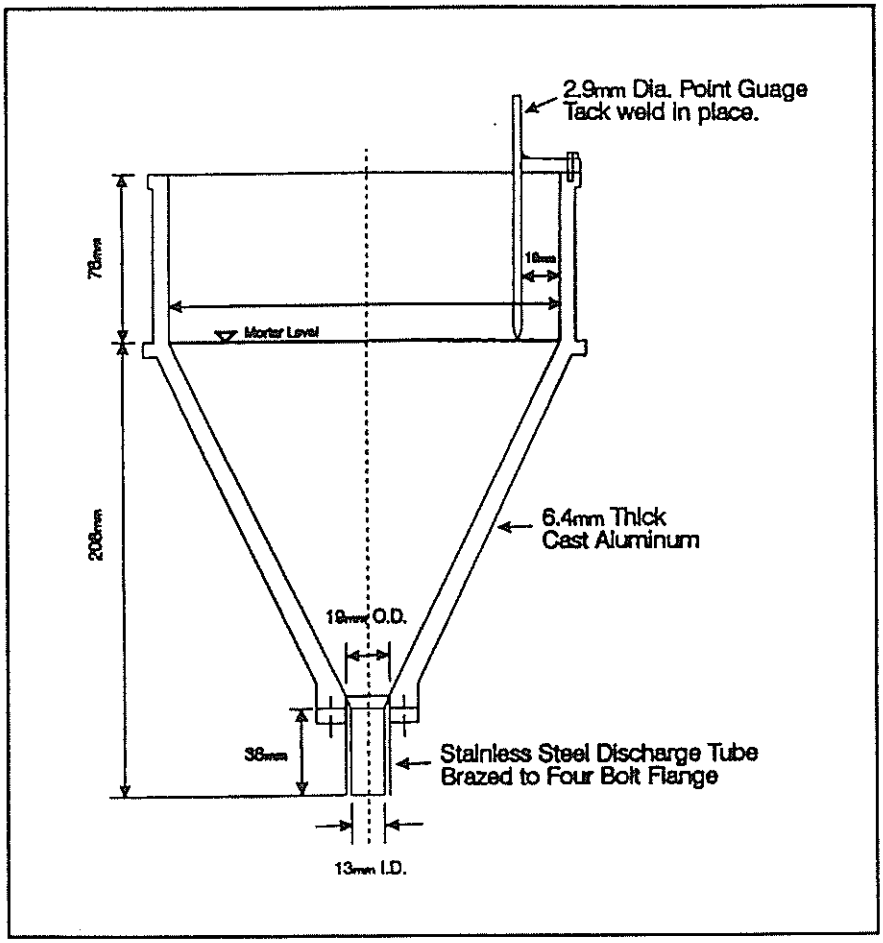

Figure 1 Typical Cross Section of Flow Cone

3. CALIBRATION OF APPARATUS

3.1 The flow cone shall be firmly mounted in such a manner that the top will be level and the cone free from vibration. The discharge tube shall be closed by placing the finger over the lower end. A quantity of water equal to 1725 mL ± 1 mL shall be introduced into the cone. The point gauge shall be adjusted to indicate the level of the water surface.

4. SAMPLE

4.1 The test sample shall consist of 1725 mL ± 1 mL of grout.

5. PROCEDURE

5.1 Moisten the inside surface of the flow cone. Place the finger over the outlet of the discharge tube. Introduce grout into the cone until the grout surface rises into contact with the point gage. Start the stop watch and remove the finger simultaneously. Stop the stop watch at the first break in the continuous flow of grout from the discharge tube. The time indicated by the stop watch is the time of efflux of the grout. At least two tests shall be made for any grout mixture.

Note 1 - A recommended procedure for insuring that the interior of the cone is properly wetted is to fill the cone with water and, one minute before beginning to add the grout sample, allow the water to drain from the cone.

5.2 Report findings on form FHWA 1612. The report shall include the following information.

- The average time of efflux to the nearest 0.2 second.
- The temperature of the grout sample at the time of testing.
- The ambient air temperature at the time of testing.
- The composition of the grout sample.
- The physical characteristics of the grout sample.

Standard Method of

Determining the Presence of Anti-Stripping Compound in Asphalt Material

FLH Designation: T 503-94

1. SCOPE

1.1 The purpose of this test procedure is to determine rapidly the presence in the asphalt material of an effective amount of anti-stripping compound. The test is not quantitative in the sense that a numerical value can be obtained.

Note 1—Only the presence of amine-type anti-stripping additives can be detected by this method.

2. EQUIPMENT

2.1 One 60 ml glass bottle such as is commonly available at drug stores, preferably with a screw cap.

2.2 An ordinary kitchen teaspoon or small spatula.

2.3 White paper toweling or blotters.

2.4 A small metal pan or ceramic bowl large enough to mix 100 grams of asphalt with about 36 grams of solvent.

2.5 Balance conforming to AASHTO M 231, Class G-2.

3. SPECIAL MATERIAL

3.1 Standard ottawa sand (ASTM C 190 sand, 600 μm - 850 μm mesh).

3.2 Clean, potable water.

3.3 Naphtha.

4. PROCEDURE

4.1 Use the following procedures for asphalt material which is liquid at temperatures between 20° and 40° C:

4.1.1 Place 20 g $\pm$ 1 g of the standard ottawa sand in the 60 ml bottle.

4.1.2 Add clean potable water sufficient to cover the sand to a depth of about 10 mm above the surface of the sand in the bottle.

Note 2—For RC 800, MC 800, RC 3000, or MC 3000 material, use water at a temperature of 40-50° C, or dilute the asphalt material with the naphtha to the consistency of an RC 250 or MC 250.

4.1.3 Add 1 g $\pm$ 0.2 g of the asphalt material to be tested by dripping it from a spoon or spatula onto the surface of the water in the bottle.

4.1.4 Stopper the bottle and shake vigorously for 30 seconds.

4.1.5 Remove stopper and pour off excess water.

4.1.6 Tap wet sand out onto a piece of white paper toweling or blotter.

4.1.7 Evaluate results in accordance with section 5.

4.2 Use the following procedures for asphalt material which is not liquid at temperatures between 20° and 40° C:

4.2.1 Weigh out approximately 100 g of asphalt into a small metal pan or ceramic bowl.

4.2.2 Heat or cool the asphalt cement to approximately 80° to 90° C and slowly add 36 percent naphtha by weight of asphalt. Some reheating of the mixture on a hot plate may be required to facilitate blending. Mix the asphalt and solvent thoroughly. This results in a cutback similar to an RC 250. Check the weight of the solvent-asphalt mixture when finished blending to insure proper amount of solvent. Add solvent if needed to attain the 36 percent solvent. Reheating is not normally required at this point.

Note 3 — WARNING!!! — The solvent will vaporize rapidly at this temperature, so this step should be done where there is good ventilation and no open flames.

4.2.3 Using the fabricated cutback, follow the procedures indicated in section 4.1.1 through 4.1.7.

5. INTERPRETATION OF RESULTS

5.1 If the asphalt material contains an effective amount of an anti-stripping additive, the wet sand and asphalt will be intimately combined in a homogeneous mixture having a uniform color. If the asphalt material is deficient in anti-stripping additive, the wet sand and asphalt will not mix. The sand may contain a few globules of asphalt on the surface, but the mass will be nonuniform in appearance.

Note 4—An effective amount of anti-stripping additive, as determined by this test method, should not be construed as a recommendation that such an amount is necessarily optimum for a particular application.

Standard Method of

Determining Longitudinal Surface Smoothness
(California Type Profilograph)

FLH Designation: T 504-96

1. SCOPE

1.1 This test method is used to measure the smoothness of a pavement surface in metric units by using a California type profilograph. The profilograph produces a hard copy trace of the surface, from which deviations in the surface are identified and measured.

2. EQUIPMENT

2.1 *Profilograph* - The profilograph shall be a California type profilograph consisting of a metal frame with multiple wheel trucks supporting each end and a center mounted measuring wheel. The unsupported length between the wheel tracks shall be 7.62 meters. The profilograph shall have steering capability.

2.1.1 The profilograph shall be equipped with a graphic recorder capable of recording the distance of travel and the magnitude of vertical variation. The recorder shall have a horizontal scale of 1 millimeter = 0.3 meter, and a vertical scale of 1 millimeter = 1 millimeter. The paper in the recorder should have non-removable tractor feed edges.

2.2 *Blanking-Band Template* - The template shall consist of a transparent plastic scale approximately 50 millimeters wide and 333.3 millimeters long for a 0.1 kilometer section (See figure A); 333.3 millimeters equates to 100 meters, or 0.1 kilometer. Each 0.1 kilometer section is considered a sublot (N). Near the center of the template a 5.0 millimeter wide opaque blanking-band shall be scribed for the full length of the template. On each side of the blanking-band, 4 or more parallel lines shall be scribed 2.0 millimeters apart.

2.3 *Bump Location Template* - The template shall consist of a piece of transparent plastic at least 130 millimeter long by 75 millimeters wide (See figure A). A line, parallel to the long side, shall be scribed on the template. This line shall be crossed with 2 perpendicularly scribed lines 25.4 millimeters apart near the center of the template. Construct a straight slot through the template, parallel to the long side and 10.0 millimeters from the first line scribed. The slot shall extend the distance between the perpendicular lines previously scribed. The 25.4-millimeter line corresponds to a longitudinal distance of 7.62 meters on the longitudinal scale of the profilogram. The 10.0 millimeter distance between the parallel lines represents the maximum allowable bump in 7.62 meters.

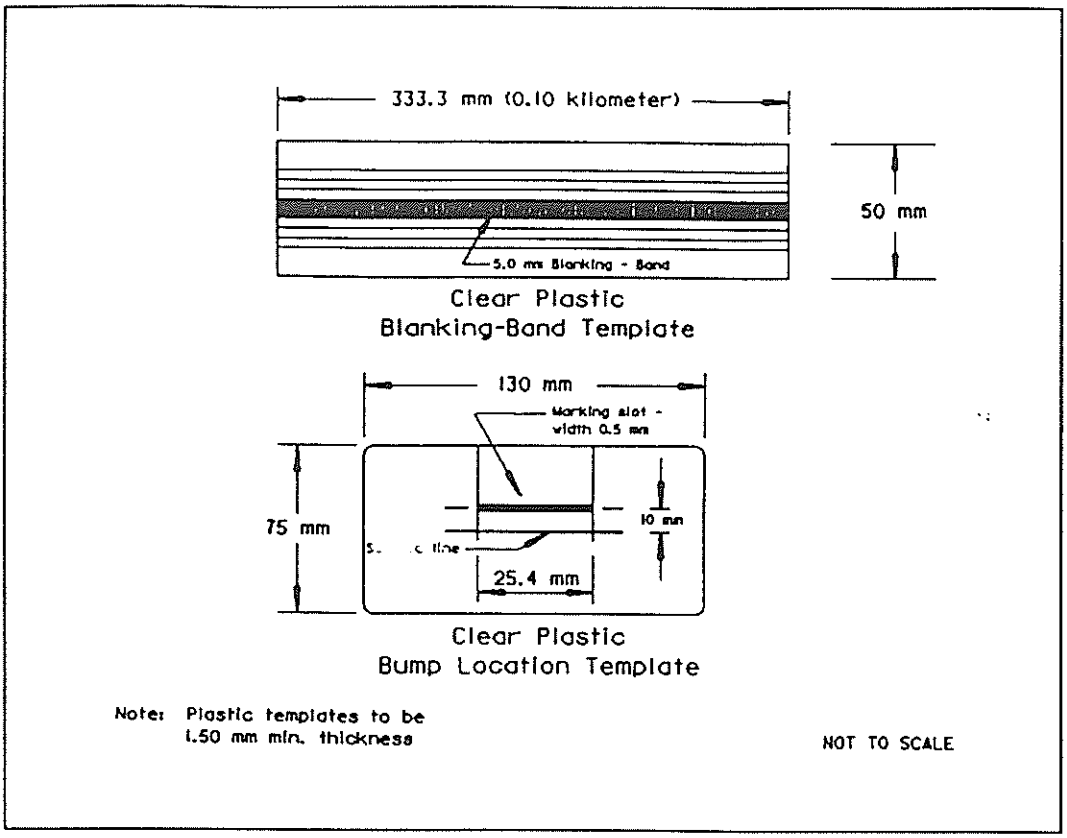

Figure A - Templates

3.0 CALIBRATION

3.1 *Longitudinal (distance) Calibration* - Check the longitudinal calibration prior to initial use and at such other times as may be required for verification. Operate the profilograph over a measured test section on a reasonably flat and level surface for approximately 100 meters. The length of the test section as measured by the graphic recorder shall be within the following tolerance:

$$\text{Longitudinal calibration} = \frac{L}{L_R} = 0.3 \pm 0.0024$$

Where:

L = length of test section in meters (±10 mm)

L_R = recorded length of test section in millimeters (±1mm)

3.2 *Vertical calibration* - Check the vertical calibration prior to initial use and at such other times as may be required for verification. Keep the profilograph stationary. Using pre-measured calibration blocks measured to the nearest 0.1 millimeter, pull or slide the block(s) under the recording wheel. Measure the vertical trace line from the base line to the peak and return. The trace line must return to the base line. Compare the actual heights of the calibration blocks with the heights of their vertical trace line. These heights should be within ± 1 millimeter.

NOTE 1—If the longitudinal and vertical calibration checks are not within the allowable tolerances specified, make the appropriate adjustments or repairs.

4.0 PREPARATION

4.1 Establish ground controls on the section of roadway to be tested. Controls should include the beginning and end with sufficient intermediate markers to facilitate correlation of areas on the graphic readout to the actual ground locations. Mark the limits of excluded areas. Excluded areas for smoothness and bump determination are bridges, cattleguards, horizontal curves with less than 150 meters radii, transverse joints with an existing pavement, and miscellaneous paved areas such as driveways, parking areas, turning or passing lanes, and side roads.

4.2 Provide for traffic control including appropriate warning signs and flaggers.

4.3 Assemble the instrument at the work site and perform the calibration procedures to assure that the equipment is operating properly.

5.0 TESTING

5.1 After determining that the profilograph is operating properly, move to the beginning point. Lower the measurement wheel, set the tracing pen on the graph paper, and run the test.

NOTE 2—Do not back the instrument while the measuring wheel is on the pavement. This will cause damage to the graphics system.

5.2 Profile each lane of the project. Profile continuously from beginning to end of project. Do not break profile at excluded areas.

5.3 Mark landmarks and excluded areas on the profilogram for documentation purposes. Mark the beginning and ending stations and identify the lane (either left or right) and the direction in which the trace is run (either ahead on line or back on line). Mark the trace by making a spike or strum at least 20 millimeters long on the upside of the trace.

NOTE 3—Interrupting the test to add notes to the profilogram will not interfere with the recording. Locations of physical features along the route such as mile markers, cross drains, bridge ends, guard rail terminals, overhead utility crossings, etc. should be noted on the profilogram. This will aid in matching the ground locations with the graphic record. The trace should be marked and the station identified approximately every 150 meters. Do not write on the trace line. Write notes at least 20 millimeters above or below the line.

5.4 Operate the profilograph at a speed no greater than a normal walk (1 to 5 km/h) to eliminate as much bounce as possible.

6.0 MEASUREMENT USING MANUAL METHOD

6.1 Determine the roughness [Profile Index (PrI)] of each 0.1 kilometer section, or sublot (N), by starting at the beginning of the profilogram and placing the blanking-band template over the first 0.1 kilometer section of the profile in such a manner as to blank out as much of the profile as possible with the opaque 5.0 millimeter blanking-band (See figure B). Mark the trace at each blanking-band template location and proceed to the next 0.1 kilometer section. The blanking-bands need not connect one section to the next vertically, but connect adjacent blanking-band template locations horizontally.

6.2 On each side of the blanking-band are parallel scribed lines 2.0 millimeter apart. These lines serve to measure the variations (called scallops) in the trace that extend above or below the 5.0 millimeter wide opaque blanking-band. Measure the *height of the scallops* appearing above and below the opaque blanking-band. Measure to the nearest ½ division (1.0 millimeter) on the blanking band. Record each scallop's count to the nearest ½ division or to the nearest millimeter on the profilogram (See figure C). Do not measure narrow scallops (spikes) less than 3 millimeters long or less than ½ division in height. When a scallop is contained in two sublots, measure the maximum height of the scallop and include the measurement in the sublot containing the maximum point.

Sum the scallop counts for each 0.1 kilometer section and multiply the total count for the 0.1 kilometer section by 10 to convert to roughness in millimeters per kilometer. Record the smoothness value on the profilogram (See figure B) and on the computation worksheet. Use Form FHWA 1620 (or QL-PAY) to record roughness values and calculations.

6.3 All sublots shall be 0.1 kilometer in length. Do not extrapolate sublot roughness from lesser lengths. The partial length of any last lane segment is excluded from measurement, except for bumps according to 6.4.

6.4 Check the profilogram for bumps using the bump template. At each prominent peak or high point on the profilogram, place the template so the crossed points of the scribed 25.4 mm line intersect the profilogram to form a chord across the base of the peak or indicated bump (See Figure D). The scribed line on the template need not be horizontal. If the parallel slot intersects the trace, mark a line in the slot as an out-of-specification bump (deviation > 10.0 millimeters in 7.62 meters).

Count the bump and record it on Form FHWA 1620.

7.0 MEASUREMENT USING PROSCAN PROFILOGRAM SCANNING SYSTEM

7.1 The preferred method for determining the roughness [Profile Index (PrI)] of each 0.1 kilometer section or sublot (N) is by using the ProScan Profilogram Scanning System or an approved equal. The ProScan Profilogram Scanning System is available from:

Devore Systems, Inc.
2617 Sumac Drive
Manhattan, KS 66502
(913) 537-1799

7.2 When using the ProScan Profilogram Scanning System it is necessary to set default values for several parameters. The following default values shall be used:

Scallop filter	15
min. height	0.5 millimeter
min. width	2.0 millimeter
resolution	1.0 millimeter
Blanking band	5.0 millimeter
Grind template	10.0 millimeter
Minimum spike height	7.6 millimeter

7.3 When using the ProScan Profilogram Scanning System it is necessary to identify and mark the beginning point of the trace. It is also necessary to identify and mark all equations. Mark the trace by drawing a heavy vertical line on the trace at appropriate locations. The vertical line should extend at least 40 millimeters above and below the trace.

7.4 Scan the trace between marked beginning and ending points. The scanned trace may consist of only one marked segment or it may consist of several segments. Provide the software with appropriate stationing information at all beginning points. When an equation is encountered, provide the software with the appropriate stationing information. Reposition the trace as necessary after reaching an ending point or equation.

7.5 After scanning a trace, print a final report and plot the scanned profile.

8.0 REPORTING

8.1 Use the measurement results to determine the final pay factor in accordance with the contract requirements. Do not use any sublot in the pay factor computation which contains any portion of an excluded area.

8.2 Report the pay factor and the statistical values which support the determination of pay factor. Attach the ProScan Profilograph Report to the profilogram trace to document the scallop computations. When the Manual Method is used, attach the work sheet (Form FHWA 1620) to document the scallop computations. The records shall also identify the type of equipment used, operators, project, lane and direction, track location, time and date of run, weather conditions, and other data deemed appropriate.

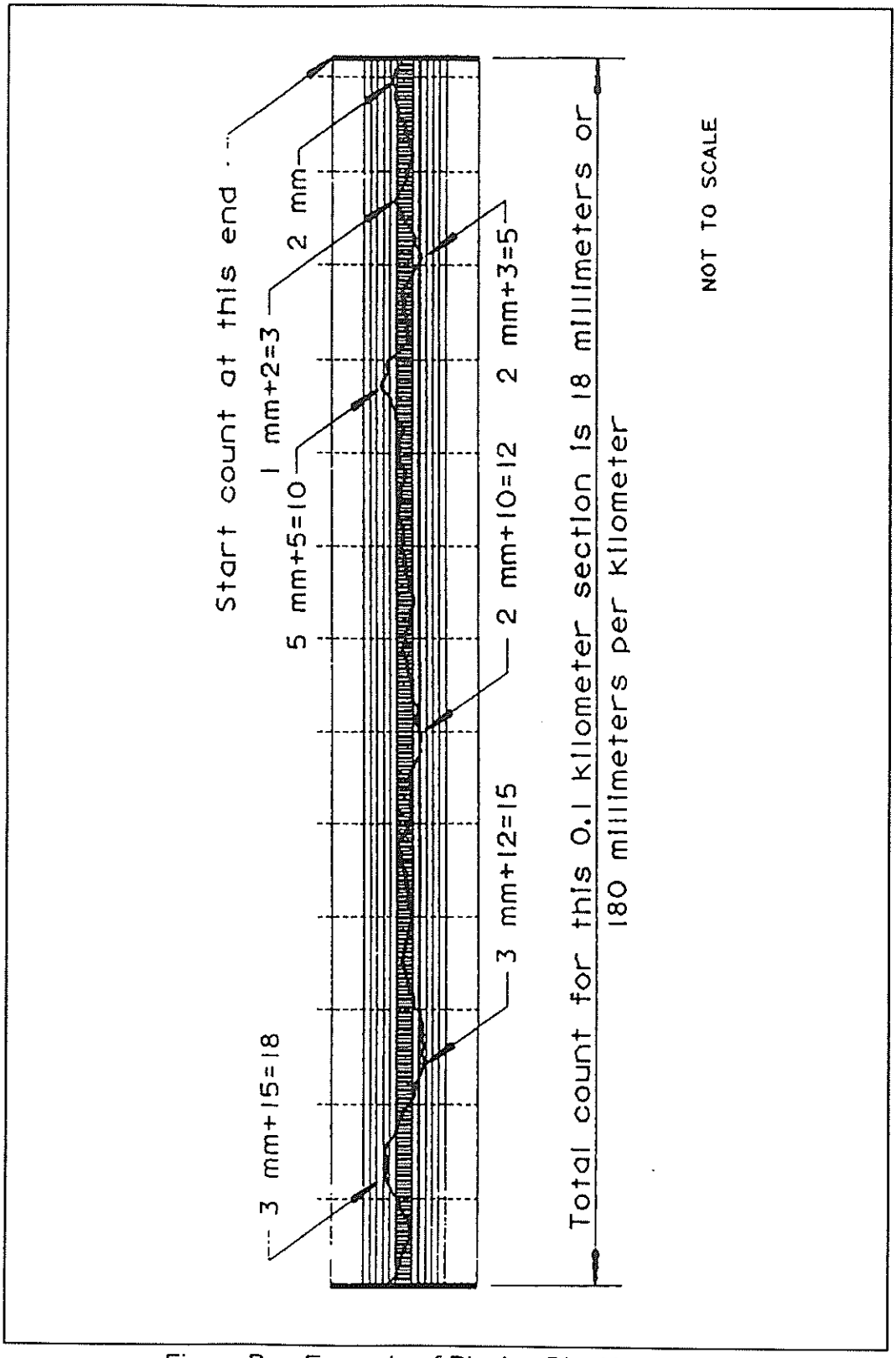

Figure B - Example of Placing Blanking Band,
Summing Scallop Count, and Determining Profile Index

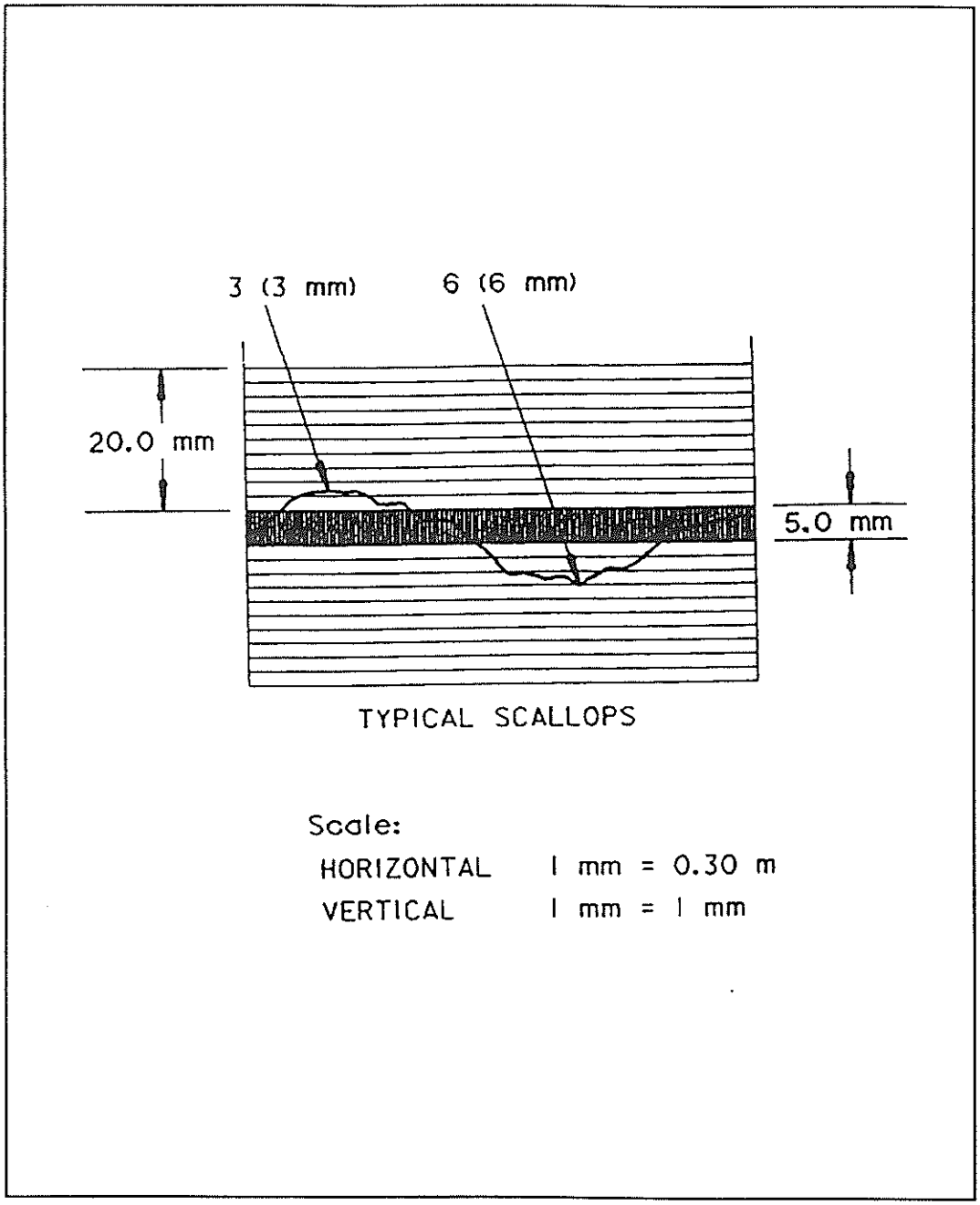

Figure C - Example of Determining Scallop Measurements

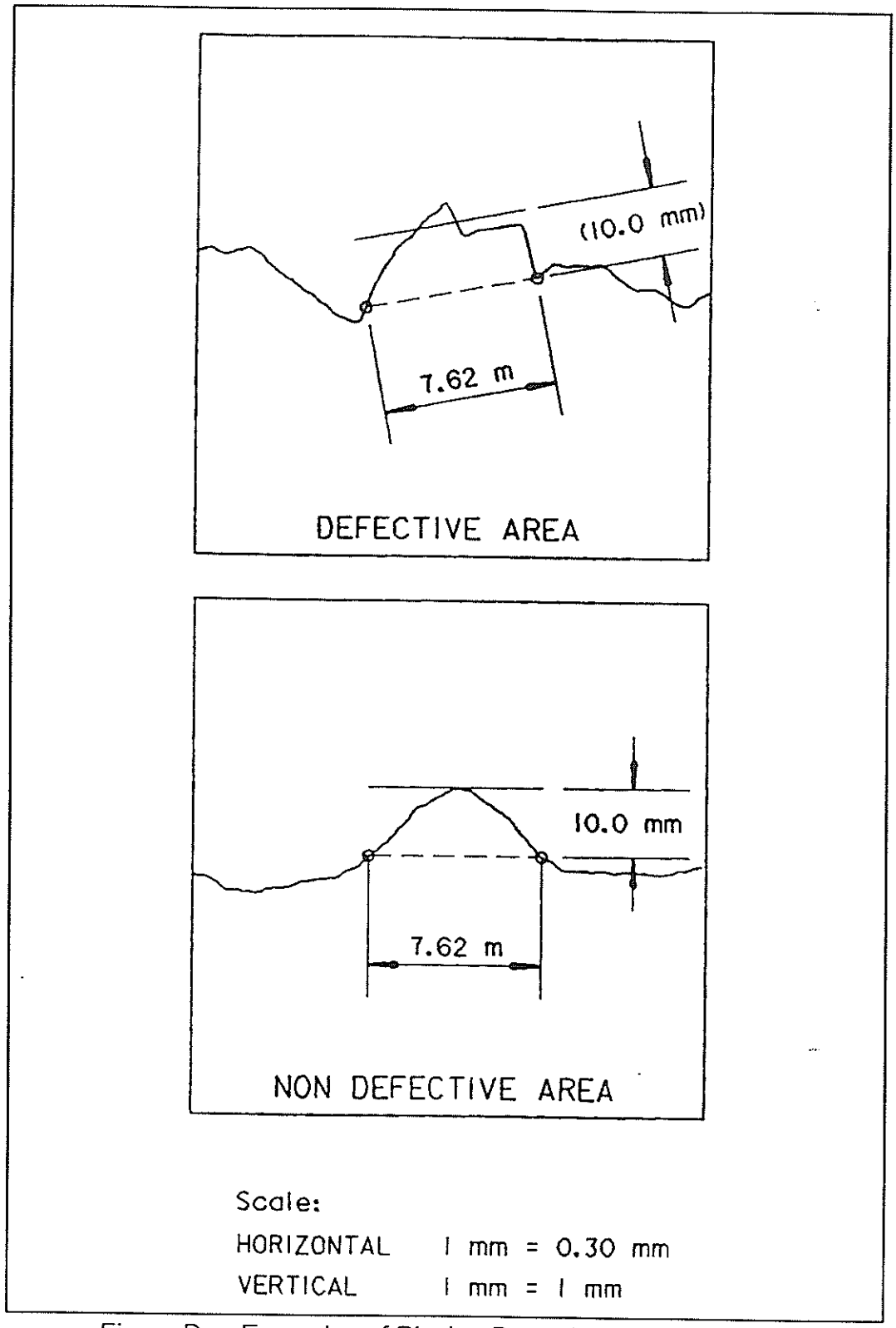

Figure D - Examples of Placing Bump Location Template

Standard Method of

Determining the Effect of Water on Asphalt-Coated Aggregate

FLH Designation: T 505-94

1. SCOPE

1.1 This method covers a rapid field test for visually determining the loss of adhesion in uncompacted asphalt-coated aggregate mixtures due to the action of boiling water.

2. APPLICABLE DOCUMENTS

2.1 ASTM E 1 for thermometers.

3. SIGNIFICANCE AND USE

3.1 The conditions of test are designed to rapidly determine, in the field, the resistance of asphalt-coated aggregate mixtures to the accelerated action of boiling water. The loss of adhesion of the asphalt to the aggregate is visually estimated.

3.2 This test method is useful as an indicator of the relative susceptibility of asphalt-coated aggregate to water but should not be used as a measure of field performance because such correlation has not been established.

4. APPARATUS

4.1 Scoop, shovel, or other implement capable of removing a representative sample from a larger mass of asphalt-coated aggregate.

4.2 Glass beakers, heat-resistant, two, 1.5 to 2 liter in size, or suitable metal containers of similar dimensions and capacity.

4.3 Source of water: at least 1 liter for each test.

4.4 Device for heating water (hot plate, camp stove, torch, etc.).

4.5 Low distillation thermometers, having a range from -2° to 300° C, and conforming to the requirements 7C in ASTM E 1.

5. PROCEDURE

5.1 Pour approximately 1 liter of water into a suitable container as described in Section 4.2 and heat to boiling.

5.2 With a suitable implement (Section 4.1), place approximately 200 grams of the asphalt-coated aggregate in the boiling water while the container is exposed to the heat source. Bring the water back to boiling and hold for 10 minutes. Avoid excessive manipulation of the asphalt-coated aggregate. The temperature of hot mixtures should be below boiling temperature (100° C) before placing in boiling water.

5.3 At the end of 10 minutes, remove the container from the heat source, drain the water from the mixture, empty the wet mix onto a white paper towel, and allow to dry. Place a similar amount of fresh (unboiled) asphalt-coated mixture (approximately 200 grams) on a separate white paper towel. Allow both samples to cool to room temperature before taking the initial readings.

5.4 By observation after boiling and 24 hours later, estimate the percentage of the total visible area of the aggregate that retains its original coating to the nearest 5 percent. Any thin, brownish, translucent areas are to be considered fully coated. Also look to see that the fine aggregate is coated.

6. REPORT

6.1 Report the estimated original coated area for both samples at both times; i.e., after boiling and 24 hours later. Use Form FHWA 1612 to record and report test results. See exhibit 3.5 in chapter 3 of the FLH Field Materials Manual for a sample format.

6.2 Tabulate results as follows:

Sample Type	Percent Retained Coating	
	Initial Reading	24 Hours Later
Unboiled		
Boiled		

7. ACTIONS

7.1 If the unboiled sample does not show over 95 percent retained coating initially and the asphalt content and gradation are within the job mix formula tolerances, the wet mixing time may need to be increased.

7.2 If the unboiled sample shows over 95 percent retained coating initially but less than 95 percent after 24 hours, the aggregate may not have been dried sufficiently before mixing occurred. Drying time and/or temperature may need to be increased.

7.3 If the boiled sample fails to have over 95 percent retained coating and anti-strip additive is specified in the approved job mix, verify that anti-strip additive is being added to the asphalt, using FLH T 503, and verify that the equipment adding the anti-strip additive on-site is functioning properly.

7.4 If the boiled sample fails to have over 95 percent retained coating and anti-strip is not required, notify the Project Engineer and send loose mix box samples to the Division Materials Laboratory for evaluation of the retained strength by AASHTO T 165. Repeat the Marshall-Immersion test (15 and 20 blow) to verify the retained strength by this procedure.

Standard Method of

Determining Multiple Fractured Faces on Coarse Aggregates

FLH Designation: T 506-94

1. SCOPE

1.1 This test method is used to determine the percentage by weight of the material retained on the 4.75 mm sieve which has one or more fractured faces.

2. DEFINITION OF TERM

2.1 *Fractured Face*—A fractured face on an aggregate particle is any sharp edge created either by man-made or natural methods. A fractured face with rounded edges, regardless of how the rounding occurred (natural or man-caused), shall not be counted as a fractured face.

3. APPARATUS

3.1 *Mechanical Splitter*—A sample splitter conforming to AASHTO T 248.

3.2 *Balance*—The balance shall conform to AASHTO M 231 for the class of general purpose balance required for the principal sample weight of the sample being tested.

3.3 *Sieve*—A 4.75 mm sieve conforming to AASHTO M 92.

3.4 Miscellaneous equipment, such as scoops, shovels, trowels, brushes, etc.

4. SAMPLE PREPARATION

4.1 Following AASHTO T 248, split out a representative sample that will yield retained 4.75 mm material in accordance with weights shown in table 1.

Table 1
Required Sample Size

Maximum Nominal Particle Size	Maximum Weight Retained on 4.75 mm Sieve
37.5 mm	1500 grams
25 mm	500
19 mm	300
12.5 mm	200
9.5 mm	150
4.75 mm	150

4.2 Sieve the above representative sample over the 4.75 mm sieve. Use all of the material retained on the 4.75 sieve in the fracture test.

5. PROCEDURE

5.1 Weigh and record the weight of the material to be tested.

5.2 By visual inspection separate the particles into the following categories:

- Particles with one fractured face.
- Particles with more than one fractured face.
- Rounded or sub-rounded particles with no fractured faces.

6. CALCULATIONS

6.1 Divide the weight of the particles having one fractured face by the total weight of the material tested. Multiply this decimal by 100 to find the percent of aggregate particles with one fractured face.

6.2 Divide the weight of the particles having more than one fractured face by the total weight of the material tested. Multiply this decimal by 100 to determine the percent of aggregate particles with more than one fractured face.

6.3 Add the percentage of aggregate particles with one fractured face (subsection 6.1) to the percentage of aggregate particles with more than one fractured face (subsection 6.2) to determine the percentage of aggregate particles with one or more fractured faces.

7. RESULTS

7.1 Report the following results to the nearest whole percent:

- Percent with one fractured face.
- Percent with more than one fractured face.
- Percent with one or more fractured faces.

Standard Method of

Determining Fractured Faces on Coarse Aggregates

FLH Designation: T 507-94

1. SCOPE

1.1 This test method is used to determine the percentage by weight of the material retained on the 4.75 mm sieve which has at least one fractured face.

2. DEFINITION OF THE TERM "FRACTURE"

2.1 Fracture on gravel is any sharp edge created either by man-made or natural methods. A gravel that was previously fractured and then weathered so as to round off the edges would not be considered sharp or fractured.

3. APPARATUS

3.1 *Mechanical Splitter* — A sample splitter conforming to AASHTO T 248.

3.2 *Balance* — The balance shall conform to AASHTO M 231 for the class of general purpose balance required for the principal sample weight of the sample being tested.

3.3 *Sieve* — A 4.75 mm sieve conforming to AASHTO M 92.

4. SAMPLE PREPARATION

4.1 Following AASHTO T 248, split out a representative sample which will yield retained 4.75 mm material in accordance with weights shown in table 1.

4.2 Sieve the above representative sample over the 4.75 mm sieve. Use all of the material retained on the 4.75 mm sieve in the fracture test.

Table 1
Required Sample Size

Maximum Nominal Particle Size	Minimum Weight Retained on 4.75 mm Sieve
37.5 mm	2 500 grams
25 mm	1 500
19 mm	1 000
9.5 mm	700
4.75 mm	500

5. PROCEDURE

5.1 Weigh and record the weight of the material to be tested.

5.2 By visual inspection separate the particles with one or more fresh, mechanically fractured face from the rounded or sub-rounded particles.

5.3 Weigh and record the weight of the particles having one or more fractured face.

6. CALCULATIONS

6.1 Divide the weight of the particles having fractured faces by the total weight of the material tested. Multiply this decimal by 100 to find the percent of fractured faces.

7. RESULTS

7.1 Report results to the nearest percent.

Standard Method of

Determining the Flakiness Index and Average Least Dimension of Aggregates

FLH Designation: T 508-96

1. SCOPE

1.1 This method describes a procedure to determine the Flakiness Index and the average Least Dimension of Aggregates. The sieve analysis shall be performed in accordance with Section 3. The median size shall be determined in accordance with Section 5. The Flakiness Index shall be determined in accordance with Section 6. The Average Least Dimension shall be determined in accordance with Section 8.1.

2. APPARATUS

2.1 An appropriate size scale or general purpose balance conforming to AASHTO M 231.

2.2 A metal plate approximately 1.6 millimeters thick with slotted openings conforming to the design and dimensions shown in Figure 1.

2.3 Appropriate sieves conforming to AASHTO M 92.

3. SIEVE ANALYSIS PROCEDURE

3.1 A surface or oven dried sample shall be weighed and the distribution of particle sizes obtained by sieving in accordance with AASHTO T 27. See Table 1 for minimum sample size.

Table 1
Minimum Weight of Sample

Nominal Size of Aggregate (mm)	Approximate Mass (grams)
25.0	5000
19.0	2500
16.0	2000
12.5	1200
9.5	800
6.3	500

3.2 After sieving, weigh the material retained on each sieve and record. Determine the mass passing each sieve and express these masses as a percentage of the total mass of the sample. Record these percentages.

4. REPORT

4.1 Report results of the sieve analysis to the nearest percent. Plot the results and draw a gradation curve on the worksheet for determining median size of aggregate (Form FHWA 1613).

5. MEDIAN SIZE

5.1 The median size is that theoretical sieve size in millimeters through which 50 percent of the material will pass. Determine the median size from the gradation curve and record on Form FHWA 1613.

6. FLAKINESS INDEX PROCEDURE

6.1 Aggregate retained on each sieve (4.75-millimeter sieve and larger) which comprises at least 4 percent of the total sample shall be tested particle by particle for its ability to pass through an appropriate slotted sieve or plate with enlongated openings. The size of slots required for each fraction is given in Table 2 and shown in Figure 1.

6.2 Record the masses of the aggregate particles retained on each slotted sieve and that pass each slotted sieve on the Flakiness Index worksheet (Form FHWA 1615). The total amount passing the appropriate slotted sieve openings shall be weighed to an accuracy of at least 0.1 percent of the mass of the test sample.

Table 2

Slot Size for Each Aggregate Fraction

Range of Aggregate Size		Width of Slotted Sieve Opening (mm)
Material Passing (mm)	Material Retained (mm)	
25.0	19.0	13.34
19.0	12.5	9.52
12.5	9.5	6.68
9.5	6.3	4.67
6.3	4.75	3.33

6.3 Compute the Flakiness Index. Flakiness Index is the total mass of the material passing the slotted sieve openings expressed as a percentage of the combined mass of the fractions tested on the slotted sieves. Record to the nearest whole percent.

7. EXAMPLE

7.1 A sample of asphalt surface treatment aggregate with a dry mass of 10 000 grams has been taken and a sieve analysis performed in accordance with AASHTO T 27. The sieve analysis is shown in Table 3. Record this data on the Flakiness Index worksheet.

Table 3
Sample Sieve Analysis

Sieve Designation (mm)	Mass Retained (grams)	Mass Passing (grams)	Total Passing (%)
25.0	0	10 000	100.0
19.0	2080	7920	79.2
12.5	6610	1310	13.1
9.5	500	810	8.1
6.3	370	440	4.4
4.75	300	140	1.4

7.2 Determine the median size of the aggregate in accordance with section 5.1. Plot the aggregate gradation curve. See figure 2 for an example plot. Locate the intersection of the gradation curve with the 50 percent passing line and determine the screen opening size (median size) for this point on the horizontal scale. In this example, **the median size is 16 millimeters.**

7.3 Determine the aggregates Flakiness Index in accordance with section 6.1. See figure 3 for an example flakiness index work sheet. The total mass of aggregate particles tested should equal the total mass of the sample less the mass of the aggregate particles passing the 4.75-millimeter sieve. Compute the Flakiness Index (%) by dividing the total mass of particles passing their slotted sieves by the total mass of the sample tested for flakiness and multiplying by 100. In this example, **the Flakiness Index is 28 percent** (28.49% rounded).

7.4 Determine the Average Least Dimension of the aggregate in accordance with section 8.1. In this example, a flakiness index diagonal representing 28 percent was inserted and the **Average Least Dimension was determined to be 10.75 millimeters.** See figure 4 for an example of an average least dimension plot.

8. AVERAGE LEAST DIMENSION

8.1 Determine the Average Least Dimension using Form FHWA 1614. Locate the median size of the aggregate on the horizontal axis. Identify a diagonal to represent the sample's Flakiness Index. When necessary, draw in an appropriate diagonal line. Proceed vertically from the median size on the horizontal axis to the diagonal line representing the sample's Flakiness Index. From this point of intersection, proceed left horizontally and determine the Average Least Dimension value on the vertical axis.

9. REPORT

9.1 Report the Flakiness Index to the nearest whole percent and the Average Least Dimension to the nearest 0.25 millimeter. Good embedment properties are desirable characteristics for aggregates used in asphalt surface treatments. The flakiness index and the average least dimension values are indicators on how well the aggregates will embed in the asphalt surface. Low flakiness index values and high average least dimension values indicate cubical particles and cubical particles mean improved adhesion with the asphalt surface.

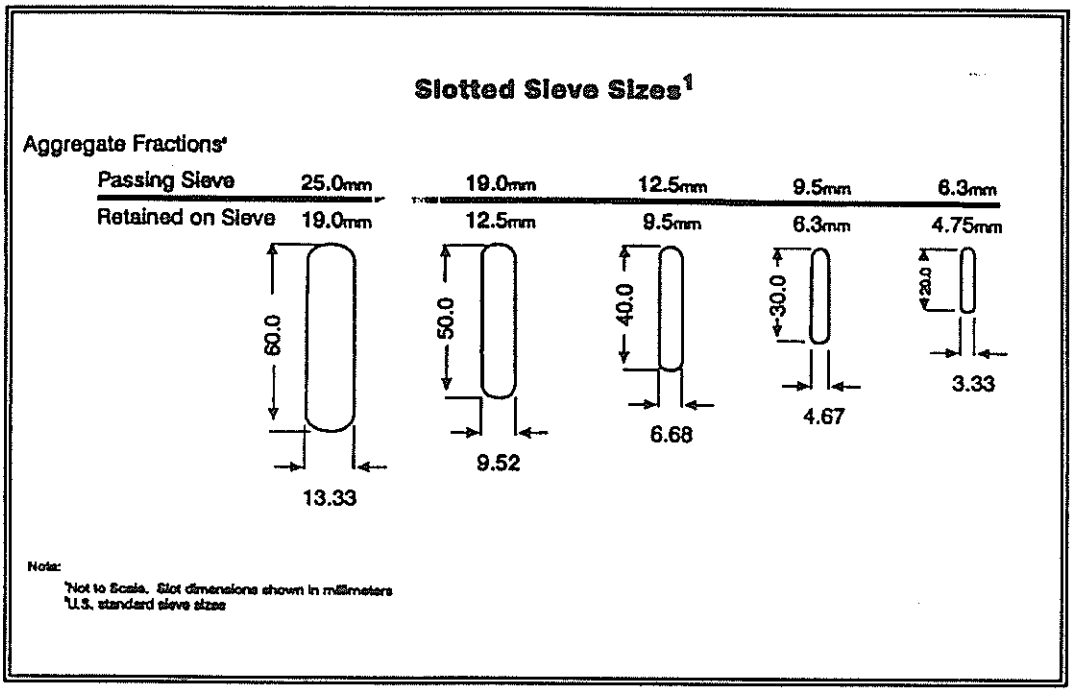

Figure 1 - Slotted Sieve Openings in Millimeters

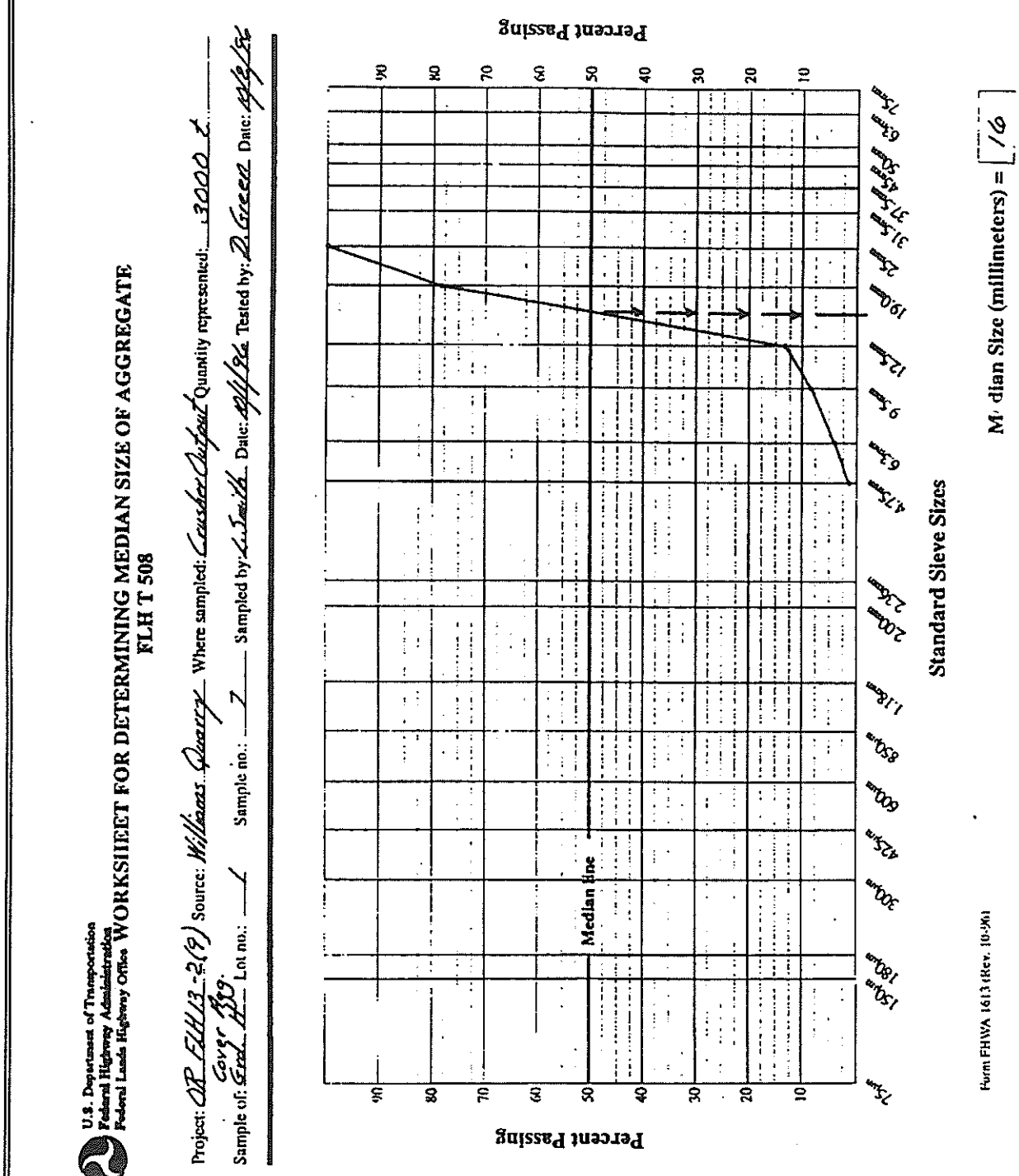

Figure 2 - Example of Determining the Median Size of Aggregate

U.S. Department of Transportation
Federal Highway Administration
Federal Lands Highway Office

FLAKINESS INDEX WORKSHEET
FLH T 508

Project: OR FLH 13-2(9) Source: Williams Quarry
Where sampled: Crusher Output Quantity represented: 3000 t
Sample of: Cover Agg., Grad. H Lot no.: 1 Sample no.: 7
Sampled by: L. Smith Date: 10/4/96 Tested by: D. Green Date: 10/8/96

Aggregate Gradation			Data for Determination of Flakiness Index			
	A[1]	B	C	D	E	F[1]
Sieve Size (mm)	Mass Retained (g)	Total Passing (g)	Flakiness Plate Slot Size Identification	Mass Retained on Flakiness Plate (g)	Mass Passing Slot on Flakiness Plate (g)	Total Mass (D + E) (g)
25.0	0	10 000				
			25.0 to 19.0	1500	580	2080
19.0	2080	7920				
			19.0 to 12.5	4800	1810	6610
12.5	6610	1310				
			12.5 to 9.5	350	150	500
9.5	500	810				
			9.5 to 6.3	210	160	370
6.3	370	440				
			6.3 to 4.75	190	110	300
4.75	300	140				
TOTAL	9860	/	TOTAL	7050	2810	9860

Flakiness Index[2] = $\frac{\text{Total of Column E}}{\text{Total of Column F}} = \frac{2810}{9860}$ (100) = 28

[1] For each size aggregate tested for flakiness, the total mass tested (Column F) should be the same as the mass retained (Column A) for the corresponding size of aggregate.
[2] Rounded to the nearest whole percent.

Form FHWA 1615 (Rev 10-96)

Figure 3 - Example of Determining Flakiness Index

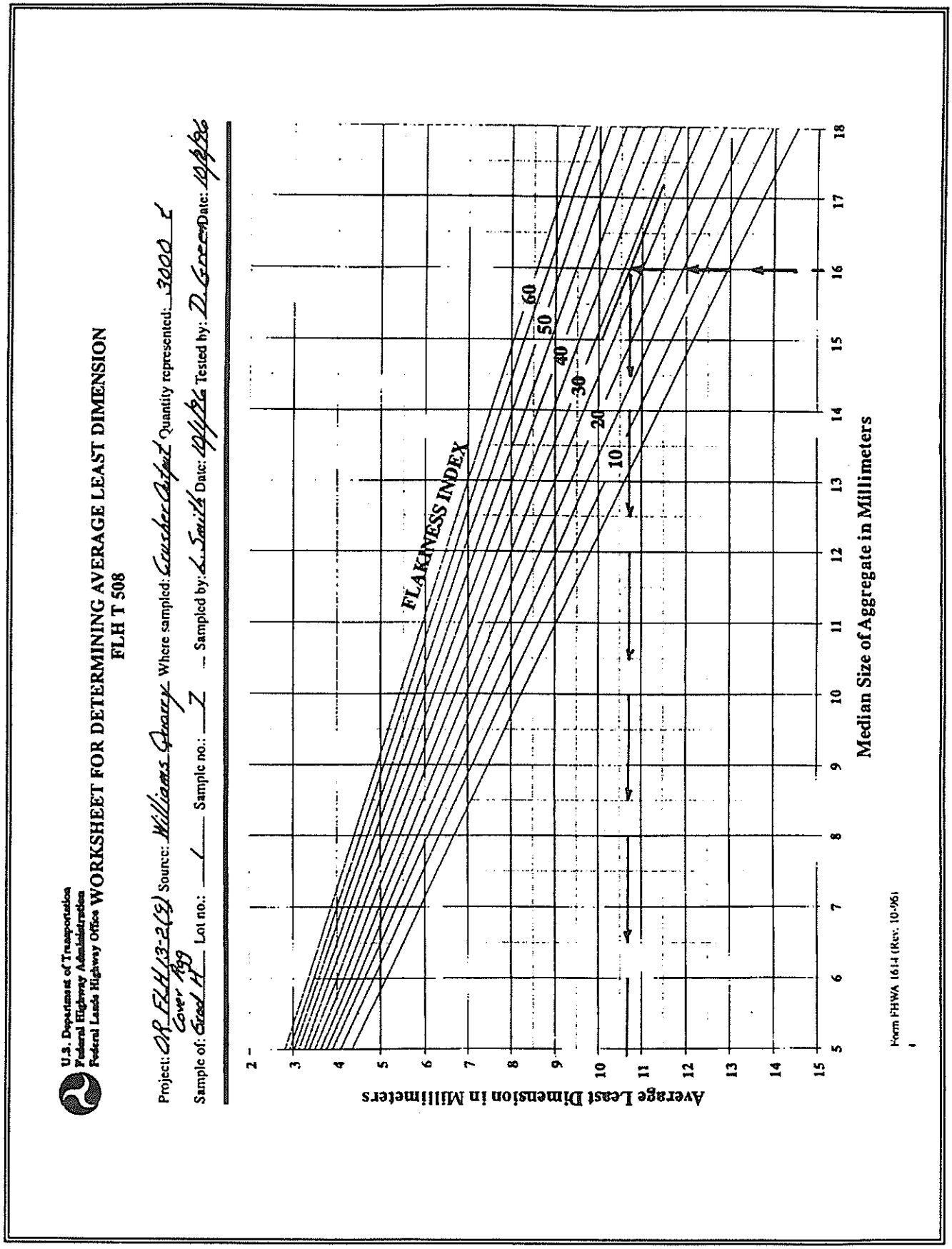

Figure 4 - Example of Determining the Average Least Dimension

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Standard Method of

Drying Soil and Aggregate Samples Using a Microwave Oven

FLH Designation: T 509-94

1. SCOPE

1.1 This method covers the use of microwave ovens to dry soils or aggregates to a constant weight.

2. APPLICABLE DOCUMENTS

2.1 AASHTO Test Procedures:
T 11 Materials Finer Than 75 μm Sieve in Mineral Aggregates by Washing
T 27 Sieve Analysis of Fine and Coarse Aggregates

3. SIGNIFICANCE AND USE

3.1 Either at the beginning of a test procedure or during a test procedure, moisture composed of water must be removed from the sample to determine the dry weight of the sample.

3.2 The microwave oven causes the moisture to gain temperature at an accelerated rate and lessens the time required to dry a sample to a constant weight. Conventional ovens, convection or forced-draft, heat the aggregate and moisture by heat transfer from the heated air in the interior of the oven to the aggregate and moisture. Microwave ovens cause the molecules in the moisture to oscillate at a high rate and become heated by molecular friction. The microwave is an efficient method of drying soil and aggregate material.

4. APPARATUS

4.1 *Balance*—Balance shall conform to AASHTO M 231 for the class of general purpose balance required for the principal weight of the sample being tested.

4.2 *Microwave oven*—An oven rated at 1,000 watts minimum. The power output shall be continuously variable from 0 to 100% of maximum output. The internal chamber shall be approximately 0.05 cubic meters in size. (See note 1.)

4.3 *Drying pans*—Pans or dishes composed of heat-tempered glass. Glass manufacturers produce dishes of various sizes and shapes specifically to be used in microwave ovens.

4.4 *Stirring tools*—Spatulas, spoons, or other utensils to mix the sample to facilitate the even heating of the particles.

NOTE 1—Microwave ovens should be tested at least once a month for leakage around the edges of the door. Document the findings. If leakage is above the level recommended by the manufacturer, the oven should not be used until repaired. A simplified leakage test can be performed with a small low wattage neon tube held next to the door. If the tube lights at all, contact the FLHD Safety Officer.

5. SAMPLING

5.1 Sampling shall be governed by the test procedure in which the microwave oven will be used. Table 1 will generally yield a sample of sufficient size to meet the requirements for a given test procedure. The samples for testing shall be prepared in accordance with AASHTO T 248 or other approved method to achieve the required size.

Table 1
Minimum Sample Size for Drying

Nominal Size of Aggregate	Sample Weight (grams)
2.36 mm	100
4.75 mm	500
9.5 mm	1000
12.5 mm	1500
19.0 mm	2500
25.0 mm	3000
37.5 mm	5000

6. PROCEDURE

6.1 If a moisture determination is required, the sample shall be weighed and the weight recorded before drying.

6.2 Estimate the drying time required as follows.

6.2.1. Identify the microwave oven's output capacity in watts and, using the following formula, approximate an initial drying time for an estimated moisture content.

$$t = \frac{(4.18)(c)(\Delta t)}{W}$$

Where:
- t = Drying time in seconds.
- c = Estimated moisture content of sample in grams.
- Δt = Temperature rise in degrees Celsius necessary to raise the temperature of the sample to 100° C.
- W = Power output of microwave oven in watts.

6.2.2 The following is an example of the use of the formula for an estimated drying time:

Given:	Weight of sample	= 2500 grams
	Temperature of sample	= 25° C
	Microwave power output	= 1000 watts
	Estimated moisture content	= 10%

Therefore:

$$t = \frac{(4.18)(250)(75)}{1\,000} = 78.4 \text{ seconds}$$

In this example, round drying time to 80 seconds. Adjust the drying time as conditions and material warrant.

6.3 Place the sample in the oven and set the timer for approximately half the estimated time determined in section 6.2. When drying moist fine-grained particles, cover the sample with a paper towel or reduce the time of the drying cycles to prevent loss of fine particles.

6.4 When the timer expires, open the oven door and stir the sample. If the sample is still moist, set the timer for the remainder of the estimated drying time and continue drying.

6.5 When the sample appears dry, cool the sample to room temperature and determine the weight of the sample. Place the sample back into the microwave for additional 30-second intervals until there is no measurable loss in weight between subsequent weighings.

6.6 After the sample is dried to a constant weight, proceed with testing.

7. CALCULATION AND REPORT

7.1 Use Form FHWA 1616 to record data and report test results. See exhibit 3.19 in chapter 3 of the FLH Field Materials Manual for a sample format.

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Standard Method of

Determining the Natural Cementation of Aggregate Fines

FLH Designation: T 510-94

1. SCOPE

1.1 The cementation test is used to determine the unconfined compressive strength of fines taken from a material that is to be used for crushed aggregate surfacing and is primarily applicable to material with a plasticity index of less than four. Some non-plastic or slightly plastic material has natural cementing qualities superior to plastic material, especially under wet conditions.

1.2 Most specifications require a plasticity index (AASHTO T 90) of 4 to 12 for assurance that the binder of an aggregate, material passing a 2.00 mm sieve, will make a gravel surface that will not ravel. Material having a natural cementation of over 1200 kPa make excellent gravel surfacing. If the natural cementation is between 500 kPa and 1200 kPa, the material is marginal for gravel surfacing. If the natural cementation is below 500 kPa, the material is unsuitable for gravel surfacing. The above criteria are independent of the plasticity index of the aggregate.

2. APPARATUS

2.1 *Sieves* — Sieves (4.75 mm and 2.00 mm) shall conform to AASHTO M 92.

2.2 *Oven*—An oven able to maintain a drying temperature of 110° C ± 5°.

2.3 *Specimen Molds*—Specimen molds for 50 mm cube specimens shall conform to AASHTO T 106, Section 5.3.

2.4 *Balance*—Balance shall conform to AASHTO M 231, Class G-2.

2.5 *Tamper*—Tamper shall conform to figure 1.

2.6 *Mechanical splitter*—Splitter shall conform to AASHTO T 248.

2.7 *Straightedge*—Trowel or straightedge shall have a steel blade 100—150 mm in length with straight edges.

2.8 *Testing Machine*—Testing machine shall be able to maintain a controlled rate of strain and shall conform to AASHTO T 106.

3. SAMPLE PREPARATION

3.1 Shake a properly quartered or split sample over the 2.00 mm screen. Approximately 750 g of the material passing a 2.00 mm sieve is needed for the two specimens required by this test procedure.

4. PROCEDURE

4.1 Oven dry the sample at 60° C ± 5°.

4.2 Mix the sample with water until the sample contains 5 percent more moisture than in the saturated surface dry condition, as determined by AASHTO T 84. For normal aggregates 6.5 percent total moisture may be used.

4.3 Apply a coating of light oil to the inside wall and the base plate of the molds.

4.4 Compact each soil specimen in two 25 mm layers with the tamper, using 25 drops of the sliding mass per layer.

4.5 Strike off the top of the molds to a smooth surface.

4.6 Dry the compacted specimens in the mold to a constant mass at 110° C ± 5°.

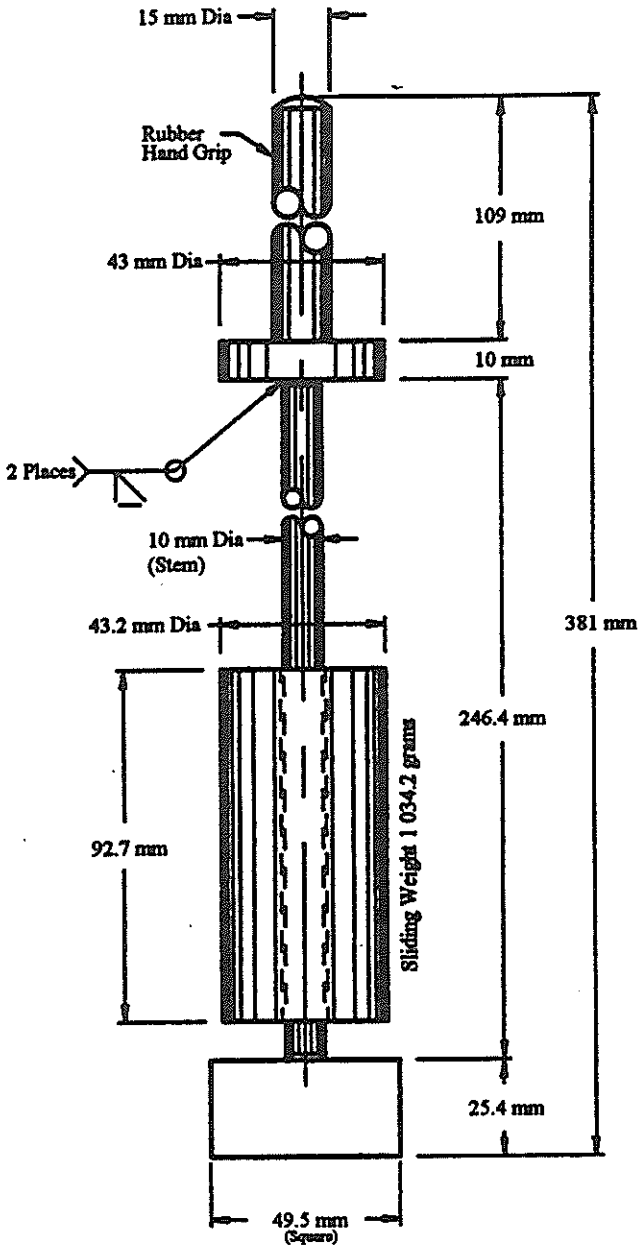
4.7 Remove the specimens from the molds and allow to cool to room temperature.

4.8 Carefully place the specimen in the testing machine below the center of the upper bearing block. The load should be applied to the specimen faces that were in contact with the true plane surfaces of the mold. Prior to the testing of each cube, it shall be ascertained that the spherically seated block is free to tilt. Load the specimens at a controlled rate of strain of 1.3 mm/minute. Make no adjustment on the controls of the testing machine while a specimen is yielding rapidly immediately before failure.

5. CALCULATION AND REPORT

5.1 Record the total maximum load indicated by the testing machine. If the cross sectional area of a specimen varies more than 5 percent from the nominal, use the actual area for calculation of the compressive strength. The compressive strength of all sound and cubical test specimens from the sample shall be averaged and reported to the nearest kPa.

Use Form FHWA 1617 to record and report test results. See Exhibit No. 3.20 in Chapter 3 of the FLH Field Materials Manual for a sample format.



Note: Dimensions may be varied with the exception of the free fall of the sliding weight and the square hammer base.

Not to Scale

Figure 1 — Cementation Hammer

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Standard Method of

Determining the Adherent Coating on Coarse Aggregates

FLH Designation: T 512-94

1. SCOPE

1.1 This test method is used to determine the adherent coating or adherent fines on coarse aggregate (aggregate retained on the 4.75 mm sieve) or on total aggregate for the following purposes:

1.1.1 Preliminary investigation of mineral aggregate sources.

1.1.2 Control of mineral aggregates used in hot asphalt concrete pavements, seal coats, cover coats, surface treatments, and portland cement concrete at the source of supply.

1.1.3 Control of mineral aggregate processing requirements.

1.1.4 Acceptance or rejection of aggregates based on adherent coating or adherent fines.

2. APPLICABLE DOCUMENTS

2.1 AASHTO T 2, Sampling Aggregates.

2.2 AASHTO T 11, Materials Finer Than 75 μm Sieve in Mineral Aggregates by Washing.

2.3 AASHTO T 27, Sieve Analysis of Fine and Coarse Aggregates.

3. SUMMARY OF METHOD

3.1 Aggregate for hot asphalt concrete pavement and coarse aggregate for portland cement concrete.

3.1.1. A weighed sample of dry aggregate is separated on the 4.75 mm sieve and the difference in the amount of material passing the 75 μm sieve on the coarse aggregate (material retained on the 4.75 mm sieve) between dry sieving and washing is determined and reported as adherent coating or adherent fines.

3.2 Aggregate for seal coats, cover coats, and surface treatments.

3.2.1 A weighed sample of dry aggregate is sieved and then washed. The difference in the amount of material passing a 75 μm sieve on the aggregate between dry sieving and washing is determined and reported as adherent coating or adherent fines on the aggregate.

4. SAMPLING

4.1 Sample the aggregate in accordance with AASHTO T 2.

4.2 Thoroughly mix the sample and reduce it to an amount suitable for testing, using the applicable procedures described in AASHTO T 248. The sample for testing shall be approximately the weight desired when dry and shall be the end result of the reduction. Reduction to an exact predetermined weight is not permitted.

4.3 The weight of the test sample shall conform to table 1 below.

Table 1
Weight of Test Sample

Nominal Maximum Size	Weight of Test Sample	
Square Openings (mm)	Minimum (Kg)	Maximum (Kg)
9.5	1	2
12.5	2	3
19.0	5	7
25.0	10	12
37.5	15	18

5. PROCEDURE

5.1 Aggregate for hot asphalt concrete or portland cement concrete.

5.1.1 Conduct a sieve analysis of fine and coarse aggregate with a nested 4.75 mm sieve in accordance with AASHTO T 27.

5.1.2 Weigh the total material retained on the 4.75 mm sieve.

5.1.3 Determine the amount of material finer than the 75 μm sieve coating the material retained on the 4.75 mm sieve in accordance with AASHTO T 11.

5.2 Aggregate for seal coats, cover coats, and surface treatments.

5.2.1 Conduct sieve analysis of fine and coarse aggregates in accordance with AASHTO T 27.

5.2.2 Weigh the total material retained on the 75 μm sieve.

5.2.3 Determine the amount of material finer than the 75 μm sieve coating the material retained on the 75 μm sieve in accordance with AASHTO T 11.

6. CALCULATION

6.1 Aggregate for hot asphalt concrete and portland cement concrete.

6.1.1 Calculate the amount of coated material (material passing the 75 μm sieve) by washing the material retained on 4.75 mm sieve in accordance with AASHTO T 11.

6.1.2 Calculate the adherent coating on the coarse aggregate as follows:

$$\text{Adherent Coating} = \frac{A}{W_a}(100)$$

Where:

A = Weight of material passing 75 μm sieve washed off the coarse aggregate.
W_a = Dry weight of aggregate retained on the 4.75 mm sieve after sieving in accordance with AASHTO T 27 and before washing.

6.2 Aggregate for seal coat, cover coat, and surface treatment.

6.2.1 Calculate the amount of coated material (material passing the 75 μm sieve) by washing the material retained on the 75 μm sieve in accordance with AASHTO T 11.

6.2.2 Calculate adherent coating on the aggregate as follows:

$$\text{Adherent Coating} = \frac{B}{W_b}(100)$$

Where:

B = Weight of material passing 75 μm sieve washed off the aggregate.
W_b = Dry weight of aggregate before sieving in accordance with AASHTO T 27.

7. REPORT

7.1 Report the adherent coating (adherent fines) to the nearest 0.1 percent on Form FHWA 1612.

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Standard Method of

Determining In-Place Density and Moisture Content of Soils and Aggregates Using a Troxler 3411-B Nuclear Instrument

FLH Designation: T 513-94

1. SCOPE

1.1 This method of test is used to find the percent of relative compaction by first determining the actual moisture content and dry density of material in-place.

2. APPARATUS

2.1 A nuclear moisture/density gauge, Troxler 3411-B.

2.2 Peripheral equipment shall include:

- Guide Plate
- Extractor
- Instruction Book
- Radioactive Signs
- Steel Pin
- Standard Block
- A.C. Charger Cord

3. DETERMINING STANDARD COUNTS

3.1 Turn POWER/TIME switch to SLOW.

3.2 Allow gauge to stabilize for 10 minutes.

3.3 Place standard block on soil, asphalt, or concrete with a minimum density of 1600 kg/m^3 that is located at least 6 meters from any large object (vehicle, trees, etc.) and at least 15 meters from any other nuclear gauge.

3.4 Place gauge into the recessed area on the standard block, with the scaler end pulled against the metal plate (see Figure 1).

3.4.1 Remove probe lock.

3.4.2 Put index handle in SAFE position.

3.4.3 Move POWER/TIME switch to SLOW.

3.4.4 Depress and hold down key labeled SHIFT.

3.4.5 Depress the STANDARD/MEASURE key and then release it.

3.4.6 Release the SHIFT key. The gauge will automatically start to count. An ERR message will appear in the upper left corner of the liquid crystal display. When the ERR message disappears, the count has been completed.

3.4.7 Depress DS (Density Standard) key and record the count (see note 1).

3.4.8 Depress MS (Moisture Standard) key and record the count (see note 1).

NOTE 1—The DS and MS counts are stored in the gauge's memory and may be recalled by pressing MS or DS keys. They will remain in the gauge's memory until the POWER/TIME switch is turned to the OFF position, or until a new standard count is initiated.

4. STATISTICAL STABILITY TEST

4.1 This test is used to determine if the gauge is monitoring the radiation from the radioactive source within the limits of normal statistics.

4.2 The same steps are followed to do this test as the steps prescribed for testing for standard counts, except for the following:

- The POWER/TIME switch is set at 1 minute.
- The SHIFT key is not depressed.
- The ERR message appears as the counting is accumulating. When ERR disappears, 1-minute count has been completed.
- Depress DC key to display Density Count.
- Depress MC key to display Moisture Count.
- Record counts.

4.3 Continue this process (section 4.2) until twenty 1-minute counts have been read and recorded.

4.4 Add the standard counts and then divide by 20 to find "n."

4.5 Find the error for each individual count by subtracting "n" from the count.

4.6 Find "E^2" by squaring each error.

4.7 Find "E" by totaling "E^2."

4.8 Calculate the ratio for moisture and density. These ratios must fall between 0.18 and 0.35 to prove that the gauge is operating properly.

5. PERCENT RELATIVE COMPACTION

5.1 Setting percent PR (Percent of Proctor)

$$\text{Percent PR} = \frac{DD}{Z} \times 100$$

Where: DD = Dry Density
Z = Proctor Density

5.1.1 Turn POWER/TIME switch to NORM.

5.1.2 Depress and hold SHIFT key while momentarily depressing the SET key.

5.1.3 The display will show the value of "Z" for 5 seconds. When the gauge is turned on, it automatically sets "Z" = 2,000 kg/m^3.

5.1.4 To change "Z," perform the following steps:

5.1.5 Set the moisture correction switch to increase (+) or decrease (—).

5.1.6 Depress and hold the SET key until the correct density is displayed.

5.1.7 If the SET key is depressed for over 5 seconds, the rate of change in the displayed density is increased.

5.1.8 To stop the change, release the SET key.

5.1.9 The density can be raised or lowered until the correct proctor dry density is displayed.

6. DETERMINING THE PERCENT MOISTURE AND THE DRY DENSITY OF SOILS AND BASES

6.1 Site preparation.

6.1.1 Use a table of random numbers, or other approved method, in conjunction with tonnage or station to find the location where the test is to be completed.

6.1.2 Scrape and tamp an area with the guide plate. Remove loose stones. Fill and compact voids with native fines.

6.2 Hole preparation.

6.2.1 Punch hole at least 50 mm deeper than the depth to be used.

6.2.2 Stand on the guide plate when the pin is being driven (see note 2).

6.2.3 Extract the pin vertically. If the pin resists, it may be easier to extract after it has been rotated.

6.2.4 Place the gauge solidly on the prepared surface.

6.2.5 Lower radioactive source to the desired depth into the hole.

6.2.6 Set POWER/TIME switch to NORM.

6.2.7 Set DEPTH switch to appropriate depth.

6.2.8 Pull the gauge backward to ensure that the extended rod is tight against the side of the hole.

6.2.9 Depress the STANDARD/MEASURE key momentarily.

6.2.10 When the ERR message disappears, the count has been completed.

6.2.11 Press and record:

DD = Dry Density
%M = Percent Moisture
%PR = Percent Relative Compaction

NOTE 2—CAUTION—When driving the pin into a soil or aggregate, remember you are applying considerable force with each hammer blow. The pin will mushroom and flake with time, and metal chips will fly from the pin as it is struck with the hammer. The pin can be ground to lessen this effect. Safety glasses are advised.

7. ENGLISH/METRIC READOUT

7.1 PCF—English readings are in pounds per cubic feet (lb./ft.^{3}).
SI—Metric readings are in kilograms per cubic meter (Kg/m^3).

7.2 To change readout:

7.2.1 Release four thumb screws which retain electronic module.

7.2.2 Remove electronic module from gauge, leaving ribbon connected.

7.2.3 On back side of electronic module (lower right side from front view) locate the slide switches labeled SI and PCF.

7.2.4 Place switch in desired mode.

7.2.5 Replace electronic module and finger-tighten thumb screws.

8. MOISTURE CORRECTION

8.1 This instrument calculates a "K" factor to correct for hydrogen in the measured material which is not contained in the free water removed during standard oven-drying procedures. This correction factor, as used with other types of equipment, is a function of the dry density and is only valid for one value of dry density. The correction used in this instrument is independent of dry density and correctly adjusts the apparent moisture to a true moisture, regardless of the dry density.

8.2 There are two ways to get the correction factor. The first and easier method uses the instrument in the field to calculate the value of "K."

8.2.1 Assuming that the soil is a type which allows an accurate "fast dry," a sample can be taken from under the gauge and a value of %M obtained while the count data is stored in the gauge memory.

8.2.2 Depress %M. If the displayed value is higher than the value obtained from the "fast dry," set the sign switch on "—." Use "+" if the computed %M is lower than the "fast dry." Increment the MOISTURE CORRECTION switches, beginning with 00, until the computed value is equal to the "fast dry" value, and record the final switch setting. Repeat this procedure for four or more sites and average the "K" values. This average can now be set up as the MOISTURE CORRECTION constant and can be used for all future tests on this soil.

8.2.3 An easy way to set the MOISTURE CORRECTION switches is to depress and hold down the %M key while turning the CORRECTION switches. This places the processor in a continuous calculation mode. If ERROR 40 appears while adjusting the switches, release and depress the key again. ERROR 40 occurs if the processor attempts to read the switches at the instant the switch was rotated.

8.3 The second method of getting the correction factor is to make four or more gauge %M measurements with the MOISTURE CORRECTION switches set to "+" 00. Samples from each site should be taken to the laboratory for the oven-dry. The minimum recommended sample size is 500 grams. Care should be taken to keep the samples from drying out.

8.3.1 For each sample, the "K" factor can be computed by the following formula:

$$K = \frac{\%M\ (True) - \%M\ (Gauge)}{\%M\ (Gauge) + 100} \times 1{,}000$$

8.3.2 The final value of "K" should be the average of four or more samples rounded to an integer. The value will fall between —99 and +99. This value is then set into the gauge MOISTURE CORRECTION switches and used for all measurements on the particular soil.

NOTE 3—Use the second method described in section 8.3 when "fast dry" methods described in section 8.2 are not available in the field.

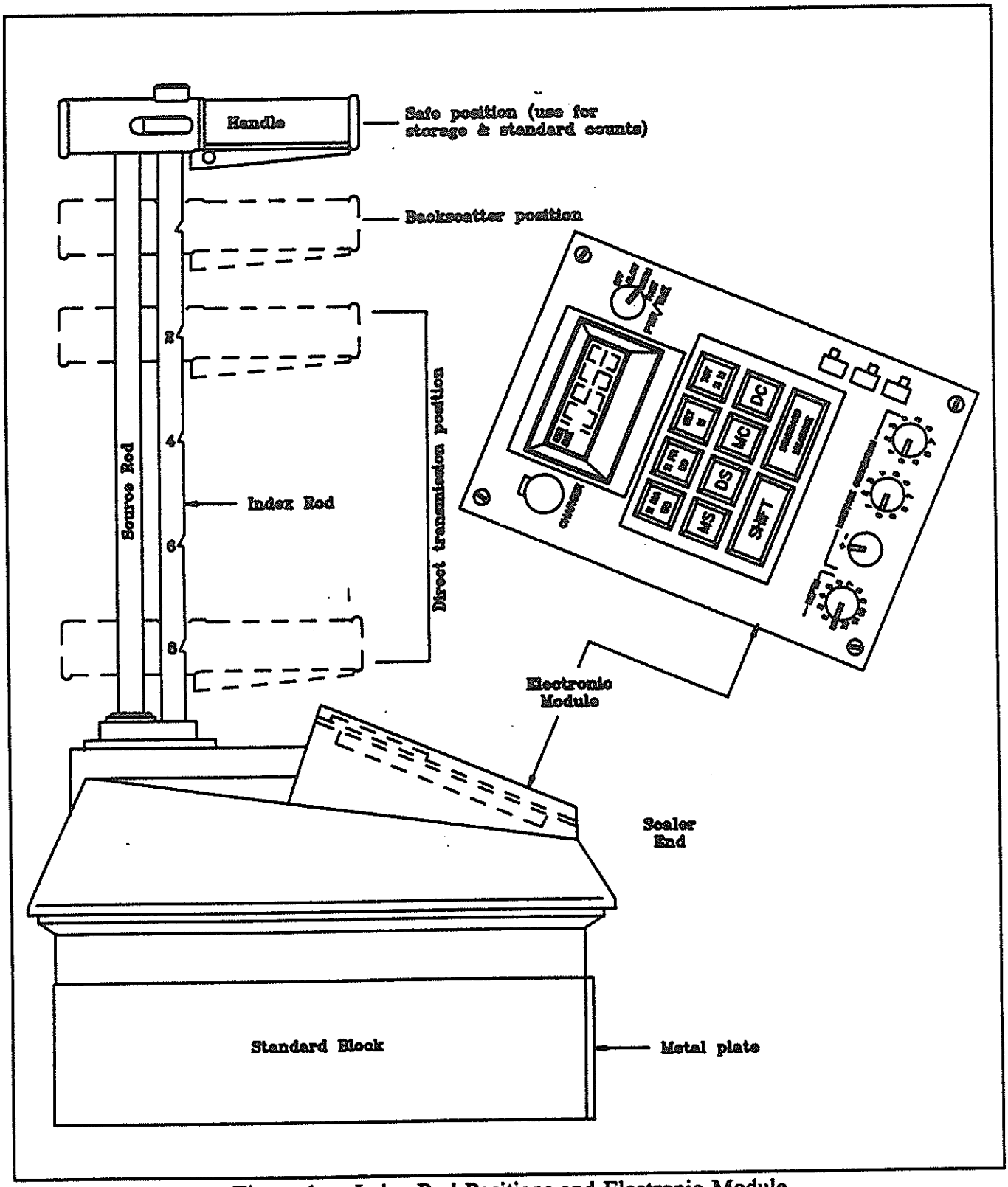

Figure 1 — Index Rod Positions and Electronic Module

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Standard Method of

Removing Asphalt from Asphalt Concrete Paving Mixtures Using Biodegradable Solvents

FLH Designation: T 514-96

1. SCOPE

1.1 This method covers a procedure for removing asphalt from hot-mixed paving mixtures using a biodegradable solvent. Aggregates obtained by this method may be used for sieve analysis following the procedures of AASHTO T 30.

2. APPLICABLE DOCUMENTS

2.1 AASHTO Procedures:

- M 92, Wire-Cloth Sieves for Testing Purposes.
- M 231, Weighing Devices Used in the Testing of Materials.
- T 30, Mechanical Analysis of Extracted Aggregate.
- T 168, Sampling Bituminous Paving Mixtures.
- T 248, Reducing Field Samples of Aggregate to Testing Size.

3. APPARATUS

3.1 *Balance*—The balance shall conform to AASHTO M 231, Class G 5.

3.2 *Sieves*—The 1.18 mm and 75 μm sieves of 305 mm diameter with square openings shall be mounted on substantial frames constructed in a manner that will prevent loss of material during washing. Suitable sieve sizes shall be selected to furnish the information required by the specifications covering the material to be tested. The sieves shall conform to AASHTO M 92.

3.3 *Sieve Pan*—A 305 mm diameter container capable of firmly holding the nested sieves and having a capacity of 8 to 40 liters.

3.4 *Graduated cylinders.*

3.5 *Plastic wash bottle.*

3.6 *Spoon, spatula, etc.*

4. REAGENT (Solvent)

4.1 The biodegradable solvent shall have been formulated to permit the solvent to be removed from aggregate by washing with water. The solvent shall be supplied in clean and appropriately lined metal containers.

5. SAMPLE

5.1 The size of sample shall be governed by the nominal size of particles of aggregate in the mixture. The minimum size of sample shall conform to Table 1.

TABLE 1
Minimum Sample Size for a Given Size of Aggregate

Nominal Aggregate Size U.S. Standard Sieves [1]	Sample Size (grams)
4.75 mm	500
9.5 mm	1000
12.5 mm	1500
19.0 mm	2000
25.0 mm	3000
37.5 mm	4000

NOTE 1— Sieves conforming to AASHTO M 92.

6. PROCEDURE

6.1 Determine the asphalt content, using a nuclear test instrument in accordance with FLH Test Procedure T 513, T 516, or T 517. Record data.

6.1.1 Determine moisture content, using a microwave oven in accordance with FLH Test Procedure T 515. Record data.

6.1.2 Weigh the sample and record the mass.

6.1.3 Calculate and record the mass of dry aggregate.

6.2 Cover the sample of asphalt concrete mixture with 1200 mL of solvent and allow it to soak for 20 minutes. After the soak period, agitate and decant the solution over the 1.18 mm and 75 μm mesh sieves nested over the container described in section 3.3. Add additional increments of solvent (300 mL) and stir for 2-minute periods before decanting. In usually five to eight washes, the solvent will become a cocoa-brown color when agitated. See Note 2. At this point, discontinue the solvent rinses. Dispose of the resulting asphalt and solvent solution in a manner consistent with appropriate governing regulations.

6.3 Wash the sample vigorously with water as in AASHTO T 11. Agitate the sample vigorously to result in the complete separation from the coarse particles of all particles finer than the 75 μm sieve and bring them into suspension in order that they may be removed by decantation of the wash water. Care shall be taken to avoid, as much as possible, the decantation of the coarse particles of the sample. The operation shall be repeated until the wash water is clear.

NOTE 2—Vigorous washing with solution to remove the asphalt from the aggregate may cause some aggregate degradation. To determine the extent, if any, of the degradation, perform a minimum of 3 companion wash tests (AASHTO T 27 and AASHTO T 11) on processed aggregate without asphalt. The comparison of these results should identify the amount of degradation occurring. If degradation is occurring, an adjustment in the percent passing the sieves may be required. Do not adjust test results if the difference of an individual sieve size percent passing is less than 10 percent of the mean percent passing the given sieve in the companion test results.

6.4 All material retained on the nested sieves shall be returned to the container. The washed aggregate in the container shall be dried to constant mass at a temperature of 110 °C ± 5° and weighed to the nearest 0.1 gram and recorded.

6.5 The aggregate shall then be sieved over sieves of the various sizes required by the specification covering the mixture, in accordance with AASHTO T 30 and recorded. The summation of these various weights must check the dried weight after washing within 0.2 percent of the total weight. The weight of dry material passing the 75 μm sieve by dry-sieving shall be added to the weight of minus 75 μm material removed by washing in section 6.4, in order to obtain the total amount passing the 75 μm sieve.

7. REPORT

7.1 The results of the sieve analysis shall be reported as the total percentages passing each sieve. Percentages shall be reported to the nearest whole number except for the percentage passing the 75 μm sieve, which shall be reported to the nearest 0.1 percent.

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Standard Method of

Determining Moisture Content in Asphalt Concrete Paving Mixtures Using a Microwave Oven

FLH Designation: T 515-94

1. SCOPE

1.1 This method covers the use of microwave ovens to determine moisture content in asphalt concrete paving mixtures using a microwave oven.

2. SIGNIFICANCE AND USE

2.1 This method is used to determine the amount of moisture content in a sample of asphalt concrete paving mixture. The method is intended to be used in combination with nuclear asphalt content test procedures.

2.2 The microwave oven causes the moisture to gain temperature at an accelerated rate and lessens the time required to dry a sample to a constant weight. Conventional ovens, convection or forced-draft, heat the sample by heat transfer from the heated air in the interior of the oven to the sample. Microwave ovens cause the moisture molecules in the sample to oscillate at a high rate and become heated by molecular friction.

3. APPARATUS

3.1 *Balance* — Balance shall conform to AASHTO M 231 for the class of general purpose balance required for the principal weight of the sample being tested.

3.2 *Microwave oven* — An oven having an output of 1000 watts minimum and an internal chamber approximately 0.05 cubic meters in size. The oven interior shall have a metal or ceramic lining. The oven shall have a variable power control mode. (See note 1.)

3.3 *Drying pans*—Pans or dishes composed of heat-tempered glass. Glass manufacturers produce dishes of various sizes and shapes specifically to be used in microwave ovens.

3.4 *Stirring tools*—Spatulas, spoons, or other utensils to mix the sample to facilitate the even heating of the particles.

NOTE 1—Microwave ovens should be tested at least once a month for leakage around the edges of the door. Document the findings. If leakage is above the level recommended by the manufacturer, the oven should not be used until repaired. A simplified leakage test can be performed with a small low wattage neon tube held next to the door. If the tube lights at all, contact the FLHD Safety Officer.

4. SIZE OF SAMPLE

4.1 The size of sample used for moisture determinations shall be 500 to 1000 grams. The samples for testing shall be prepared in accordance with AASHTO T 248 using the quartering method.

5. PREPARATION OF SAMPLE

5.1 When the asphalt concrete material to be used to determine asphalt content of the paving mixture is separated out from the sample taken, also quarter-out an approximate amount of material for determining its moisture content. Thoroughly mix the sample and break up any large lumps. Weigh out an amount not less than 500 grams for the test. Keep the remainder of the sample in a tightly covered container.

6. PROCEDURE

6.1 Prepare a sample in accordance with section 5.1. Weigh and record the weight of the sample, place the sample in a dish and place it in the microwave oven. Set the oven timer to 25 minutes and set the oven to operate at a low power setting. As the drying cycle progresses, the sample should be checked periodically to assure that it is not being heated above 140° C. If overheating occurs, the sample will smoke and a portion of the oils in the asphalt cement will be driven off. If overheating occurs, the sample should be discarded and another sample tested. (See note 2.)

NOTE 2 — Every mix will require a slightly different drying time. A definite drying time can usually be ascertained by checking the dry weight of the mix at 5-minute intervals until a constant weight is obtained.

6.2 Record the dry weight of the sample. Calculate and record the percent moisture by original weight of sample as described in section 7.1.

7. CALCULATIONS

7.1 Calculate the moisture content of the wet sample as follows:

$$\% \text{ Water} = \frac{\text{Original Weight of Sample} - \text{Final Weight of Sample}}{\text{Original Weight of Sample}} \times 100$$

7.2 Record the percent moisture content to the nearest 0.1 percent.

Standard Method of

Determining Asphalt Content of Asphalt Concrete Paving Mixtures Using a Troxler 3241-B Nuclear Instrument

FLH Designation: T 516-94

1. SCOPE

1.1 The nuclear asphalt content gauge is used to determine the amount of asphalt contained in loose asphalt concrete mixtures.

2. APPARATUS

2.1 Model 3241 Series B Troxler nuclear instrument.
2.2 4.54 kg rammer and sleeve as used in AASHTO T 180.
2.3 A scale conforming to AASHTO M 231, Class G20.
2.4 Drying oven capable of heating to 175° C ± 5°.
2.5 A steel compaction plate as shown in figure 1.
2.6 Splitter conforming to AASHTO T 248.
2.7 Straight edge.
2.8 Appropriate steel pans.

3. CALIBRATION

3.1 Obtain a representative sample of the processed aggregate (without asphalt) and dry to a constant weight at 110° C ± 5° for at least 4 hours (30 000 grams ± 1000 grams).

3.2 Split or quarter the aggregate into 4 fractions.

3.3 Weigh one of the pans provided with the gauge and record its tare weight on the calibration worksheet (Form FHWA 1631).

3.4 Fill the tared pan with a representative portion of the dry aggregate. Rock the pan back and forth by lowering and raising first the right side then the left side. Raise and lower each side 10 times.

3.5 If the aggregate has consolidated in the pan, add sufficient material to refill the pan. Strike off the excess material with a straightedge.

3.6 Weigh and record the weight of pan and aggregate. Subtract the pan tare weight from the gross weight and determine the net weight of the aggregate. This net weight of the aggregate will be used to determine the weight of mix to be placed in the pan during calibration and subsequent testing. Save the tared pan filled with dry aggregate.

3.7 Using one of the other splits, weigh and add exactly a quantity of asphalt equal to the desired asphalt content target value less 1.0% by weight of total mix. Record data on an appropriate form.

3.8 After mixing, bring the mix to a temperature of 110° C ± 5°. (When testing for asphalt content from Section 5.2, the moisture sample should also be heated to 110° C ± 5° and tested for moisture content.)

3.9 The mix shall be compacted in two layers of equal weight not to exceed the net aggregate weight specified in 3.6.

3.10 Tare a pan and weigh one half of the weight necessary to fill the pan.

3.11 Preheat the compaction plate (figure 1). Use the plate and the 4.54 kg rammer to densify the mix with seven compaction blows. Drop the hammer from a height of 457 mm.

3.12 Remove the compaction plate and add additional mix until the predetermined weight is met. (Calculated weight = tare weight + compacted net aggregate weight)

3.13 Again use the 4.54 kg rammer, dropped from a height of 457 mm, with the compaction plate to densify the top layer with seven blows.

3.14 The compacted mix is now ready. Refer to Test Procedure for Gauge Calibration in annex B.

3.15 An additional calibration sample must be made using an asphalt content equal to the desired asphalt content target value plus 1.0% asphalt. Repeat the procedures in 3.7 through 3.14.

NOTE 1—All calibration and subsequent test samples must be of the same weight and height in the sample pans. This cannot be over-emphasized. Due to sampling errors and statistics, the calibration and test samples should be as large as possible. Usually this can be accomplished by using the weight of dry aggregate that it takes to exactly fill the sample pan. This weight of a hot sample containing asphalt will always fit into the sample pan.

4. MOISTURE CURVE DETERMINATION

4.1 After calibration of the nuclear asphalt content gauge has been completed, a moisture correction curve should be determined, using the following procedure.

4.2 Place tared pan containing the dry aggregate (saved in accordance with section 3.6 above) into the gauge and follow instructions for asphalt determination in annex B. The aggregate must be cooled to room temperature before the moisture calibration is attempted. The initial measured count on the aggregate represents no moisture or ZERO. This count must be subtracted from the counts at 0.5% and 1.0% moisture content to determine the effect of the moisture in relation to the count.

4.3 Record measured count (MC) on line A, Form FHWA 1631.

4.4 Remove pan from gauge.

4.5 Calculate 0.5% moisture by total weight of the sample.

4.6 Set pan filled with aggregate on the scale and pour the calculated weight of water over the sample.

4.7 Place pan in the gauge and follow section 4.2 again.

4.8 Record MC on line (B) and calculate corrected moisture MC [B - A] and record.

4.9 Remove pan from the gauge.

4.10 Add an additional 0.5% moisture as in 4.5 and 4.6 to bring total to 1.0% moisture.

4.11 Place pan in the gauge and follow section 4.2 once again.

4.12 Record MC on line (C) and calculate corrected moisture MC [C - A] and record.

4.13 Plot the three points that represent the difference in count in relationship to the moisture on the Moisture Curve Worksheet (Form FHWA 1632) and develop the moisture correction curve (often a straight line).

5. ASPHALT DETERMINATION

5.1 Split or quarter a representative portion of the mixture to the approximate weight required to fill the pan.

5.2 Use the same procedure outlined in sections 3.8 through 3.13.

5.3 Refer to the test procedure for asphalt determination in Annex B and follow the indicated instructions. Read and record the measured count (MC) on Form FHWA 1619.

5.4 A correction for the moisture present must be made. Refer to FLH Test Procedure T 515 for details and record percent moisture.

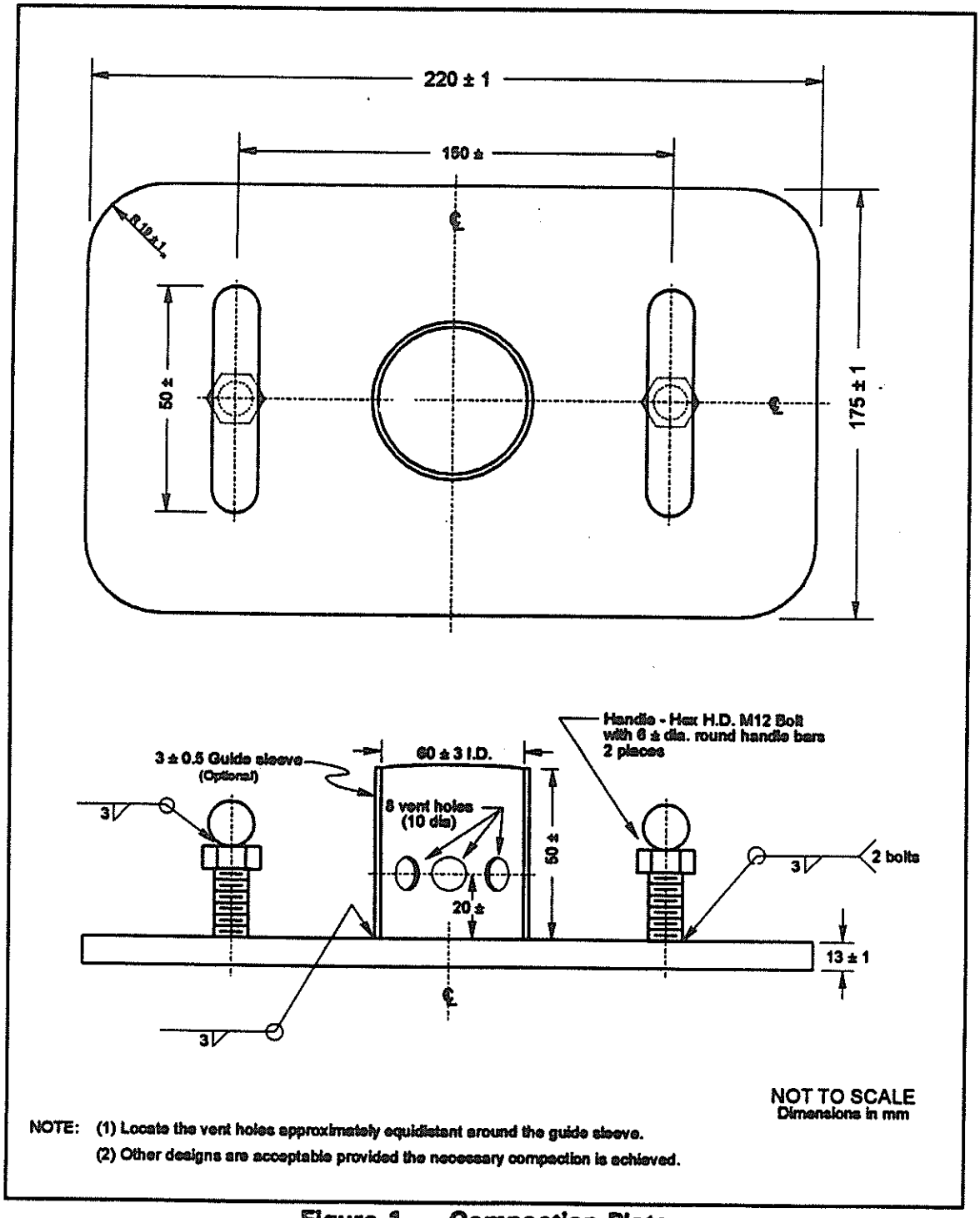
5.5 The percent moisture should be plotted on the Moisture Curve Worksheet to determine the corresponding MC.

5.6 The corrected MC for asphalt (MC for the mix less the MC for moisture) should be recorded.

5.7 Asphalt content (AC) in percent is determined by the following calculation:

$$AC = (C)(S) + (I)$$

Where: C is the asphalt MC corrected for moisture, S is the slope ratio representing the change in asphalt content to the MC, and I is the point on the Y-axis where the line representing the slope ratio intersects the Y-axis (always a negative number). Record asphalt content to the nearest 0.1 percent.



NOTE: (1) Locate the vent holes approximately equidistant around the guide sleeve.
(2) Other designs are acceptable provided the necessary compaction is achieved.

Figure 1 — Compaction Plate

ANNEX A

Test Procedure for Gauge Calibration
Troxler 3241-B Asphalt Content Gauge

[ ]	— Depicts gauge reading.
Push	— Depicts what the operator will enter manually in the gauge.

1. Check voltage on back of gauge; set to proper voltage
2. Plug in
3. Function switch to TEST
4. Power/Time switch to CALIBRATE
5. [RAM OK
PROM OK]
6. [GAUGE
OPERATIONAL]
7. [MANUALLY ENTER
CALIB? YES/NO]
8. Push INC
YES
9. [% AC & COUNT
YES/NO]
10. Push DEC
NO
11. [SLOPE/INTERCEPT
YES/NO]
12. Push DEC
NO
13. [NEW CALIBRATION?
YES/NO]
14. Push INC
YES
15. [FUNCTION SWITCH
TO CALIBRATE]
16. Set function switch on CALIBRATE
17. [LOAD CALIB PAN 1
PRESS START]
18. Put mix in calibration pan #1 with the AC content = TV - 1.00%
19. Push START
ENTER
20. [ENTER % AC = ____
INC/DEC ENTER/ *]

ANNEX A (continued)

21. Push START
ENTER

22. COUNTING T=16

NOTE: * If you want to take only one 4 minute count, move the POWER/TIME switch to NORMAL after step 20, then:

21A. Push START
ENTER

22A. COUNTING T=4

23. At the end of counting period:

MEASURE COUNT:
MC =

24. Push START
ENTER

25. LOAD CALIB PAN 2
PRESS START

26. Put mix in calibration pan #2 with the AC content = TV + 1.00%

27. Push START
ENTER

28. ENTER % AC = ____
INC/DEC ENTER/ **

29. Push START
ENTER

NOTE: ** If the POWER/TIME switch is not at the CALIBRATE position, the instrument will beep and the gauge will read:

INCORRECT CALIB
TIME SELECTED

Then it will stop beeping and start counting.

30. COUNTING T=4

31. At the end of counting period:

MEASURE COUNT:
MC =

32. Push START
ENTER

33. REVIEW CAL DATA?
YES/NO

34. Push INC
YES

35. CALPAN1 =
CALCNT1 =

ANNEX A (continued)

36. Push START
ENTER

37. CALPAN2 =
CALCNT2 =

38. Push START
ENTER

39. SLOPE x 1000 =
INTERCEPT =

40. Push START
ENTER

41. DATA CORRECT?
YES/NO

42. Push INC
YES

43. NEW CALIBRATION
COMPLETE

44. SELECT
FUNCTION

45. To measure a sample Function switch to MEASURE

46. LOAD SAMPLE PAN
PRESS START

47. Put in sample to be measured

48. Push START
ENTER

49. COUNTING T=4

50. At the end of counting period:

% AC = (readout)
MC = (readout)

51. Push START
ENTER

This will put you back to step 46.

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ANNEX B

Test Procedure for Asphalt Determination
Troxler 3241-B Asphalt Content Gauge

	— Depicts what the gauge will read.
Push	— Depicts what the operator will enter manually in the gauge.

1. Check voltage on back of gauge; set to proper voltage
2. Plug in
3. Function switch to TEST
4. Power/Time switch to CALIBRATE
5. RAM OK
   PROM OK
6. GAUGE
   OPERATIONAL
7. MANUALLY ENTER
   CALIB? YES/NO
8. Push DEC
   NO
9. NEW CALIBRATION?
   YES/NO
10. Push DEC
    NO
11. REVIEW CAL DATA?
    YES/NO

Note: The gauge will retain the calibration data in its memory until unplugged.

To Measure a Sample:

12. Push DEC
    NO
13. LOAD SAMPLE PAN
    PRESS START
14. Push START
    ENTER
15. COUNTING T=16

NOTE: If you want to change to only one 4 minute count, move the POWER/TIME switch to NORMAL and restart.

16. At the end of counting period:

    % AC = (readout)
    MC = (readout)

17. Push START
    ENTER
18. LOAD SAMPLE PAN
    PRESS START
19. This will put you back to step 13.

ANNEX B (continued)

Review Data before unplugging gauge:

1. Push INC
   YES
2. CALPAN1 =
   CALCNT1 =
3. Push START
   ENTER
4. CALPAN2 =
   CALCNT2 =
5. Push START
   ENTER
6. SLOPE x 1000 =
   INTERCEPT =
7. Push START
   ENTER
8. SELECT
   FUNCTION
9. Function switch to MEASURE
10. LOAD SAMPLE PAN
    PRESS START

Review Data after gauge is unplugged:

1. Push DEC
   NO
2. SELECT
   FUNCTION
3. Function switch to MEASURE
4. GAUGE NOT
   CALIBRATED *

Note: * See calibration procedures.

Standard Method of

Determining Asphalt Content of Asphalt Concrete Paving Mixtures Using a Troxler 3241-C Nuclear Instrument

FLH Designation: T 517-94

1. SCOPE

1.1 The nuclear asphalt content instrument is used to determine the amount of asphalt contained in loose asphalt mixtures.

2. APPARATUS

2.1 Model 3241 Series C Troxler nuclear instrument.
2.2 4.54 kg rammer and sleeve as used in AASHTO T 180.
2.3 A scale conforming to AASHTO M 231, Class G20.
2.4 Drying oven capable of heating to 175° C ± 5°.
2.5 A steel compaction plate as described in figure 1.
2.6 Splitter conforming to AASHTO T 248.
2.7 Straight edge.
2.8 Appropriate steel pans.

3. CALIBRATION

3.1 Before the 3241-C Series instrument can be calibrated or used for testing, a background count and statistical stability test should be performed (see attached procedures).

3.2 Obtain a representative sample of the processed aggregate (without asphalt) and dry to a constant weight at 110° C ± 5° for at least 4 hours (30 000 grams ± 1000 grams).

3.3 Quarter the aggregate into 4 fractions.

3.4 Tare one of the pans provided with the instrument and record on calibration worksheet.

3.5 Fill the tared pan with a representative portion of the dry aggregate. Rock the pan back and forth by lowering and raising first the right side then the left side. Raise and lower each side approximately 10 times.

3.6 If the aggregate has consolidated in the pan, add sufficient material to refill the pan. Strike off the excess material with a straightedge.

3.7 Weigh and record the weight of pan and aggregate on Form FHWA 1631. Determine the net weight of the aggregate. This net weight of the specimen will be used when determining the weight of mix to be placed in the pan during calibration and subsequent testing. Save the tared pan filled with dry aggregate.

3.8 Using one of the other quarters that has been split out, weigh and add exactly a quantity of asphalt equal to the designed asphalt content (TV - 1.00%) by weight of total mix. Record data on Form FHWA 1631.

3.9 After mixing, bring the mix to a temperature of 110° C ± 5°. (When testing for asphalt content from Section 5, the moisture sample should also be heated to 110° C ± 5° and tested for moisture content.)

3.10 The mix will be compacted in two layers of equal weight.

3.11 Tare a pan and weigh one half of the weight necessary to fill the pan.

3.12 Preheat the compaction plate (figure 1). Use the plate and the 4.54 kg rammer to densify the mix with seven compaction blows. Drop the hammer from a height of 457 mm.

3.13 Remove the compaction plate and add additional mix until the predetermined weight is met. (Calculated weight = tare + compacted aggregate.)

3.14 Using the rammer and the compaction plate, densify the top layer with seven blows. Drop the hammer from a height of 457 mm.

3.15 The compacted mix is now ready. See "Instrument Calibration Procedure" in annex C.

3.16 Two additional calibration samples must be tested. One sample with an asphalt content equal to the designed asphalt content TV and one sample equal to the designed asphalt content TV plus 1.0% asphalt. Repeat procedures 3.8 through 3.15.

NOTE 1—All calibration and subsequent test samples must be of the same weight and height in the sample pans. This cannot be over-emphasized. Due to sampling errors and statistics, the calibration and test samples should be as large as possible. Usually this can be accomplished by using the weight of dry aggregate that it takes to exactly fill the sample pan. This weight of a hot sample containing asphalt will always fit into the sample pan.

4. MOISTURE CURVE DETERMINATION

4.1 After calibration of the nuclear asphalt content instrument has been completed, a moisture correction curve should be determined, using the following procedure.

4.2 Place tared pan containing the dry aggregate (saved in accordance with section 3.7 above) into the instrument and follow instructions for asphalt determination in "Asphalt Mix Testing and Measurement Procedure" in annex D.

4.3 Record measured count (MC) on Form FHWA 1631.

4.4 Remove pan from instrument.

4.5 Calculate 0.5% moisture by total weight of the sample.

4.6 Set pan filled with aggregate on the scale and pour the calculated weight of water on the sample.

4.7 Place pan in the instrument and repeat section 4.2.

4.8 Record the MC. Determine the MC correction for a moisture content of 0.5% by subtracting the dry aggregate MC.

4.9 Remove pan from the instrument.

4.10 Add an additional 0.5% moisture as in 4.5 and 4.6 to bring total to 1.0% moisture.

4.11 Place pan in the instrument and follow section 4.2 once again.

4.12 Record the MC. Determine the MC correction for a moisture content of 1.0% by subtracting the dry aggregate MC.

4.13 Plot the three points on a Moisture Curve Worksheet (Form FHWA 1632) and develop the moisture curve.

5. ASPHALT DETERMINATION

5.1 Split or quarter a representative portion of the mixture to the approximate weight required to fill the pan.

5.2 Use the same procedure outlined in sections 3.9 through 3.14.

5.3 Refer to "Asphalt Mix Testing and Measurement Procedure" in annex D and follow the indicated instructions. Read and record the MC on Form FHWA 1619.

5.4 A correction for the moisture present must be made. Refer to FLH Test Procedure T 515 for the details and record percent moisture.

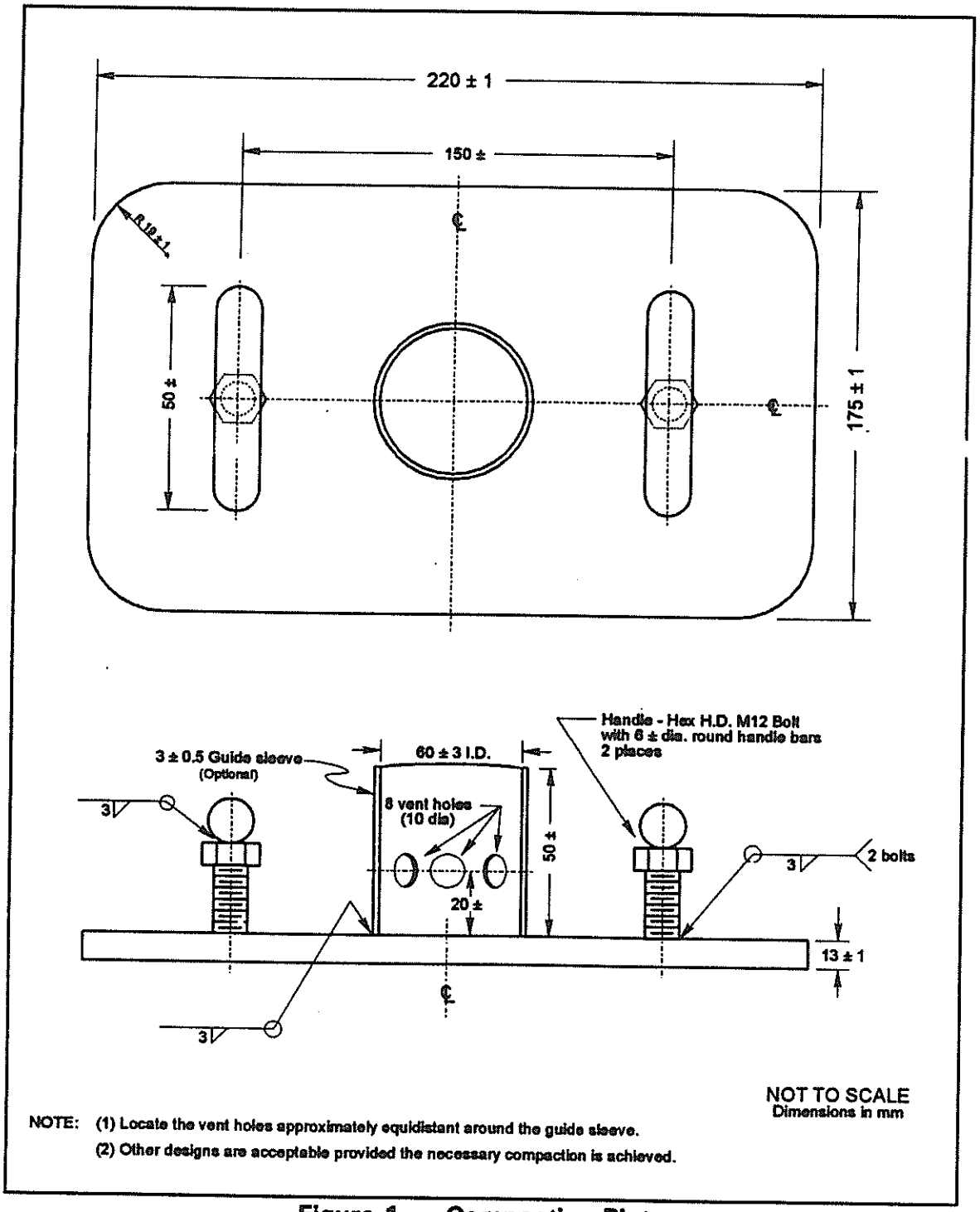
5.5 The percent moisture should be plotted on the Moisture Curve Worksheet and corresponding MC recorded.

5.6 The corrected MC for asphalt (MC for the mix less the MC for moisture) should be recorded.

5.7 Asphalt content (AC) in percent is determined by the following calculation:

$$AC = (0.001)(C)(S) + (I)$$

Where: C is the MC corrected for moisture, S is the slope ratio representing the change in asphalt content to the MC, and I is the point on the Y-axis where the line representing the slope ration intersects the Y-axis (always a negative number). Record asphalt content to the nearest 0.1 percent.



NOTE: (1) Locate the vent holes approximately equidistant around the guide sleeve.
(2) Other designs are acceptable provided the necessary compaction is achieved.

Figure 1 — Compaction Plate

ANNEX A

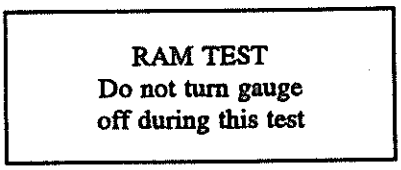
Test Procedure to Determine Background Count with Troxler 3241-C Asphalt Content Instrument

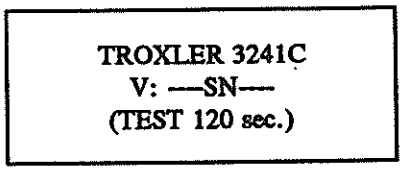
A Background Count Test should be taken daily and/or when the instrument is moved. After the Background Count has been completed, a Stat Test (see annex B) should be performed when initially setting up the instrument or if the instrument appears not to be operating properly.

— Depicts instrument reading.

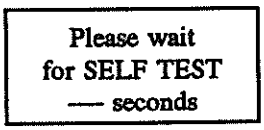
---

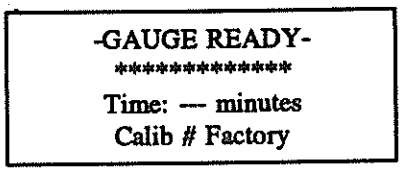
1. Turn instrument on

2.


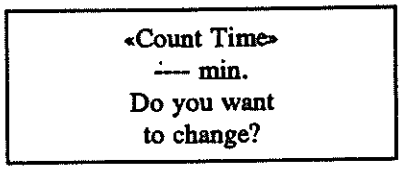
3.


NOTE: During Self Test, pressing any key displays:



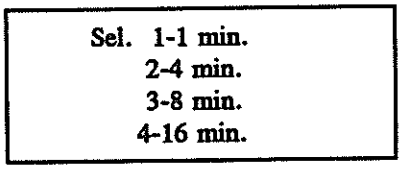
4.


5. Press TIME

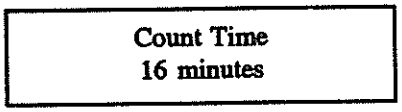
6.


NOTE: Pressing CE will return the display to:

7. Press YES

8.


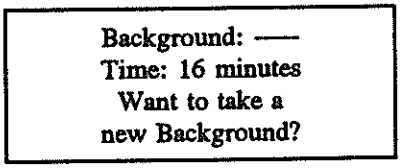
9. Press #4

10.


NOTE: Pressing CE will return the display to:

11. Make sure sample chamber is empty and the door is closed and latched.

12. Press BKG

13.


ANNEX A (continued)

14. Press YES

15.

Empty chamber & Press START for 16 minute Background count

16. Press START

17.

New Background count: ****** Want to use the new count?

18. Press YES

NOTE: If NO is pressed, the display returns to Step 11. If YES is pressed, the background count is completed and the instrument returns to the READY mode.

ANNEX B

Statistical Stability Test Procedure (Stat Test) with Troxler 3241-C Asphalt Content Instrument

The Stat Test is used to determine if the instrument is operating properly and should be performed after the background count has been taken. Upon completion of the test, the ratio of instrument readings should fall between 0.35 and 0.71, with 0.50 being ideal.

	— Depicts instrument reading.

1. Press SHIFT and SPECIAL

2.
```
SPECIAL FUNCTION
YES - (next menu)
1- Stat Test
2- Drift Test
```

3. Press 1

4.
```
-STAT TEST-
Time: —— min.
Do you want
to change?
```

5. Press YES (unless time reads 1 min.)

6.
```
Sel:  1-1 min.
      2-4 min.
      3-8 min.
      4-16 min.
```

7. Press 1

8.
```
Statistical
Stability Test -
Close door &
Press Start
```

9. Press START

10.
```
-STAT TEST-
Reading #1
Time: — sec.
```

Note: Step 10 shows number of readings for twenty 1-minute counts)

11.
```
Avg. cnts. ——
R: —.— Pass
Want to view
Stat Test data?
```

NOTE: If instrument displays a [FAIL] reading, check to see if there are any nuclear instruments close by or excessive moisture present. If not, run the test again. If the instrument fails again, contact the Materials Engineer or Troxler.

12. Press NO

13.
```
GAUGE READY
```

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ANNEX C

Instrument Calibration Procedure with Troxler 3241-C Asphalt Content Instrument

Upon completion of the Background and Stat Tests, the display should read GAUGE READY. The instrument is now ready for calibration. Use Form FHWA 1631 and Form FHWA 1632 for recording calibration data.

Sample pan tare weights should be marked on the front of each pan. The sample should always be put into the sample chamber with the front of the pan facing the door.

— Depicts instrument reading.

---

1. Press CALIB

2.
> Calib # Factory
> 1- Review Calib
> 2- Stored Calib
> 3- New Calib

NOTE: Select 1 to review a stored calibration. Select 2 to activate a stored calibration. Select 3 to enter a new calibration.

3. Press 3

4.
> Select source
> for New Calib.
> 1- Keypad input
> 2- Gauge derived

NOTE: If the instrument loses the stored calibration, you can re-enter it using keypad input from your calibration sheet.

5. Press 2

6.
> Background ----
> Time: 16 minutes
> Want to take a
> new background?

NOTE: If Time is not 8 minutes, change to 8 minutes and start again at Step 1. The background count must also be current.

7. Press NO

8.
> Blank sample
> net wt. ___ g.
> Input and
> press ENTER

9. Input net specimen weight from calibration record and press ENTER.

10.
> How many samples
> (2-12)? _____
> Input and
> press ENTER

11. Input 3 and press ENTER

12.
> Sample #1
> % AC: ____%
> Input and
> press ENTER

13. Input % AC from calibration record. Calibrate Pan No.1. Press ENTER

14.
> Load Sample #1
> Close door &
> Press START
> Time: --- sec.

ANNEX C (continued)

15. Press START

16. counts: ____
Press ENTER

17. Record Measured Counts. Pan #1 at count MC ___. Press ENTER

18. Sample #2
% AC ____%
Input and
press ENTER

19. Input known % AC from Calib. Record. Calibrate Pan No. 2. Press ENTER

20. Load Sample #2
Close Door
Press START

21. Press START

22. Counts: ____
Press ENTER

23. Record Measure Counts. Pan #2 at Count MC ___. Press ENTER

24. Sample #3
% AC ____%
Input and
press ENTER

25. Input known % AC from Calib. Record. Calibrate Pan No. 3. Press ENTER

26. Load Sample #3
Close Door
Press START

27. Press START

28. Counts: ____
Press ENTER

29. Record Measure Counts. Pan #3 at Count MC ___.

30. Press ENTER

31. WORKING

32. Fit. Coef: ____
Want to
review data?

NOTE: The Fit. Coef. is actually the goodness of fit. Values above 0.95 are good. 1.00 is perfect.

33. Press YES

34. Select method of
viewing data:
1- Screen
2- Printout

35. Press 1

36. Review Data
Weight: ---- g.
Background: ----
(press YES)

37. Press YES

ANNEX C (continued)

38.

A1: -____ A2: ____ A3: 00000

NOTE: A1 = The Intercept (a negative No.).
A2 = The Slope.
A3 = Always Zero.

39. Record Slope and Intercept.
Press YES

40.

#1: _____% AC counts: ------ Diff. = _____ % AC (press YES)

41. Press YES

42.

#2: ____% AC counts -------- Diff. = ____% AC (press YES)

43. Press YES

44.

#3: ____% AC counts -------- Diff. = ____% AC (press YES)

45. Press YES

46.

Fit. Coef: _.____ Want to review data?

47. Press NO

48.

WORKING

49.

CALIBRATION ACTIVATED WANT TO STORE CALIBRATION?

50. Press YES

51.

CALIBRATION #? - _____ Input and press ENTER

NOTE: Use project I.D. numbers.

52. Input project numbers and press ENTER

53.

What is mix ID? _____ Input and press ENTER

NOTE: Mix I.D. is usually the same as the project number.

54. Input ID numbers and press ENTER.

55.

CALIBRATION STORED

56.

GAUGE READY

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ANNEX D

Asphalt Mix Testing and Measurement Procedure with Troxler 3241-C Asphalt Content Instrument

Perform a background count at the beginning of each day before using the instrument. Follow the background count test procedures in annex A. If the instrument appears to be operating in an erratic manner or questionable, a Drift Test may be necessary. Contact the Materials Engineer for instructions.

After the background count is completed, make sure that the correct calibration has been activated. Follow the instrument calibration procedures in annex C.

— Depicts instrument readings.

1. GAUGE READY
*** DATE ***
Time: — minutes
Calib # _____

2. Count Time
— min.
Do you want
to change?

3. Press YES

4. Sel: 1-1 min.
2-4 min.
3-8 min.
4-16 min.

5. Press 2

6. GAUGE READY
*** DATE ***
Time: 4 min.
Calib # _____

7. Put sample to be tested into sample chamber and press START.

8. Calib # _____
Input empty pan
Weight: _____ g
and press ENTER

9. Input empty pan weight and press ENTER

10. Fill Sample Pan
until weight = — g.
Press ENTER)

NOTE: This is the weight of the sample plus the tare weight of the pan. If you have already filled the pan, just press ENTER.

11. Press ENTER

ANNEX D (continued)

12.

Calib # _____
Time: 240 sec.

NOTE: Time will count down from 240 sec. (4 min.)

13.

CALIB # _____
Counts: _____
% AC = _._____

14. Record the Measured Counts on line A of worksheet Form FHWA 1619.

15. Press START

16.

GAUGE READY
Date
TIME: 4 min.
CALIB: _____

17. The instrument is now ready for the next sample.

Standard Method of

Determining Cement Factor and Water/Cement Ratio Based on Measured Unit Mass and Air Content

FLH Designation: T 518-96

1. SCOPE

1.1 This test method covers verification procedures to determine if actual values of a concrete mixture conform to the values established in the approved mix design for cement content and water/cement (W/C) ratio.

2. SIGNIFICANCE AND USE

2.1 These procedures are intended to verify the validity of concrete mix designs and process control procedures. These procedures are not to be used for acceptance tests. However, if computed results consistently deviate from the approved mix design parameters or from the W/C ratio indicated on the producer's batch ticket, the cause for the discrepancies shall be determined.

If there are errors in the original mix design parameters such as the specific gravities of the aggregates, this will cause the measured unit mass to be consistently higher or lower than the design unit mass. However, if the mix design parameters are reasonably accurate, chronic discrepancies in cement factor or W/C ratio can generally be attributed to poor contractor process control and corrective action should be taken.

3. APPLICABLE DOCUMENTS

3.1 AASHTO T 121, Weight per Cubic Meter, Yield, and Air Content of Concrete
3.2 AASHTO T 152, Air Content of Freshly Mixed Concrete by the Pressure Method

4. PROCEDURES

4.1 Identify the following mix design parameters.

- Class of concrete.
- Minimum cement content.
- Maximum water/cement ratio.
- Design unit mass
- Design air content.
- Design water/cement ratio.

4.2 Determine the unit mass (kilograms per cubic meter) of the concrete according to AASHTO T 121 and record the value.

4.3 Verify the total batch masses of all components. Record net batch mass delivered. Normally, the batch masses will equal the design masses with minor adjustments for mix water which is withheld or added at the work site. Water in addition to the design mix water may be added only if the maximum permissible water/cement (W/C) ratio is not exceeded.

4.4 Determine the mass of water added to the batch at the work site and record the value. Assume one liter of water weighs 1.00 kilogram.

4.5 Calculate the net mass of a cubic meter of concrete using the net batch mass from 4.3 and the mass of added water from 4.4. Determine the yield by dividing this net mass by the unit mass from 4.2.

4.6 Calculate the cement factor by dividing 1 by the yield from 4.5.

NOTE 1—The contractor's process control can be considered adequate if the cement factor is between 0.98 and 1.02.

4.7 Determine the air content (%) of the concrete according to AASHTO T 152 and record the value.

4.8 Using the design air content (%) and the air content determined in 4.7, determine a Unit Weight Correction Factor using form FHWA 1633.

4.9 Divide the unit mass from 4.2 by the design unit mass (kg/m^3) and determine a Measured Unit Weight Factor.

4.10 Using the Measured Unit Weight Factor from 4.9 and the Unit Weight Correction Factor from 4.8, determine a W/C Ratio Correction Factor using form FHWA 1634.

4.11 Determine an approximate W/C ratio for the batch of concrete by multiplying the design W/C ratio by the W/C Ratio Correction Factor determined in 4.10.

NOTE 2—The maximum water/cement ratio is established by the contract specifications and should not be exceeded.

5. EXAMPLE

5.1 Design Parameters

- Class A(AE) concrete
- Minimum cement content - 360 kg/m^3
- Maximum water/cement ratio - 0.44
- Design unit mass - 2300.6 kg/m^3
- Design air content - 5.5%
- Design water/cement ratio - 0.43

5.2 Field Data

- Mass of a 6.12 m^3 batch (delivery ticket) - 13 800.0 kg
- 18.9 liters of water added at work site - 18.9 kg

  Total batch mass - 13 818.9 kg
- Measured unit mass - 2220.2 kg/m^3
- Measured air content - 8.1%

5.3 Determinations

- Yield $= \dfrac{13\,818.9}{(6.12)(2220.2)} = 1.017$
- Cement Factor $= \dfrac{1}{1.017} = 0.9832$
- Using form FHWA 1633 (see figure 1), horizontally locate the measured air content (8.1) intercept on the diagonal line representing the design air content (5.5). Move vertically down from this intercept to the X-axis and read the Unit Weight Correction Factor of 0.973.
- Measured Unit Weight Factor $= \dfrac{2220.2}{2300.6} = 0.965$
- Using form FHWA 1634 (see figure 2), plot the 0.973 unit weight correction factor on the 1.00 W/C ratio correction factor line. Draw a line through this point that parallels the existing diagonals. Locate the unit weight factor (0.965) on the X-axis and vertically intercept the 0.973 diagonal line. From this intercept, move horizontally left from this intercept to the Y-axis and read the W/C Ratio Correction Factor of 1.075.
- Estimated W/C Ratio = (1.075)(0.43) = 0.462

6. PRECISION

6.1 No measurement precision data are presently available for this test method.

U.S. Department of Transportation
Federal Highway Administration
Federal Lands Highway Office

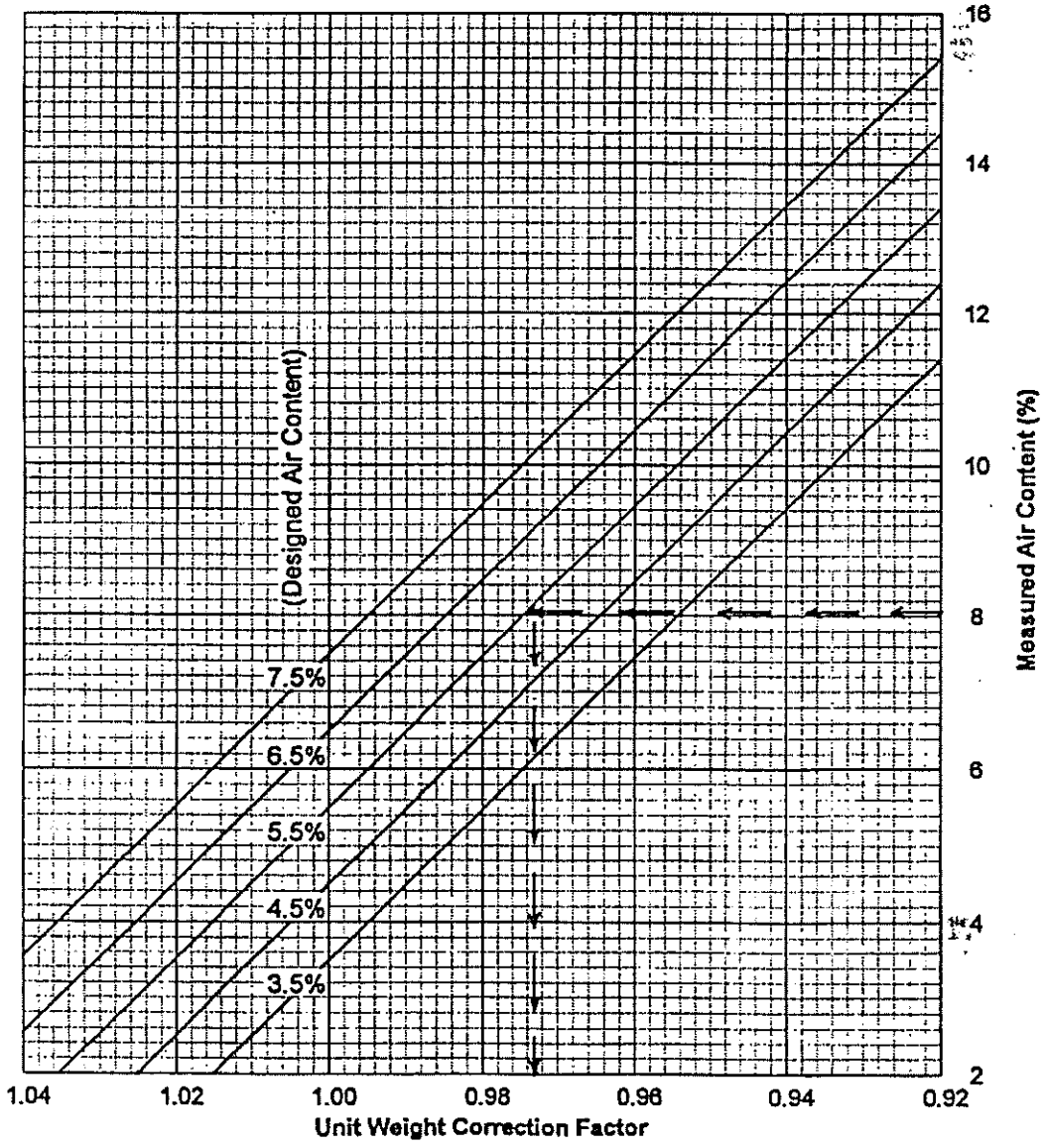
Worksheet for Determining a Concrete Unit Weight Correction Factor
FLH T 518

Project MT 72-6(8) Blue Bridge Source S.F. Ready Mix Co.

Where Sampled discharge chute Quantity Represented 10 m³

Sample Of Class P(AE) Lot No. 1 Sample No. 1

Sampled By J. Duke Date 10/4/96 Tested By J. Duke Date 10/4/96



Form FHWA 1633 (9-90)

Figure 1 - Example of Determining a Unit Weight Correction Factor

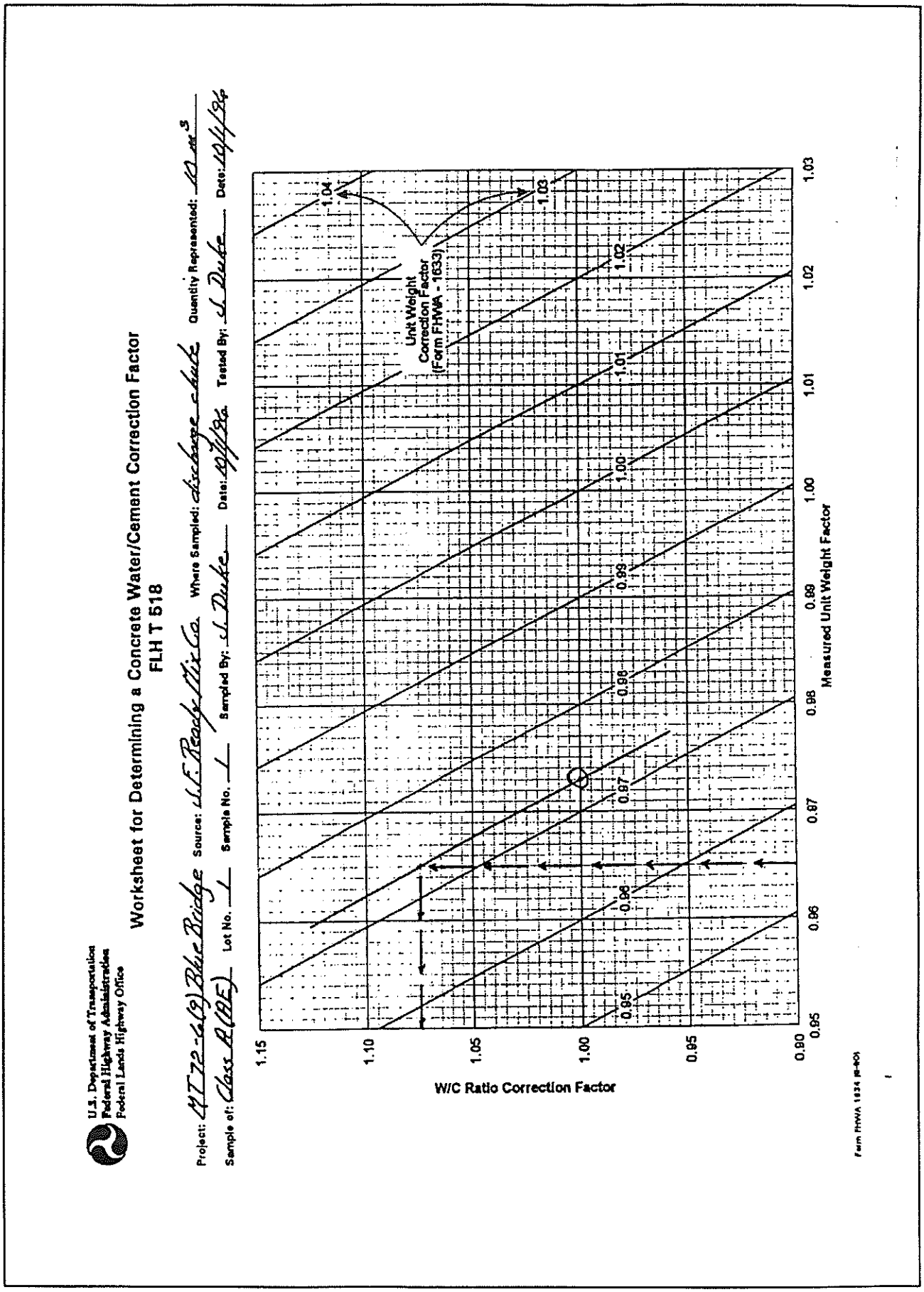


Figure 2 - Example of Determining a W/C Ratio Correction Factor

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Standard Method of

Determining Operator Retention Factor for Extraction of Asphalt from Asphalt Paving Mixtures

FLH Designation: T 519-95

1. SCOPE

1.1 This method covers the procedure for the determination of an operator asphalt retention factor to be used in conjunction with the quantitative extraction of asphalt from asphalt paving mixtures (AASHTO T 164).

2. APPLICABLE DOCUMENTS

2.1 AASHTO Test Procedures:
T 2, Sampling Aggregates
T 40, Sampling Bituminous Materials
T 164, Quantitative Extraction of Bitumen from Bituminous Paving Mixtures

3. SIGNIFICANCE AND USE

3.1 Before an operator performs the AASHTO T 164 test procedures for extracting asphalt from asphalt paving mixtures for process control or acceptance, a retention factor shall be determined. A retention factor is obtained using samples of fabricated asphalt mixture containing exact quantities of asphalt and aggregate. These samples are prepared by using the asphalt and aggregate actually used on the project.

4. APPARATUS

4.1 In addition to the apparatus listed in AASHTO T 164, the following apparatus is required for determining the retention factor (R_F).

4.1.1 *Oven* - An oven capable of maintaining a temperature of 150° C ± 5°, except when polymer modified asphalts are specified the oven shall be capable of maintaining a temperature of 170° C ± 5°.

4.1.2 *Mixing Bowl* - Mixing bowl of suitable design and shape to allow thorough mixing of the asphalt mixture. A large stainless steel salad, or mixing bowl with a capacity of approximately 8 liters is acceptable.

4.1.3 *Miscellaneous Apparatus* - Thermometers, spatulas, stirring spoons, gloves, metal pans, and metal pouring containers as necessary.

5. TEST MIXTURES

5.1 Three asphalt concrete mixtures each containing approximately 2.5 kilograms of dried aggregate and the appropriate quantity of asphalt shall be combined into a mixture and the asphalt cement then extracted from the mixture prior to production and/or quality control testing.

5.1.1 *Preparation of Aggregates* - Obtain a sample of aggregate (at least 10 kilograms) in accordance with AASHTO T 2 from the cold feed conveyor belt or if the plant is not operational, from the stockpiles. Dry, sieve, and separate the aggregate into appropriate sizes. Batch the aggregates for the 3 separate portions to conform to the target values established in the Job Mix Formula. Dry the three portions of aggregate to a constant weight at 150° C ± 5° except when using polymer modified asphalt cements dry the aggregate to a constant weight at 170° C ± 5°. Maintain the temperature for mixing.

Note: The aggregate for this procedure shall be obtained from the aggregates that have been produced for use in the production of the asphalt concrete mixture for the project work.

5.1.2 *Asphalt Cement* - Obtain a sample of the asphalt cement (approximately one liter) in accordance with AASHTO T 40 from the same asphalt cement that will be used in the production of the asphalt concrete mixture. Heat the liquid asphalt in a separate container to the appropriate temperature specified in 5.1.1.

5.1.3 *Mixing Equipment* - Pre-heat the mixing bowl and spoon to the appropriate temperature as specified in 5.1.1 above.

6. PROCEDURE

6.1 *Preparation of Test Mixes* - Weigh the heated aggregate to the nearest 0.1 gram and record the weight. To obtain the weight of asphalt needed, multiply the weight of the heated aggregate by the percent asphalt (by weight of aggregate) specified in the approved Job Mix Formula.

$$\textit{Note:}\quad \%\ \textit{asphalt by weight of aggregate} = 100 \times \frac{\%\ \textit{asphalt by weight of mix}}{100 - \%\ \textit{asphalt by weight of mix}}$$

6.2 Pre-tare the heated mixing bowl and spoon. Place the heated aggregate in the tared mixing bowl, make a small crater in the center of the aggregate, and add the required amount of heated asphalt. Record the weight of asphalt added to the nearest 0.1 gram. Hand mixing using the spoon and bowl has been found to be an acceptable mixing method. Reheating the mixture in the oven may be necessary to completely coat all the aggregate. Use caution not to lose any of the mix (aggregate or asphalt) from the spoon or bowl. After mixing is complete, weigh the mixed sample, the bowl and mixing spoon to the nearest 0.1 gram. The dry original weight of the mixture before extraction is obtained by subtracting the bowl and spoon tare from this weight.

6.3 Quantitative extraction of the asphalt concrete mixture is then performed according to AASHTO T 164 and the method specified in the contract. Use caution not to leave any material in the bowl or on the spoon. The endpoint of the retention extraction should not differ from the endpoint of a normal extraction test.

6.4 Repeat the steps set forth in sections 5.1 through 6.3 above for the remaining two separate test mixes. Determine a percent asphalt and calculate a retention factor for each test mixture.

7. CALCULATIONS

7.1 Calculate the percent of asphalt extracted from each test mix in accordance with the appropriate method in AASHTO T 164. Calculate the actual percent asphalt added to the aggregate for each test mix using the weight of asphalt added and weight of the heated aggregate from section 6.

A retention factor for each test mix is then determined by subtracting the percent asphalt extracted from the actual percent asphalt added to the aggregate.

Report the retention factor to the nearest 0.01 percent.

The overall retention factor for the ***same operator***, performing the tests on all asphalt extractions using the same Job Mix Formula (Mix Design), is the mean of three valid tests.

Note: A new retention factor determination must be made for each Job Mix Formula requiring a new mix design.

8. PRECISION

8.1 If the results of any of the three retention factor determinations are not within 0.10 of the mean of the three tests, the tests are considered invalid and must be rerun.

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Standard Method of

Determining the Roundness of Large Glass Beads

FLH Designation: T 520-93

1. SCOPE

1.1 This test method covers the determination of the roundness of glass bead specimens.

2. SIGNIFICANCE AND USE

2.1 This procedure is designed to determine the percent of round beads in a sample of large size beads. A round bead is defined as a spherical or fundamentally oval bead with an aspect ratio of 1.2:1 or less and having no other particles adhered to the parent bead.

3. GENERAL REQUIREMENTS

3.1 The beads shall be transparent, clean, colorless glass conforming to AASHTO M 247 and the gradation requirements for the Type specified. Use appropriate safety procedures and devices for eye protection. Clean up any spillage of beads immediately to avoid slipping or falling accidents.

4. APPARATUS

4.1 Microfiche Reader (Bell and Howell Model ABR VIII or equivalent) with a 20 mm lens.

4.2 Transparencies that define a 1.2:1 aspect ratio for the following sizes of beads:
- 1.70 mm
- 1.40 mm
- 1.18 mm
- 1.00 mm
- 850 μm

4.3 1/1 Mini-splitter

4.4 Clear, transparent, adhesive tape

4.5 Syringe, 3 cm^3 capacity, with a 0.32 ± 0.07 mm inside diameter needle

4.6 Microscope slide

4.7 Standard 1.5 refractive index liquid (a Wesson®* cooking oil or equivalent with an approximate 1.5 refractive index is acceptable)

4.8 Appropriate containers and utensils such as scoops, spoons, brushes, etc.

* Hunt-Wesson Inc., Fullerton, California 92634

5. SAMPLING

5.1 Sample the beads and perform the sieve analysis test according to ASTM D 1214.

6. TESTING PROCEDURES

6.1 Perform all testing on properly split or riffled specimens.

6.2 After determining the gradation by sieving, retain separately those fractions that contain the 2 largest quantities of particles. Use the mini-splitter to reduce each fraction to just enough beads to cover a microscope slide when they are adhered to a clear tape. Retain each reduced specimen separately.

6.3 Place a piece of tape, adhesive side up, over the open side of an empty pan or container. Carefully pour one of the specimens over the tape so the beads adhere to the tape. Recover any particles that fall into the pan and again pour over the tape until all particles have adhered.

6.4 Place a microscope slide on top of the adhered beads and attach by bringing the ends of the tape over the top of the slide. The beads are now sandwiched between the slide and the tape. Repeat for the other mesh size retained.

6.5 Lightly wet the beads with the refractive index liquid by injecting a few drops onto the beads (under the tape) using the syringe and needle. Use sparingly to avoid excess from running off the slide.

6.6 Place the slide (beads up) between the 2 glass plates on the sample tray of the Microfiche reader. Turn on the light and adjust the sample tray so the beads are visible on the screen. Count at least 200 beads on each slide. If necessary, use more than 1 field on a slide to obtain a minimum 200 count. Focus in on the beads and count the number of round beads (less than 1.2:1 aspect ratio).

6.7 Determine the aspect ratio of the beads using the appropriate transparencies depending on the mesh size being examined. Select the proper transparency and determine which of the inner circles best matches the width of the bead in question (match up at the center of the particle). Then slide the overlay so the end of the bead lines up with the outer circle. If the edge of the particle does not protrude beyond the opposite edge of the outer circle and its shape is either spherical or slightly oval, count the bead as round. If the other end of the bead protrudes beyond the opposite edge of the outer circle, the beads aspect ratio is greater than 1.2:1 and the bead is not considered round.

Do not count particles that are twins, satellites, agglomerates, angular, or fire polished as a round bead.

6. CALCULATIONS

6.1 Calculate the percentage of round beads in each sieve fraction as follows:

$$\% \ Rounds = \frac{100 \ (Total \ Number \ of \ Round \ Beads)}{Total \ Number \ of \ Particles \ Counted}$$

7. REPORT

7.1 Report the percentage of round beads for each sieve fraction tested to the nearest 0.5%. Round according to the rounding-off method of AASHTO R 11.

8. PRECISION

8.1 No measurement precision data are presently available for this test method.

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